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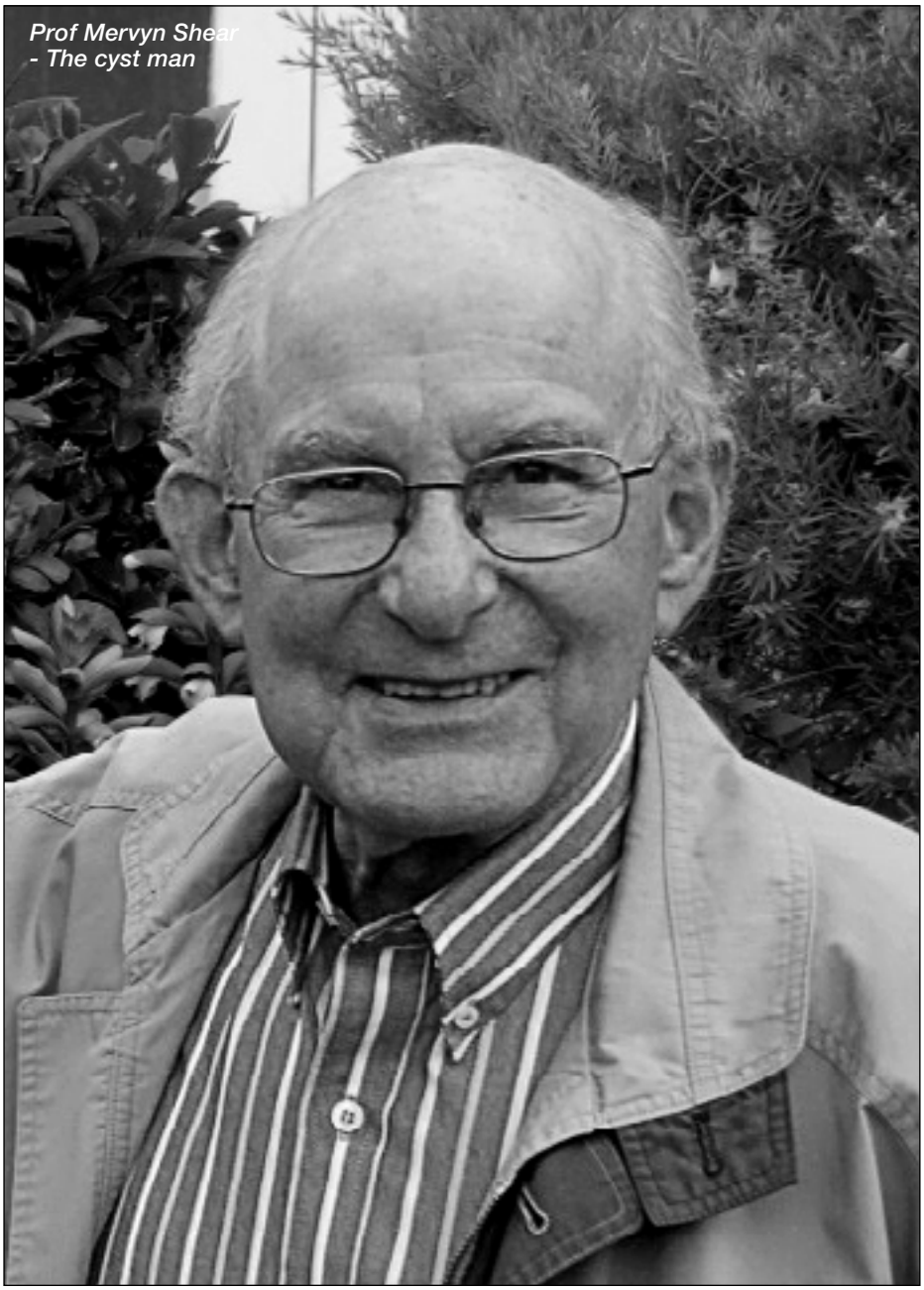

Prof Mervyn Shear

Professor Mervyn Shear, BDS (Rand), MDS (Oral Pathology) (Rand), FRC Path (Royal College of Pathologists), DSc (Dentistry) (Wits). Known as "the cyst man," Mervyn was the prime mover in the establishment of Oral Pathology as a speciality in South Africa. He authored over 115 scientific papers and his "Cysts of the Oral and Maxillo-facial Regions" (fourth edition published in 2007) held central place as the favoured reference for the topic.

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CONTENTS

Our Front Cover for this Issue…

The theme for the Front Cover of the South African Dental Journal this year provides for some historical figures, some characters illuminating dental history and some important achievements in South African Dental history.
The cover for the July looks at a dentists who made an important contribution to Oral Pathology in South Africa.

Prof Mervyn Shear
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Publisher and Project manager

Mr René Smulders

GENERAL AND ADVERTISING ENQUIRIES

Mr René Smulders
Email: rene@edoc.co.za

Design and Layout

Ms Reine Combrinck
Email: production@edoc.com

Website smalls advertising / CPD Enquiries and Member contact detail update

South African Dental Association
Tel: +27 (0)11 484 5288
Email: info@sada.co.za

CONTENTS

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Prof Mervyn Shear

… a towering presence in Oral Pathology

BDS (Rand),
MDS (Oral Pathology) (Rand),
FRC Path (Royal College of Pathologists),
DSc (Dentistry) (Wits)

Professor Mervyn Shear made immense contributions to the discipline of Oral Pathology and indeed was the founder of the speciality in South Africa, holding the first Chair of Oral Pathology in the country.

He graduated BDS from Wits in 1964, Neil to MDS (Oral Pathology) in 1961 and to the FRC (Pathology) from the Royal College of Pathologists in 1965. His passion for the discipline motivated his determination that Oral Pathology should be affiliated to Anatomical Pathology, a relationship which has ensured maximum exposure for South African registrars in Oral Pathology.

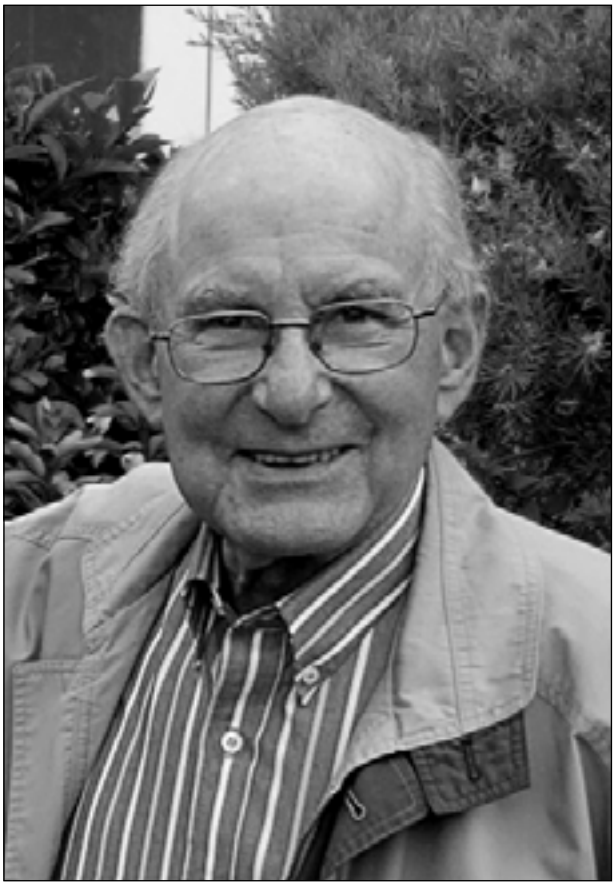
Perhaps a signal event in the professional life of Prof Shear was his publication in 2007 of a book which was to become the authorative reference on the subject... ”Cysts of the Oral and Maxillofacial regions”. This has now had four revisions, the latest being in 2017, now with a co-author, Paul Speight. In so many Departments of Oral Pathology this book has contributed to the erudition of students, both undergraduate and postgraduate.

Whilst a perusal of his long list of publications (over 115 papers) shows that Mervyn maintained his primary interest in cysts, he also made important contributions to the identification, interpretation and etiology of oral malignancies and explored biochemical activities in the salivary glands. A superb lecturer, Professor Shear was able to convey both his vast knowledge and his commitment to his subject to innumerable dental students... and to the many international conferences where he was a popular and respected speaker.

Indeed, Mervyn was recognised as a leading expert in the discipline by the award of honorary doctorates from Wits and the University of Pretoria, and honorary degrees from The College of Medicine of South Africa. He held positions on several international bodies and was Visiting Professor at three major universities. The publications have been cited on more than three and a half thousand occasions …an indication of just how seminal a role Professor Shear played in the global arena of Oral Pathology.

But Professor Shear also had a vital commitment to society and during the time of the controversial Extension of the Universities Act, he participated in many demonstrations and protests. He was a champion of the opening of access to tertiary education. On one such occasion he received a rubber bullet to his body, suffering considerable bruising.

On the Dental Association side, Mervyn was actively involved and served as Editor of the South African Dental Journal, working closely with Professor Frikkie van Reenen. Under their guidance the Journal achieved recognition as contributing meaningfully to dental knowledge.



Professor Mervyn Shear - an expert in the discipline of Oral Pathology (1931 - 2017)

In 1973 Professor Shear received the highest accolade from Wits. the DSc, honoris causa. He held the post of Deputy Vice Chancellor at the University from 1983 to 1990.

The profession lost a true champion when Professor Shear passed away on 24th January 2017.

Acknowledgement

Appreciation extended to Professor Shabnum Meer. SADJ 2017: 72(4); 4.

COVID-19: When recovery does not mean a return to health

SADJ July 2020, Vol. 75 No. 6 p286

NH Wood
Managing Editor of the SADJ

The number of COVID-19 cases in South Africa is steadily increasing. The reports and daily updates we receive from the National Department of Health and from the National Institute for Communicable Diseases (NICD) reflect the daily numbers of new cases, of deaths, and the number of recoveries.

It is the latter category that is more ominous than the label implies. What does it mean when "recoveries" are reported? Those cases that have not demised as a direct result of SARS-CoV-2 infection, and whom have surpassed the number of days to be considered free from SARS-CoV-2 infection, are listed as having recovered from COVID-19.

What the recovery figure does not tell us, is that there are several multi-system effects that manifest long after the virus has cleared from the body. The pulmonary effects that range from mild to severe residual lung abnormalities are the first to receive attention in the literature. Some studies are focussed on the deleterious cardiac effects that result after persistent inflammation.[1] Still more are reporting on chronic fatigue.

The final form of any post-COVID-19 chronic conditions is yet to be revealed, and the rehabilitation of these patients may take years to achieve. The ongoing impact of these "recoveries" should therefore not be underestimated. The long-term influence and strain on the healthcare system, on the economy and the education system to name only a few is undetermined as yet.

The situation is compounded by the recent WHO report[2] in which the lack of studies into antibody development and into antibody-mediated immunity against SARS-CoV-2 is highlighted. The risk for reinfection, and subsequent further transmission and spread is deeply concerning within the relative data vacuum.

Neil H Wood: Managing editor. Email: neil.wood@smu.ac.za

The lag in COVID-19 testing, and number of tests currently performed must also be taken into account.

We are all responsible for the lives of others during this pandemic. Please be reminded to remain safe: don't let your guard down, maintain distancing, look out for potential super-spreading events, and be vigilant with regards to infection control against the spread of SARS-CoV-2. Someone else's life depends on your behaviour.

I thank Dr NP Metsing who briefly shares with us her experience having dealt with COVID-19. At this point in time we all know someone who has been infected or directly affected by this virus. Some of us have already lost loved ones, colleagues and friends.

We extend our well-wishes to those who are currently fighting this infection, and to those who have loved ones currently infected. Thank you also to all our contributors to this issue of the South African Dental Journal.

Reference

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2. World Health Organisation. "Immunity passports" in the context of COVID-19 https://www.who.int/news-room/commentaries/detail/immunity-passports-in-the-context-of-covid-19?gclid=CjwKCAjw9vn4BRBaEiwAh0muDlEBkyy4RTvfumy4mNa4v039DzT-xmp5h_KkijXC4zcVA4Ktbef7uxoCOJEQAvD_BwE.

From practitioner to patient

- My COVID journey

SADJ July 2020, Vol. 75 No. 6 p287 - p288

NP Metsing
Head of Professional Development at SADA

It was on Wednesday the 24th of June when I started to feel fluish. Considering the pandemic that the world is currently facing, my first thought was that it may be COVID-19 yet there was another part of me that dismissed it. Within a few hours of these first symptoms, my throat felt like I had swallowed a ball of fire, I was coughing, had a severe headache, and I was feeling very cold despite sitting in front of the heater.

I self-medicated and went to bed early and took a decision to self-isolate for 7 days. The next day I woke up feeling much better, so I told myself it may not be COVID-19 since it responded to the previous night's remedies. I continued using some over-the-counter preparations, however on Friday I woke up and realized I lost my senses of taste and smell and I had no appetite. By Saturday I started to feel weak and lethargic and I couldn't even get myself out of bed. I tried to eat but food nauseated me.

I spent the whole weekend either in bed, or sleeping on the couch, still not eating while taking medicine. At this time my symptoms were a loss of taste and smell, a severely sore throat and an excruciating headache.

By Monday the situation did not improve, and I decided I needed to get a COVID-19 test done. Tuesday, I started to feel worse, so my dad (All the way in Carletonville) called an ambulance for me. Unfortunately, when the paramedics arrived, they were not willing to take me to the hospital, and by that time I did not have the energy to communicate with them, so I let them leave.

Subsequently, my situation took a turn for the worse on top of the existing symptoms: I started to vomit. My father fetched me from my house and took me to hospital where I was taken into casualty. An IV line was placed, bloods were drawn, and the blood results revealed a high SARS-CoV-19 viral load.

I was feeling very dehydrated and asked the nurse for some water which made me vomit instantly after ingestion. The drip I was given (Ringer's lactate) to replace fluids and electrolytes, also contained analgesics and antiemetics. The casualty doctor recommended that I be admitted into the hospital immediately.

That is when I realized the crisis that COVID-19 had created in the hospitals: there was a huge shortage of beds. I stayed in casualty from around 12 midday until 23:30 which was the time they actually managed to find an available bed.

I was asked if I wanted to eat, but my appetite was still gone (+/- 5 days without a decent meal). To be honest, during this whole-time fear was also creeping and my anxiety level was also rising as I kept on asking myself what if I lost my senses and never regained them. I even avoided googling any information regarding this.

I remember at one point I called a Professor who is an Oral Medicine specialist to find out if there was anything I could take, because in that moment of uncertainty one's professional knowledge escapes you. The next morning in my ward I was asked what I wanted for my 3 meals for the day. I did not want to answer this because seeing food without being able to smell it made me panic, let alone not being able to taste it. I was told that I did not have a choice.

When breakfast came, I took a spoon of the porridge and asked the nurse to take it back because I felt like vomiting however something interesting happened at that time, I had a bit of taste sensation on my tongue, this was something that really lifted my mood a little bit. During lunch time I managed to eat my meal without nausea the same with supper.

That morning the hospital took a decision to re-swab me since my swab results were still not back. That evening at 21:30 I received an email from Ampath laboratory with my results which proved what I had already instinctively known, that I had COVID-19. I informed the nurse that was on duty and immediately I was taken to an isolation room as I was in a room with another patient at that time. I won't lie, even though I tried very hard to stay positive, receiving a COVID-19 positive test result did depress me a little bit, and I believe that is the time when your emotional intelligence really gets tested.

Although my senses were starting to improve and my appetite was recovering, night-time was my most dreaded time. I had severe headaches, sore throat, and shortness of breath at night. When the attending doctor on ward rounds consulted me, I requested him to discharge me. Even though he was skeptical, I assured him that I was able to take care of myself from home. I felt trapped in the hospital room, and I wanted to avoid having to deal with mental issues in addition to all the symptoms I was already experiencing.

Day one out of the hospital went well, and I felt of a little stronger than previous 2 weeks. By this time my sense of taste was almost fully restored. My sense of smell was still recovering and it was a strange experience.

I was able to smell some things and others not: could not smell the soap in the shower while I was showering nor could I smell food, but I could smell scents like eucalyptus oil. I was happy though because I noticed the progress even though I still remained fatigued and had shortness of breath when standing, even for a short period.

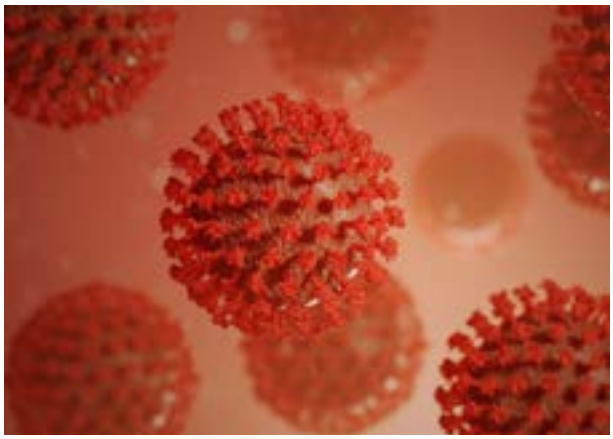
On Monday the 6th of July I woke up feeling a great improvement, to the extent that I felt that I could resume work in a day or two. Around midday I was feeling fatigued and I started feeling very cold but it was nothing that a nap could not sort out, my sense of smell (the most stubborn of all senses lost) was now coming back although being lost intermittently.

On Tuesday the 7th of July, my mom came over to look after us and to also to assist with some housekeeping. I cannot overemphasize importance of family during this time, and support structures are extremely important to facilitate recovery. The fact that my mother is a nurse was an added bonus because my family was able to observe the full protocol while providing us the necessary emotional and physical support.

Words fail me when I have express my gratitude to my family for the love and support during this time even though I had moments of depression and at times I would lose my temper, my family never left me. It was my mother who insisted that I go to the hospital when she realized that my condition was deteriorating.

Throughout my journey with COVID-19 I never once had a high temperature. The highest reading while I was in hospital was 37° (the acceptable body temperature), which made me wonder about the heavy emphasis being placed on a fever as an indicator of possibly being COVID-19 positive. We must be aware that there are exceptions to these averages, and not to take any symptom or sign lightly.

Most people might ignore these symptoms all because they are not “running a high temperature”. This may be dangerous because we may have positive people in public spaces potentially spreading the virus without ever knowing it. It is important for people to appreciate that this virus affects our bodies differently, and that not all of us will necessarily experience the same symptoms that are emphasized.



On one end of the spectrum, some people die and on the other end of the same spectrum some people experience no symptoms throughout the entire period of their infection. There appears to be extremely little to no focus on those in between, and who suffer the long-lasting sequelae of this infection. I really hope my story resonates with the readers, and that people who do get symptomatic may know that they are not alone in this scary journey.

I also realized the importance of safeguarding your mental health and remaining positive. Many of us have vastly different ways to approach this significant challenge. Personally, spiritual growth is eminent. If you follow any religion, it is during this time that divine intervention is of great importance to many. To me, as a Christian, my spiritual growth was very evident in my utterances and I started to pray more.

Thank you for taking your time to read my story.

Regards,

Dr NP Metsing
Head of Professional Development at SADA

In the face of COVID-19, SADA continues to deliver to its members

SADJ July 2020, Vol. 75 No. 6 p289 - p290

KC Makhubele
CEO of SADA

SADA is proud to be amongst the small elite group of professional associations representing healthcare practitioners, fully recognised worldwide. Recently we held both the SADA Annual General and National Council Meeting virtually through a meetings electronic platform – Zoom.

We have indeed entered a new era in the history of the Association as these were the first members meetings held electronically. We are pleased that members registered and attending were able to actively participate and exercise their voting rights on various issues tabled at these meetings.

All Branch, National Council, Board and Board Committee meetings will be conducted by electronic means in the foreseeable future. It is also reported with regret that the 2020 Dental Congress and Exhibition had to be cancelled at the Emperors Palace Conference Centre in Gauteng. Several alternatives and strategies are being investigated to meet the educational and CPD needs of members for the year.

We are proud to announce the appointment of Dr Rhonin Naidoo (Kwa-Zulu Branch) as the new President of the Association and Dr Anthony Julius (North-West Branch) as the Vice-President of the Association, they will both serve for a two-year term. On behalf of the Board, National Council and management, we welcome them and express our profound and heartfelt congratulations on their appointment. We wish them every success and we are confident they will proudly represent our Association for the next two years.

Image Source: Jürgen Randma / CC BY-SA (https://creativecommons.org/licenses/by-sa/4.0)

As we enter advanced level 3 of the COVID-19 pandemic, the extreme challenges facing our members are becoming more dire with shortages of required PPE, staff testing positive for COVID-19, patients fearful about consulting their dentists, some practitioners contemplating earlier retirement than anticipated, as a measure of supporting our members, we have offered two months free membership. Members have been requested to provide their banking details to permit the Association refund them much needed funds.

The extended Dental Practice Committee together with the different workstreams specifically mandated to deal with different aspect of the pandemic have been hard at work from the start of the lockdown and after and we are proud to make available to the entire dental fraternity Protocols to guide members working under COVID-19 conditions.

The protocols have been enthusiastically received by all stakeholders we have been engaging with not only in South Africa, but even internationally it is seen as a leading protocol document. We are happy to report that dental professional associations abroad are equally impressed with the contents of a well-researched document.

The different workstreams have also been hard at work holding webinars every week keeping members properly informed about the different challenges facing the profession during this time. Many more are being planned and we have consciously decided to make these available to members and non-members alike in the interests of fulfilling our duties as citizens in contributing to the prevention of the spread of the disease.

The electronic book titled “Infection Control Guidelines for Oral Health Care” by Dr Jeanné Oosthuysen and co-authors is available for members on the website which we hope guide our members in keeping their patients, staff and themselves safe.

Members were introduced to services of two labour consultants who will offer their services on labour related challenges members are likely to face now and in the coming months. Members are encouraged to utilise their services to prevent unnecessary and costly labour disputes. Several guidelines have been issued for the benefit of practitioners as employers.

Engagements with medical schemes, medical scheme administrators and third-party funders are ongoing as regards providing benefits for additional PPE for AGPs and non-AGPs performed by practitioners.

While some schemes are willing to consider benefits for the practitioner and assistants, others have resisted despite the fact these are also required for the protection of their members.

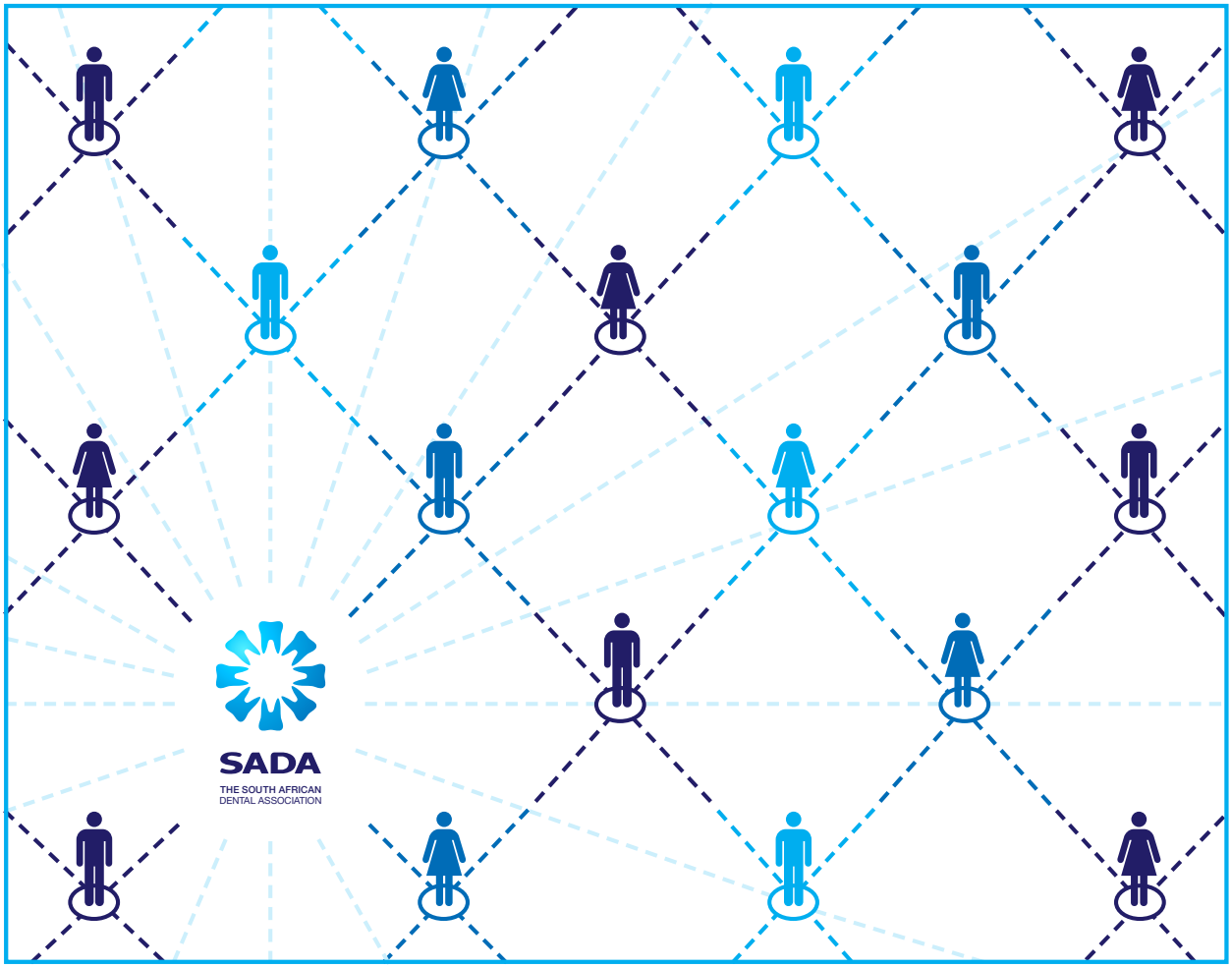
Members have also started the debate about the continued reliance of the profession on third party funders and its devastating impact on the future of the profession. To this end, the Board has grappled with this subject and will survey members about their practice circumstances and reliance in these tough economic times.

Perhaps the time has come for the profession to re-consider their position now and in the post pandemic era, to make their patients to whom they provide treatment responsible to them for payment of services rendered. It is now time that the profession takes charge of their own practices and like other businesses, rely on their customer to pay for services received.

Members would also have followed through webinars that Dental Protection is seeking to establish service centres and more personnel to assist members at a local level to provide more efficient and quicker turn-around for members seeking guidance, facing complaints and/or claims.

We are also pleased to announce the appointment of the erstwhile President, Professor P Moipolai to the South African Dental Technicians Council as a member attached to an academic institution. The Chairperson of the SADA Board of Directors, Dr R Putter was successfully appointed to the PPS Trust Board. We wish them both success in their appointment. The Board also appoint two new independents, Mrs Carina Wessels (Admitted Advocate of the High Court of South Africa and Executive: Governance, Legal and Compliance at Alexander Forbes) and Mr Hiten Keshave (A charted accountant and CFO at PRP Solutions (Pty) Ltd.

Amidst all of the challenges the profession is facing, the business of the association continues.



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Throughputs of two cohorts of dental students at Sefako Makgatho Health Sciences University: A comparison

SADJ July 2020, Vol. 75 No. 6 p291- p297

SR Mthethwa[1], PM Nyalunga[2], TS Gugushe[3]

ABSTRACT

Introduction
The numbers of student dentists enrolled at dental schools across the country do not give an indication of the students' progress to degree.

Aims and objectives
To describe and compare the throughputs of dentistry course for two cohorts of students at Sefako Makgatho Health Science University.

The progress to degree of the 2005 and 2010 cohorts of first year dental students was tracked and compared.

Design
A comparative cross-sectional study.

Methods
Academic records of the 2005 and 2010 cohorts of first year dental students were followed up over a five-year period. Data related to the demographic characteristics, numbers enrolled, numbers who dropped out, and the numbers who graduated were acquired and then captured in Microsoft Excel software.

Results
Female students constituted the majority of enrolees in both cohorts (53.8% vs. 51.3%). The proportions of students who started the course, completed the degree and graduated within the regulation time among the 2005 and 2010 cohorts were similar (42.1% vs. 41.2%).

A lone student among the 2010 cohort dropped out of the course. The majority of students (57.9% vs. 55.9%) in both cohorts took longer to qualify.

Conclusions
The throughputs of dentistry course for the two cohorts hovered around 40%.

Author affiliations:
1. **Sibusiso R Mthethwa:** *BDS, MPH, PhD,* Sefako Makgatho Health Sciences University, South Africa. ORCID Number: 0000-0003-0420-808X
2. **Phabian M Nyalunga:** *BDT, BDS,* Sefako Makgatho Health Sciences University, South Africa.
3. **Tshepo S Gugushe:** *BSc, BDS, DHSM, MDent, MPhil,* Sefako Makgatho Health Sciences University, South Africa.

Corresponding author: SR Mthethwa
Medunsa Campus, PO Box D24, Sefako Makgatho Health Sciences University 0204, South Africa.
Email: rocky.mthethwa@smu.ac.za

Author contributions:
1. **Sibusiso R Mthethwa:** Conception; design; acquisition of data; analysis and interpretation of data; drafting the article - 33.3%
2. **Phabian M Nyalunga:** Conception; revising the article critically for important intellectual content - 33.3%
3. **Tshepo S Gugushe:** revising the article critically for important intellectual content - 33.3%

INTRODUCTION AND BACKGROUND

There is a shortage of oral health personnel in South Africa. Oral health personnel, including dental assistants, oral hygienists, dental therapists, and dentists, have been estimated to constitute 0.2 per 1000 population.[1]

A meagre dental practitioner to population ratio of 1.09 per 10,000 has been estimated.[2] There is currently a debate about how to alleviate this shortage. An argument has been made that we should be training fewer dentists and more oral hygienists and dental therapists.[3] This line of reasoning is supported by evidence emerging from epidemiological studies of the burden of disease.

Evidence indicates that dental caries is the most prevalent oral disease[4] - the latest national survey found that more than 80% of dental caries in children was untreated.[5] Previously unobserved oral health priorities, which include conditions such as periodontal disease, oral manifestations of HIV/AIDS, dental trauma, oral cancer and craniofacial anomalies, are now under consideration, adding to the burden.[6,7]

An analysis of the throughput of the various courses offered at dental schools in the country could enrich the debate on the number and mix of oral health personnel required to provide necessary services. The results of such an investigation will be useful to policy-makers in developing human resources plan for oral health and to the dental schools' management in identifying impediments to graduation in order to offer the necessary academic and mentoring support to enable success.

The median throughput of the dental therapy courses for the period between 2004 and 2014 at Sefako Makgatho Health Sciences University has recently been established to be 45 percent with an interquartile range of 37 to 58.5 percent.[8] This finding is rather disappointing. The current study seeks to describe the throughputs for two cohorts of students in the dentistry course at Sefako Makgatho Health Science University during the period between 2005 and 2014.

The results of a recent review of Health Professions Council of South Africa (HPCSA) records indicate that the number of dentists increased at around 2% per annum during the period 2002 to 2015.[9] The study revealed a welcome change in the demographic profile of dentists. It found a relatively sharp increase in the number of Coloured, Black and female registered dentists.[9]

The aggregate number of student dentists currently enrolled in the four dental schools in the country is 1 158.[10] This figure does not give an indication of the students' progress to degree. A most recent systematic review of the literature clusters the determinants of university dropout and delayed graduation into four main categories i.e. students' characteristics, abilities and behaviour; parental background and family networks; characteristics of tertiary education system and institutions, and labour market conditions.[11]

The strong association of race, gender, matriculation score and poverty with dropout or graduation at South African universities is well documented.[12,13,14] The association, if any, of student motivation with dropout or graduation is an important issue for future research. The results of a national survey among early-phase student dentists are extremely concerning. The survey found that for a third of respondents, dentistry was not a first choice – amongst the White students, it was a first choice for 82% compared with 59% amongst Black Africans.[15]

OBJECTIVES OF THE STUDY

To describe the demographic changes undergone by the 2005 and 2010 cohorts of first year dental students in successive years of study.

To track and compare the progress to degree of the 2005 and 2010 cohorts of first year dental students. To determine the median numbers of students who completed their degree and graduated within the regulation time.

MATERIALS AND METHODS

Study design

This was a retrospective, comparative cross-sectional study in which existing academic records were reviewed.

Target population

The sampling frame consisted of academic records of a subpopulation of dental students who were enrolled at Sefako Makgatho Health Sciences University during the period 2005 to 2014 i.e. academic records of cohorts of first year dental students who were enrolled in 2005 and 2010 respectively were followed up over a five-year period.

Study sample

Every available record was studied.

Data collection

Data related to the demographic characteristics of the students, the numbers enrolled, numbers who dropped out, and the numbers who graduated were acquired and then captured in Microsoft Excel software.

Definition of variables and terms

Age and gender refer to student age and sex as recorded in the academic records.

Population group breakdown of students into African, Indian, Coloured and White will be applied according to the Population Registration Act of 1950.[16]

Progress to degree refers to enrolment and academic progress.

Regulation time is the period of time normally expected for completion of the degree (five years).

Throughput, quite simply, is how many students who started studying complete the course of study. This may also be measured by the number of students who do not drop out.[17] It is also referred to as the completion rate, or graduation rate.[18]

First-timer refers to a student who was enrolled in a year of study for the first time.

Ethical considerations

Ethical approval for the study was granted by the Ethics Committee of Sefako Makgatho Health Sciences University (SMREC/D/1820/2017). Permission to conduct the study was granted by the Chief Executive Officer (CEO) of the Medunsa Oral Health Centre.

STATISTICAL ANALYSIS/ HYPOTHESIS TESTING

Collected data were subjected to univariate and bivariate analysis in Statistical Package for the Social Sciences (SPSS) software. Frequencies, means and proportions were calculated. Chi-square tests were performed to test the statistical significance of the differences in proportions. Chi-square tests for trends were performed to investigate trends in enrolments and examination pass rates. The chosen significance level of the tests was a p-value less than 0.05.

RESULTS

Academic records of the 2005 and 2010 cohorts of first year dental students were followed up over a five-year period and analysed.

The total number of enrollees followed up over the five years of study in the 2005 cohort was 10.4% more than that of the 2010 cohort. The first year class of the 2005 cohort was 28.9% larger than that of the 2010 cohort.

On the one hand, the fifth year class of the 2005 cohort was 26.9% smaller than the first year class. On the other hand, the fifth year class of the 2010 cohort was 27% larger than the first year class. Female students constituted the majority (54.5%) of the enrollees - they were the majority in all classes of the 2005 cohort.

Table 1. Gender distribution by year of study.

Cohort	Gender	Year of study					Total
		First n (%)	Second n (%)	Third n (%)	Fourth n (%)	Fifth n (%)	n (%)
2005	Male	24 (46.2)	22 (41.5)	23 (44.2)	18 (40)	15 (39.5)	102 (42.5)
	Female	28 (53.8)	31 (58.5)	29 (55.8)	27 (60)	23 (60.5)	138 (57.5)
	Total	52 (100)	53 (100)	52 (100)	45 (100)	38 (100)	240 (100)
2010	Male	18 (48.7)	22(51.2)	20 (51.3)	23 (46.9)	22 (46.8)	105 (48.8)
	Female	19 (51.3)	21 (48.8)	19 (48.7)	26 (53.1)	25 (53.2)	110 (51.2)
	Total	37 (100)	43 (100)	39 (100)	49(100)	47 (100)	215 (100)
Total	Male	42 (47.2)	44 (45.8)	43 (47.3)	41 (43.6)	37 (43.5)	207 (45.5)
	Female	47 (52.8)	52 (54.2)	48 (52.7)	53 (56.4)	48 (56.5)	248 (54.5)
	Total	89 (100)	96 (100)	91 (100)	94 (100)	85(100)	455 (100)

Table 2. Racial composition by year of study.

Cohort	Race	Year of study					Total
		First n (%)	Second n (%)	Third n (%)	Fourth n (%)	Fifth n (%)	n (%)
2005	African	44 (84.6)	45 (84.9)	46 (88.5)	40 (88.9)	32 (84.2)	207 86.3)
	Indian	5 (9.6)	5 (9.4)	4 (7.7)	3 (6.7)	4 (10.5)	21 (8.8)
	White	3 (5.8)	3 (5.7)	2 (3.8)	2 (4.4)	2 (5.3)	12 (4.9)
	Total	52 (100)	53 (100)	52 (100)	45 (100)	38 (100)	240 (100)
2010	African	27 (73.0)	32 (74.4)	36 (92.3)	46 (93.9)	43 (91.5)	184 (85.6)
	Indian	4 (10.8)	5 (11.6)	1 (2.6)	1 (2.0)	2 (4.3)	13 (6.1)
	White	6 (16.2)	6 (14)	2 (5.1)	2 (4.1)	2 (4.2)	18 (8.3)
	Total	37 (100)	43 (100)	39 (100)	49 (100)	47 (100)	215 (100)
Total	African	71 (79.8)	77 (80.2)	82 (90.1)	86 (91.5)	75 (88.2)	391 (85.9)
	Indian	9 (10.1)	10 (10.4)	5 (5.5)	4 (4.25)	6 (7.1)	34 (7.5)
	White	9 (10.1)	9 (9.4)	4 (4.4)	4 (4.25)	4 (4.7)	30 (6.6)
	Total	89 (100)	96 (100)	91 (100)	94 (100)	85 (100)	455 (100)

Table 3. Numbers of first-timers by year of study.

Cohort	First-timer	Year of study					Total
		First n (%)	Second n (%)	Third n (%)	Fourth n (%)	Fifth n (%)	n (%)
2005	No	14 (26.9)	10 (18.9)	7 (13.5)	5 (11.1)	2 (5.3)	38 (15.8)
	Yes	38 (73.1)	43 (81.1)	45 (86.5)	40 (88.9)	36 (94.7)	202 (84.2)
	Total	52 (100)	53 (100)	52 (100)	45 (100)	38 (100)	240 (100)
2010	No	3 (8.1)	10 (23.3)	8 (20.5)	23 (46.9)	5 (10.6)	49 (22.8)
	Yes	34 (91.9)	33 (76.7)	31 (79.5)	26 (53.1)	42 (89.4)	166 (77.2)
	Total	37 (100)	43 (100)	39 (100)	49 (100)	47 (100)	215 (100)
Total	No	17 (19.1)	20 (20.8)	15 (16.5)	28 (29.8)	7 (8.2)	87 (19.1)
	Yes	72 (80.9)	76 (79.2)	76 (83.5)	66 (70.2)	78 (91.8)	368 (80.9)
	Total	89 (100)	96 (100)	91 (100)	94 (100)	85 (100)	455 (100)

Table 4. Trends in examination pass rates.

Cohort	Year of study	Examination Results		Total	Chi-squared test for trend
		Pass n (%)	Fail n (%)	n (%)	
2005	First	43 (82.7)	9 (17.3)	52 (100)	
	Second	48 (90.6)	4 (9.4)*	53 (100)	
	Third	41 (78.8)	11 (21.2)	52 (100)	p = 0.254
	Fourth	36 (80)	9 20)	45 (100)	
	Fifth	26 (68.4)	12 (31.6)	38 (100)	
	Total	194 (80.8)	45 (19.2) *	240 (100)	
2010	First	34 (91.9)	3 (8.1)	37 (100)	
	Second	31(72.1)	11 (27.9)*	43 (100)	
	Third	26 (66.7)	12 (33.3)*	39 (100)	p = 0.254
	Fourth	42 (85.7)	6 (14.3)*	49 (100)	
	Fifth	47 (100)	0 (0)	47 (100)	
	Total	180 (83.7)	32 (16.3) ***	215 (100)	
Total	First	77 (86.5)	12 (13.5)	89 (100)	
	Second	79 (82.3)	15 (17.7)**	96 (100)	
	Third	67 (73.6)	23 (26.4)*	91 (100)	p = 0.254
	Fourth	78 (83.0)	15 (17)*	94 (100)	
	Fifth	73 (85.9)	12 (14.1)	85 (100)	
	Total	374 (82.2)	77 (17.8) ****	455 (100)	

*Number of students that dropped out.

Table 5. Comparison of the throughput of all first-timers between cohorts.

Cohorts	Year of study					Number of graduates	Throughput (%)	Chi-squared test
	First	Second	Third	Fourth	Fifth			
2005	38	29	27	20	16	16	42.1	p = 0.937
2010	34	30 (1)	20	16	14	14	41.2	

( ) number of students that dropped out.
Throughput = Number of graduates divided by number of students enrolled in first year.

Table 6. Comparison of the throughput of first-timers with tertiary education between cohorts.

Cohorts	Year of study					Number of graduates	Throughput (%)	Chi-squared test
	First	Second	Third	Fourth	Fifth			
2005	22	19	18	13	9	9	40.9	p = 0.454
2010	23	21	14	12	12	12	52.2	

Throughput = Number of graduates divided by number of students enrolled in first year.

Table 7. Comparison of the throughput of first-timers without tertiary education between cohorts.

Cohorts	Year of study					Number of graduates	Throughput (%)	Chi-squared test
	First	Second	Third	Fourth	Fifth			
2005	16	10	9	7	7	7	43.8	p = 0.174
2010	11	9	6	4	2	2	18.2	

Throughput = Number of graduates divided by number of students enrolled in first year.

Table 8. Comparison of the throughput of first-timers with and without tertiary education among the 2005 cohort.

Tertiary education	Graduated		Total	Chi-squared test
	Yes n (%)	No n (%)		
Present	9 (40.91)	13 (59.09)	22 (100)	p = 0.862
Absent	7 (43.75)	9 (56.25)	16 (100)	
Total	16 (42.11)	22 (57.89)	38 (100)	

Table 9. Comparison of the throughput of first-timers with and without tertiary education among the 2010 cohort.

Tertiary education	Graduated		Total	Chi-squared test
	Yes n (%)	No n (%)		
Present	12 (52.17)	11 (47.83)	23 (100)	p = 0.063
Absent	2 (18.8)	9 (81.82)	11 (100)	
Total	14 (41.18)	20 (58.82)	34 (100)	

In contrast, they were in the minority in the second and third year classes of the 2010 cohort.

African students constituted a vast majority (85.9%) of the enrolees – they were an overwhelming majority in all classes of both cohorts. Indian students comprised the second largest racial group of enrolees at a mere 7.5%.

A marginal (3.4%) increase in the proportion of White students was observed between the 2005 and 2010 cohorts.

One out of five (19.1%) enrolee was a repeater - they comprised 15.8% and 22.8% of the 2005 and 2010 cohorts respectively.

One out of four (26.9%) enrolee in the first year class of the 2005 cohort was a repeater compared with less than ten percent (8.1%) in the first year class of the of the 2010 cohort. Almost half (46.9%) of the fourth year class in the 2010 cohort were repeaters.

A steady decline in the proportion of repeaters was observed among the 2005 cohort from the first to fifth years of study.

The mean examination pass rate of the 2010 cohort was slightly higher (83.7% vs 80.8%) than that of the 2005 cohort. The difference was however not statistically significant (p>0.05).

A two-thirds examination pass rate was the lowest rate achieved by both cohorts - 68.4% was recorded in the fifth year class of the 2005 cohort compared with 66.7% in the third year class of the 2010 cohort.

Three students, who failed the examinations, dropped out of the course among the 2010 cohort compared with one student among the 2005 cohort.

There was insufficient evidence to reject the null hypothesis of no trend in the proportion of students who passed the examination in the population (p> 0.05) for both cohorts.

The proportions of students who started the course in 2005 and 2010 and completed the degree in 2009 and 2014 and graduated in 2010 and 2015 within the regulation time was similar (42.1% vs 41.2%). A lone student among the 2010 cohort dropped out of the course. The majority of students (57.9% vs. 55.9%) of both cohorts took longer to qualify.

Eleven percent more first-timers with tertiary education among the 2010 cohort compared with the 2005 cohort completed the degree and graduated within the regulation time. The difference in proportions was however not statistically significant (p >0.05). 59.1% (13/22) of students in the 2005 cohorts took longer to qualify. Twenty-five percent more first-timers without tertiary education among the 2005 cohort compared with the 2010

cohort completed the degree and graduated within the regulation time. The difference in proportions was however not statistically significant (p >0.05). 82% (9/11) of students in the 2010 cohorts took longer to qualify.

Slightly (2.84%) more students without tertiary education graduated within the regulation time than those with tertiary qualification. There was insufficient evidence (p>0.05) to reject the null hypothesis that the proportions of students that graduated were equal in the two groups in the population.

A little less than three times (2.78 times) as many students with tertiary education graduated within the regulation time as were those without tertiary education. There was however insufficient evidence (p >0.05) to reject the null hypothesis that the proportions of students that graduated were equal in the two groups in the population.

DISCUSSION

This study set out to track, over a five-year period, and compare the progress to degree of first year dental students who were enrolled in 2005 and 2010.

The number of students who completed their degree and graduated within the stipulated time was also determined.

Demographic characteristics

The current study found that the size of the 2005 cohort was 28.9% larger than that of the 2010 cohort in the first year of study (Table 1). This unanticipated discrepancy coincided with the founding of the University of Limpopo (MEDUNSA Campus), a predecessor of Sefako Makgatho Health Sciences University. It may be due to institutional inexperience.

The results of this study indicate that female students constituted the majority (54.5%) of the enrolees of both cohorts (Table 1). The present findings seem to be consistent with other research which found that female students constitute the majority of dental students.[15] The most interesting finding was that the variation in numbers of enrolees between the first and fifth year classes of both cohorts was in different directions yet similar i.e. a 26.9% decline among the 2005 cohort in contrast to the 27.0% rise among the 2010 cohort (Table 1). This rather contradictory result was due to the significant difference (31.6%) in the examination pass rates between the fifth year classes of the 2005 and 2010 cohorts.

The results of this study show that African students constituted an overwhelming majority (85.9%) of the enrolees (Table 2). This foreseeable finding is inextricably linked with the founding mission of the predecessor institutions.

Medunsa, the Medical University of Southern Africa, was founded in 1976 to address both the under-representation of blacks in the health professions and the lack of good health care in the homelands. The university trains most of the black physicians, dentists, veterinarians, and allied health professionals in South Africa.[19] The results of this study show a significant reduction in the proportion of first year repeaters from a high of 26.9% in the 2005 cohort to a low of 8.1% in the 2010 cohort (Table 3). This encouraging finding suggests that the academic and mentoring support offered is effective.

In contrast, the current study found that repeaters constituted a strikingly large size (46.9%) of the fourth year class of the 2010 cohort. The observed significant increase in the number of repeaters in the fourth year class of 2013 could be attributed to fact that the large class size (59 students) of the previous year consisted of a relatively large number of weak students. Further research is required to establish the major factors that cause students to repeat a class.

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a relatively large number of weak students. Further research is required to establish the major factors that cause students to repeat a class.

Examination pass rate

The results of this study did not show any trend in the examination pass rates (Table 4). It seems possible that these results are due to the highly variable pass rates - the pass rates ranged between 68.4% and 90.6% and between 66.7% and 100% for the 2005 and 2010 cohorts respectively.

It is however encouraging that the lowest examination pass rates were attained in different classes i.e. the fifth year class of the 2005 cohort and the third year class of the 2010 cohort respectively. These findings suggest that the lowest examination pass rates were random.

Throughput

The current study found that the throughputs of the dentistry course at Sefako Makgatho Health Sciences University (SMU) hovered around 40% (Table 5).

Local studies of comparable cohorts were not found - the through-put of dentistry courses in the four dental schools in South Africa, namely the University of the Western Cape (UWC), University of the Witwatersrand (Wits), Sefako Makgatho Health Sciences University (SMU) and University of Pretoria (UP) has not previously been described.

The findings of the current study differ greatly from the Ministry of Education's target of 20% graduation rate for a 4-year or more undergraduate degree.[20] However, they are broadly consistent with other research.

The Council for Higher Education (CHE) found that the regulation time throughput, for four year degrees, of cohorts of first year students enrolled in the years 2007, 2008, and 2009 ranged between 29% and 42%.[21]

Furthermore, a regulation time throughput of 36.9% among first year students enrolled in 2009 has been found by researchers of the Stellenbosch University working paper.[22] The throughput of the dentistry course beyond regulation time is an important issue for future research.

The results of this study indicate that prior exposure of first-timers to tertiary education did not significantly ($p>0.05$) improve throughput (Tables 6, 8 and 9). This finding was unexpected. However, with a small sample size, caution must be applied in interpreting these findings.

The results of this study indicate that a lone student among the 2010 cohort dropped out of the course (Table 5). The findings of the current study do not support the previous research – the dropout rate is much lower (2.9%) than previously reported. The Council for Higher Education (CHE) found that the dropout rate ranged between 30% and 33%.[21] The Stellenbosch University working paper reported a dropout rate of 28.4%.[22]

Limitations of the study

Data on age of the students was not available.

The determinants of university dropout and delayed graduation could not be identified as data was not available.

CONCLUSION

The throughputs of dentistry course for the two cohorts hovered around 40%.

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Comparison of three different instruments for orthodontic study model analysis

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JC Julyan[1], J Julyan[2], J de Lange[3]

ABSTRACT

Introduction

A proper model analysis forms a vital part of the orthodontic diagnosis process, but it remains a time-consuming procedure. In day-to-day practice, many orthodontists assess the models subjectively, without applying analytical tests, due to the time it takes to do proper model analysis.[1,2]

Plaster dental models have long been the gold standard for orthodontic study model analysis and to calculate the Bolton index for tooth size disproportions, as well as intra-arch space discrepancies.[3,4] Vernier callipers or needle pointed dividers are traditionally used to perform measurements on dental models.[5] More recently digital orthodontic study models that are computer-based have been developed and have the potential to replace the traditional plaster orthodontic models.[6]

Aims and objectives

The aim of this study was to do model analysis on one hundred orthodontic cases by making use of three different measuring tools. The objective was to see if a difference exists with regards to the measurements produced by the three different instruments and to compare the instruments with each other.

Material and Methods

Three different instruments were used to measure five values on one hundred orthodontic study models. The three instruments included a Boley Gauge, Digital Vernier Calliper and Carestream 3600 scanner with accompanying software.

The five values measured on the study models were: maxillary intercanine width, maxillary intermolar width, mesio-distal width of tooth 11, mesio-distal width of tooth 46 and mesio-distal width of tooth 41.

Results

The statistical analysis performed showed that the difference in measurements produced by the three instruments were not statistically significant for the inter-molar width ($p=0.849$), intercanine width ($p=0.657$), mesio-distal width of tooth 11 ($p=0.178$) and mesio-distal width of tooth 41 ($p=0.240$).

The difference in measurements for the mesio-distal width of tooth 46 were statistically significant ($p<0.01$). However no clinically significant difference was found when the measurements produced by the three instruments were compared.

Conclusions

All three of the instruments produced accurate measurements and can be used confidently when doing a comprehensive study model analysis for orthodontic diagnosis and treatment planning. The values produced were similar for all three instruments with insignificant differences between the three.

Author affiliations:

1. **JC Julyan:** *BChD (UP), PDD (UWC), MSc (UWC),* General Dentist Private Practice.
   ORCID Number: 0000-0002-6186-5724
2. **Jennifer Julyan:** *BChD (UP), PDD (UWC),* Prosthodontic registrar, University of the Western Cape, South Africa.
   ORCID Number: 0000-0002-9347-5341
3. **Johny de Lange:** *Bcomm Law (NWU), BChD (UP), MBChB (UP), DipOral Surg (CMSA), DipDent (UP),* Medical Intern George Hospital, Western Cape, South Africa.
   ORCID Number: 0000-0002-4061-5267

Corresponding author: JC Julyan
General Dentist Private Practice, 40 Wellington Road, Durbanville, Cape Town, 7550.
Email: jcjulyan@gmail.com

Author contributions:

1. **JC Julyan:** Principal researcher and author of manuscript - 70%
2. **Jennifer Julyan:** Co-author - 20%
3. **Johny de Lange:** Co-author - 10%

INTRODUCTION

Successful orthodontic treatment requires a comprehensive diagnosis and treatment plan. Some of the fundamental factors of the diagnosis include: space analysis, arch form, tooth sizes and tooth-arch discrepancies.[7]

A comprehensive model analysis is a vital part in the orthodontic diagnostic process and should always be included. Orthodontic study models are used to plan treatment and to determine the extent of space deficiency or tooth material discrepancy. A conventional model analysis consists of measuring the arch form, width and length as well as the intercanine and intermolar width.

Conventional plaster orthodontic study models have long been proven to be the gold standard for diagnosis and treatment planning in orthodontics. The plaster models also have the advantage of being inexpensive.

Their use has recently started to decline due to intra-oral scanners that can produce digital models. Begole[8] was one of the first authors introducing a computer program to aid the direct analysis of study models.

Rudge[9] devised another computer system using an electronic X-Y reader in order to relate changes in dentition as a result of orthodontic treatment. At the same time, Yen[10], proposed a simple computer program using a study model photocopy. This program predicts "required space" and compares it to "available space".

OrthoCAD (Cadent, Carlstadt, NJ) developed virtual digital dental casts in the late 1999. Soon after in 2001 E-models (GeoDigm, Chanhassen, Minn) developed their own version of digital dental casts. The technology developed by these two companies enabled orthodontists to send alginate impressions to these companies for the fabrication of a 3-dimensional (3D) computerized image.

These 3D images could then be accessed by the orthodontist and used for viewing and planning treatment of patients.[3]

The replacement of conventional plaster orthodontic study models with digital models can benefit orthodontists in the following ways:

1. Models can be accessible instantly on a computer screen without having to retrieve them from storage.

2. Save money on storage costs and laboratory fees.

3. Accurate measurement of tooth and arch sizes, and severity of malocclusion.

4. The ability to send the file containing the digital models anywhere in the world for consultation with colleagues.[3]

Digital models constructed by an intra-oral scanner do not require impression material or plaster of paris and can therefore be used to evaluate the changes after orthodontic treatment without the added laboratory costs and time that it takes to construct orthodontic study models. Most of the normal parameters on the digital models can be measured reliably, and the digital models can be used to eventually eliminate the requirement for producing and storing multiple dental casts.

The digital orthodontic models have been found to be as reliable as traditional stone models and will probably become the standard for orthodontic clinical use in the near future.[11] When doing model analysis on conventional plaster of paris orthodontic study models, instruments like the Boley gauge and digital vernier callipers are commonly used. Measurements made by callipers are regarded as the gold standard against which other techniques are compared for accuracy.[6]

Various studies have been done to compare measurements made on conventional plaster models and digital models. Studies done by Zilberman et al.[12] and Garino and Garino[13] compared linear measurements obtained from conventional plaster and digital models and found a statistically significant difference when comparing the two types of models. They did however conclude that although statistically there was a difference, it was clinically insignificant. Tomassetti et al.[14] carried out Bolton analyses on digital and plaster models.

He made use of a Vernier calliper on the plaster models and software for the digital models. No statistical significant difference was found between the two different types of models. According Hirogaki et al.[15], Santoro et al.[16], Quimby et al.[17], the use of computer based digital orthodontic study models possess the potential to replace the conventional plaster orthodontic study models.

The objective of this study was to compare measurements made on orthodontic study models by three available instruments for orthodontic study model analysis.

The measurements using the Boley guage and digital Vernier calliper were done using the same plaster orthodontic models and the digital version of the same models were measured using Carestream model software after the models were digitized using a Care Stream CS 3600 intra-oral scanner.

MATERIALS AND METHODS

The study was conducted in a private practice in Cape Town. The sample comprised of one hundred plaster orthodontic study models of treated patients. All the study models were of good quality and included Class I, II and III malocclusions. All models had fully erupted permanent teeth including incisors, canines, premolars and first molars.

The morphology of the teeth were normal without any attrition, caries, fractures or restorations affecting the measurements. The gender distribution of the 100 cases used included 65 females and 35 males. The average age of all the cases were 15 years and 11 months.

Five parameters were measured on all the orthodontic study models using the three different techniques and then compared with each other.

These parameters included:

1. Maxillary intercanine width (**tooth 13 – 23**)

2. Maxillary intermolar width (**tooth 16 – 26**)

3. Mesio-distal width of **tooth 11**

4. Mesio-distal width of **tooth 46**

5. Mesio-distal width of **tooth 41**

The Boley gauge (**Figure 1**) and digital vernier calliper (**Figure 2**) were used to measure the plaster models directly by making use of points standardized for all cases.

The same one hundred study models were then scanned and measured using software provided by the Carestream CS 3600 scanner (**Figure 3**)

All one hundred cases were marked on the mesio-palatal cusps of teeth 16 and 26, as well as the cusp tips of teeth 13 and 23 (**Figure 4**). These markings provided standardized reference points to use during the measuring process.

Figure 1. Boley gauge.

Figure 2. Digital Vernier calliper.

Figure 3. Carestream CS3600 intra-oral scanner

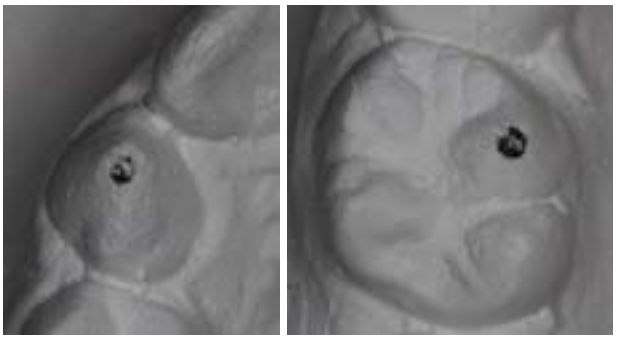

Figure 4. Canine and molar marked with diamond bur.

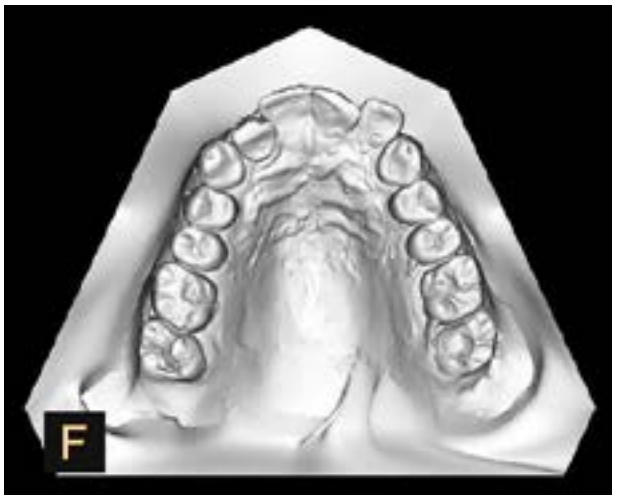

Figure 5. Example of how the standardised markings were used in order to measure on the digital orthodontic study models produced by the intra-oral scanner.

The markings were made using a small round diamond bur. The mesio-distal widths of teeth 11, 46 and 41 were measured at the greatest mesio-distal dimension between the two contact points.

The scans produced by the intra-oral scanner clearly showed the indentations made by the bur and were also used for standardizing the measurements, see Figure 5. The digital models were obtained by scanning the plaster orthodontic study models using a Carestream intra-oral scanner and imported as STL (Standard Tessellation Language) files into the Carestream model software where they could be rotated and magnified to help facilitate the measuring process.

All the measurements were done by the author of this article. All one hundred cases were measured and documented by the same operator. All the values were placed in an Excel file in order to conduct the statistical analysis of all the measurements and to compare the three different techniques with one another. The five measurements of all the cases were compared.

For the statistical analysis the three instruments were treated as independent variables. The difference between the instruments were tested per aspect in an attempt to avoid variation between the aspects and possible differences in measurement units. Models were treated as a co-variate in an attempt to control unexplained variation between the models.

RESULTS

The results for the five parameters measured by each of the three instruments are summarized below:

The difference between the instruments with intermolar as dependent variable was not significant: $F_{2,296} = 0.163$; $p = 0.849$, see Table 1.

The difference between the instruments with intercanine as dependent variable was not significant: $F_{2,296} = 0.421$; $p = 0.657$, see Table 2.

The difference between the instruments with the mesio-distal width of tooth 11 as dependent variable was not significant: $F_{2,296} = 1.735$; $p = 0.178$, see Table 3.

The difference between the instruments with the mesio-distal width of tooth 46 as dependent variable was significant: $F_{2,296} = 7.097$; $p < 0.01$, see Table 4.

The difference between the instruments with the mesio-distal width of tooth 41 as dependent variable was not significant: $F_{2,296} = 1.434$; $p = 0.240$, see Table 5.

DISCUSSION

Orthodontic study models are used routinely for model analysis and treatment planning. The use of digital study models provides the opportunity to accurately determine the effects of orthodontic treatment and to do comprehensive model analysis without the need for impressions and storage. The purpose of the study was to evaluate if a difference exists when the conventional

measuring method using a Boley gauge is compared to a digital calliper and the latest Carestream model analysis software. The study made use of three different methods for orthodontic study model analysis and evaluated the differences between the three systems. The study was conducted by measuring five parameters on the study models of one hundred cases with all three of the instruments.

A sample t-test was conducted and the statistical analysis showed the difference between the three instruments were not statistically significant for the intermolar width ($p = 0.849$), intercanine width ($p = 0.657$), mesiodistal width of tooth 11 ($p = 0.178$) and mesiodistal width of tooth 41 ($p = 0.240$). The difference in measurements between the three instruments for the mesiodistal width of tooth 46 was statistically significant ($p < 0.01$).

Although a statistically significant difference was shown on the measurements obtained for tooth 46, the difference was not found to have a clinical significance to the orthodontist when conducting a model analysis. The results of the five measurements for each of the three instruments were accurate and similar when compared to one another. An average value of 40.5 mm (intermolar width), 34.3 mm (intercanine width), 8.5 mm (mesiodistal width of tooth 11), 10.8 mm (mesiodistal width of tooth 46) and 5.4 mm (mesiodistal width of tooth 41) was found when the values of all three measuring tools were considered, see Figure 6.

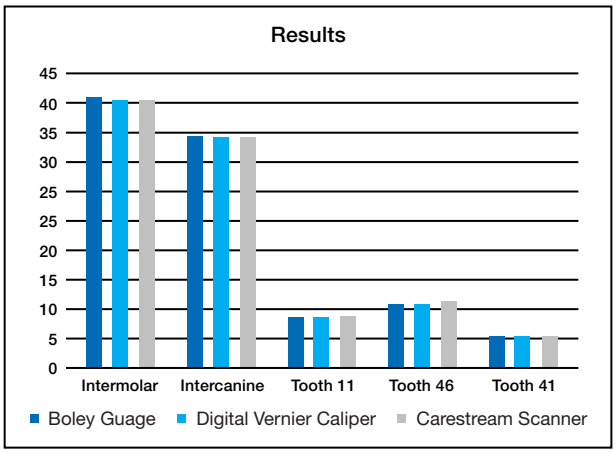

Figure 6. Results of all 5 measurements produced by the three instruments.

The values of the three instruments used in the study were very accurate which emphasizes that all three instruments are reliable and reproducible. Of the three instruments used, the digital vernier calliper took the

Table 1. Maxillary intermolar width.

Intermolar Width				
Instruments	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1. Boley`	40.597[a]	.303	40.000	41.194
2. Vernier	40.383[a]	.303	39.786	40.980
3. Carestream	40.386[a]	.303	39.789	40.983

Table 2. Maxillary intercanine width.

Intercanine Width				
Instruments	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1. Boley`	34.450[a]	.213	34.030	34.870
2. Vernier	34.196[a]	.213	33.776	34.616
3. Carestream	34.228[a]	.213	33.808	34.648

Table 3. Mesio-distal width of tooth 11.

Tooth 11				
Instruments	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1. Boley`	8.535[a]	.059	8.418	8.652
2. Vernier	8.467[a]	.059	8.350	8.584
3. Carestream	8.623[a]	.059	8.506	8.740

Table 4. Mesio-distal width of tooth 46.

Tooth 46				
Instruments	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1. Boley`	10.779	.059	10.663	10.895
2. Vernier	10.708	.059	10.592	10.824
3. Carestream	11.008	.059	10.892	11.124

Table 5. Mesio-distal width of tooth 41.

Tooth 41				
Instruments	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1. Boley`	5.411[a]	.037	5.338	5.484
2. Vernier	5.333[a]	.037	5.260	5.406
3. Carestream	5.409[a]	.037	5.336	5.482

least amount of time during the actual measuring. According to the study done by Quimby et al.[17] in 2004, the reliability of digital models are clinically acceptable

when using OrthoCAD software. A different study done by Stevens et al.[3], in 2004 showed that the use of digital models would not cause an orthodontist to make a different diagnosis and can be used in model analysis and treatment planning.

Although a different software system was used in this study, the present study's results support the findings of Quimby et al.[17] and Stevens et al.[3] regarding the accuracy and reliability of digital orthodontic study models and accompanyingsoftware for model analysis and treatment planning.

A study by Zilberman[12] showed the use of digital callipers to have the highest accuracy and reproducibility when compared to OrthoCAD software. The present study found that all three instruments used showed the same amount of accuracy and reproducibility but that the time spent doing the measurements were faster when using the digital vernier calliper.

According to Asquith et al.[6], digital models can potentially eliminate the requirement for conventional plaster models should cost not be a factor. The present study supports these findings and agrees that digital orthodontic study models can and most probably will replace conventional plaster models in the future.

According to the previous studies mentioned and this study, all three instruments will provide an accurate and reproducible result. The difference between the three comes in when cost, storage and time consumption are compared.

Both the Boley gauge and the digital vernier calliper are very affordable when compared to the intra-oral scanner and software. The scanner, however, can be used directly in the patient's mouth without the need for alginate impressions. When storage is considered the use of the intra-oral scanner and digital models are superior.

CONCLUSION

- Parameters on conventional plaster models and digital models can be reliably measured using a Boley gauge, digital vernier calliper or Carestream software.
- All three of the instruments produced accurate measurements and can be used confidently when doing a comprehensive study model analysis for orthodontic diagnosis and treatment planning.
- A specialist orthodontist choosing one of these instruments should only compare the cost, time and storage differences since the accuracy of the three instruments are the same.
- The current advantages and future possibilities of digital orthodontic models should make them the new gold standard for model analysis.

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The effect of off-axis seating on the marginal adaptation of full coverage all ceramic crowns

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GP Babiolakis[1], CP Owen[2]

ABSTRACT

Introduction
No studies on the marginal gap or internal fit of crowns have reported the effect of non-axial seating which may often occur inadvertently clinically.

Aim
Therefore this *in vitro* study sought to investigate the off-axis seating of CAD/CAM crowns and its effect on the marginal gap and internal fit.

Method
A standardised crown preparation on a typodont tooth was used to design and mill 30 crowns with a flat occlusal surface. Ten Zirconia (Dentsply Sirona, Germany), 10 Enamic (Vita, Austria), and 10 Brilliant Crios (Coltene, Switzerland) crowns were milled, five of each milled with a luting space of 100 µm, and five of 200 µm. The marginal gap was measured in two and three dimensions after luting with silicone on a 3D-printed metal replica. Seating occurred axially, at 5° buccally and 5° lingually. The silicone was used to calculate the internal fit.

Results
Axial seating with a 100 µm luting space obtained the smallest marginal gap, irrespective of material or luting space. 3D measurements were larger than 2D measurements, but not significantly. The maximum off-axis gap was 117 µm, on the opposite side to which pressure was applied.

Conclusions
Care must be taken clinically to ensure that luting takes place in an axial direction only.

Author affiliations:
1. **George P Babiolakis:** *BDS (Wits), MScDent (Wits),* Postgraduate student, Department of Prosthodontics, School of Oral Health Science, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa.
2. **C Peter Owen:** *BDS, MScDent, MChD, FCD(SA),* Emeritus Professor, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa.
ORCID Number: 0000-0002-9565-8010

Corresponding author: CP Owen
Faculty of Health Sciences, 7 York Road, Parktown, 2193, South Africa.
Email: peter.owen@wits.ac.za

Author contributions:
1. **George P Babiolakis:** Conceptualization, methodology, validation, investigation, writing - review and editing - 50%
2. **C Peter Owen:** Conceptualization, methodology, validation, formal analysis, resources, writing - original draft, writing - review and editing, supervision, project administration - 50%

Keywords
Marginal gap, Internal fit, Luting Space, full crown.

INTRODUCTION

The introduction of Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) technology has allowed for improved aesthetics compared with ceramo-metal crowns.[1]

The luting space within a prosthesis is created to allow the formation of a film of luting agent between the tooth and prosthesis. With CAD/CAM this space is created by selecting the milling parameters within the software to produce a pre-defined cement space when the restoration is milled. However, different manufacturers (of which there are now more than 70)[2] have recommended different luting spaces, and several studies have linked luting space to marginal gap measurements.[3-7]

Recommendations have ranged from 10 µm to 100 µm, with the larger spaces generally producing the smaller marginal gaps both before and after actual or replicated cementation.[4-6,8-12]

The milling process to achieve the luting space is limited by the size of the burs used, and the movements of the axes of the milling machine. This in turn influences the preparation form, and in case that form is not ideal, manufacturers have recommended a luting space of up to 100 µm. The smallest diameter bur is generally 1 mm and so any sharp edges in a preparation would not be reproduced, hence the 100 µm recommended space.

The marginal gap can be defined as the vertical and horizontal dimension from the finish line of the preparation to the margin of the restoration. The internal fit can be described as the area between the crown and the tooth that will be occupied by cement.[13]

Failure of restorations to seat completely can result in a sizeable marginal gap and occlusal prematurities resulting in sensitivity, and may cause the prosthesis to loosen prematurely.[14]

Discrepancies in the marginal gap can lead to microleakage;[15] plaque retention at the margin;[16] secondary caries and pulpal involvement;[17,18] and changes in the microflora causing the development of periodontal disease,[19-21] any and all of which could ultimately result in failure of the crown.

Many studies have measured the marginal gap and internal fit of full coverage restorations using different methods, with varying results. It is generally accepted that marginal gaps below 120 µm are clinically acceptable.[22-26] With regards to the internal fit, it is clinically relevant to ensure that adequate space is created to allow an even thickness of dental cement.

The marginal gap was was originally measured at a few points around the circumference but it has been found that to determine an accurate marginal gap it is necessary to measure at least 18 locations around the circumference of the tooth.[27]

Several methods have been used to evaluate the marginal gap including the use of an optical microscope;[28-33] using a profile projector;[3] profilometry;[34] embedding in epoxy resin and sectioning and measured with a three-dimensional microscope;[35-39] cementation and use of microCT;[40-43] and the use of a silicone luting replica technique.[3,13,30,35,41,43,44] The silicone replica technique can also be used to measure the overall total fit of the crown and provides a correlation with the marginal gap.

None of the studies have reported on the effect of non-axial seating discrepancies, and these are known to happen in the clinical environment, as finger pressure is used to cement a crown.

Therefore this *in vitro* study sought to investigate the off-axis seating of CAD/CAM crowns and its effect on the marginal gap and internal fit, using three different materials, a zirconia (Dentsply Sirona, Germany), a polymer infiltrated ceramic network (PICN) (Enamic, Vita, Austria), and a composite (Brilliant Crios, Coltene, Switzerland).

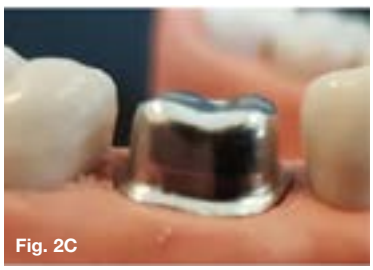

Figure 1. A milled crown with a flat occlusal surface.
Figure 2. Images showing the replicated typodont tooth into metal.

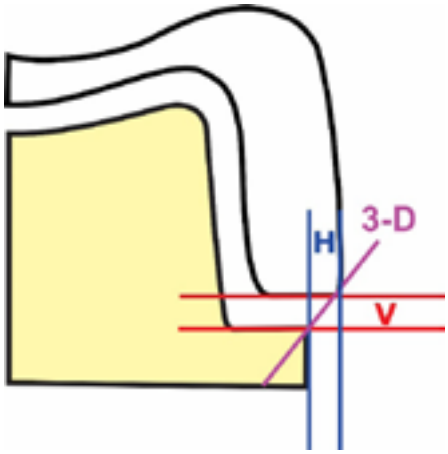

Figure 3. Two-dimensional measurement only records the vertical height (V) but does not consider any overlap (either positive or negative), hence the 3-dimensional measurement taking into account both the horizontal (H) and vertical gap in three dimensions (3-D) is a more realistic representation of the marginal gap.

METHOD

A resin typodont molar tooth was prepared to produce a standardised crown preparation with a total convergence angle of 12 degrees as measured digitally from the scanned image using Finite Element Analysis (FEA) Software (Solidworks, SolidWorks Corp, United States), internally rounded shoulder margins of 1.5 mm circumferentially, and an occlusal reduction of 1.5 mm. All line angles were rounded. The surface area of the preparation was calculated from the scan using the FEA software, to aid in the internal fit calculations.

The typodont tooth was scanned with the CEREC Omnicam intra-oral scanner (Sirona Dental Systems. Germany), and 30 crowns were milled with a flat occlusal surface. The flat occlusal surface of the crowns aided in seating the crown off-axis and axially. Ten Zirconia, 10 Enamic, and 10 Brilliant Crios crowns were milled using a CEREC MC X milling machine (Sirona Dental Systems, Germany). In each group, five crowns were milled with a luting space of 100 µm and the other five crowns with a luting space of 200 µm.

Each crown was then seated on the metal replicated tooth set in a typodont model with adjacent teeth to provide contact points. The typodont model was set on a custom-made tilting device (adapted from the model-holding device of a model surveyor) that allowed the model to be tilted 5 degrees to either side, and a standard 3 kg weight was lowered parallel to the ground simulating cementation pressure.

Each crown was filled with light-body polyvinyl siloxane material (Express XT light-body quick, 3MESPE, Germany) to represent the luting agent and seated onto the tooth. A constant load was placed on the crown with the 3 kg weight for 10 minutes with the model either straight, tilted 5 degrees buccally or 5 degrees lingually.

Excess impression material was removed using a scalpel. Thereafter the marginal gap was measured at 12 points according to marking points on the metal tooth at 6 points buccally and 6 points lingually.

The marginal gaps were measured at these points using a Reflex Microscope (Reflex Measurement Ltd., Cambridge, UK) which is a microscope and an optical plotter that uses a virtual point of light to measure objects in

two and three dimensions (Fig. 3), with an accuracy of 4 µm.[45] There is some difficulty in locating the virtual point of light, especially on the z-axis, and so the entire experiment was repeated on three separate occasions to assess measurement consistency.

The crown was then removed, and the silicone impression material removed and weighed to calculate the overall internal fit according to the formula:[3]

$$\text{thickness } (\textit{internal gap}) = \frac{\text{weight}}{\text{surface area x density}}$$

Sample size and statistical analysis

The literature review has shown that marginal gaps of greater than 120 µm were considered the limit of clinical acceptability.

Given an expected mean marginal gap of 110 µm for any group, and aiming to detect a difference of more than 20% from this, given a within-group relative standard deviation of 22% (which corresponds to an effect size of d = 0.83), 80% power and the 5% significance level, a total sample size of 24, i.e. 4 per group, would be required.[46] It was decided, however, to use 5 per group as the expected mean gap may differ from the above.

Reliability was tested by the Intra-class Correlation Coefficient (ICC). Test-retest reliability for whether or not the marginal gap exceeded 120 µm was determined by Cohen's kappa.

Post-hoc tests were carried out using the Tukey-Kramer adjustment for unequal group sizes (to allow for the deletion of outliers). From the *post-hoc* tests, the material-luting space combinations which had the smallest values for the outcomes were determined.

All measurements were below the limit of 0.120 mm, so it was not necessary to measure comparisons between the experimental groups. Comparison of the marginal gap between matching 3D measurements was carried out using the paired samples t-test.

Within each material, across both luting spaces, the difference between buccal and lingual readings for each seating direction was compared using the paired samples t-test. The effect of luting space on the 2D and 3D outcomes for each direction of seating, was determined by a repeated measures ANOVA with the outcome as the dependent variable, luting space as the independent variable, and experiment as the repeated measure. The effect of material was determined similarly. Data analysis was carried out using Statistical Analysis Software (SAS) version 9.4 for Windows. The 5% significance level was used.

RESULTS

The Intraclass Correlation Coefficients (ICC) for the marginal gap measurements ranged between 0.78 and 0.99, representing excellent agreement and so the average of all three sets of measurements was used for further analysis.

Marginal gap measurements

Table 1 shows the minimum, maximum, and mean marginal gap measurements in all scenarios.

In all circumstances, the marginal gap did not exceed 120 µm. For all materials and luting spaces, the maximum value (117 µm) occurred on the buccal marginal gap when seating was applied at an angle to the lingual, and on the lingual marginal gap (112 µm) it occurred when seating was applied at an angle to the buccal.

For all 2D and 3D measurements and their differences between buccal and lingual, the ANOVA showed that the three-factor interaction was significant for each measurement set (Table 2).

The differences between the buccal and lingual marginal gap measurements for each seating direction were calculated and then compared, combining the 100 and 200 µm measurements.

In all cases, the buccal and lingual measurements differed significantly for buccal and lingual seating angles except for two 3D measurements for Enamic and Zirconia which were not significantly different for axial seating, but this direction yielded the smallest difference ranging from 3.2 µm - 20.1 µm.

When comparing materials, there were no significant differences between materials for any seating angle. The smallest differences were again found for the axial seating. For 2D measurements, this ranged from 10.4 µm – 20.1 µm, and for 3D measurements, this ranged from 3.5 µm - 9.4 µm.

For all materials, the differences between the buccal and lingual marginal gaps were grouped into the buccal, axial and lingual seating directions, to compare the luting spaces (Table 3).

The only statistically significant differences between the 100 µm and 200 µm spaces, for both the 2D and 3D measurements, were for the axial direction of seating. The actual gaps averaging all buccal and lingual measurements for the axial seating only are shown in Table 4.

All 2D and 3D measurements, irrespective of material, pressure and luting space were then compared. The 3D measurements for the buccal marginal gap were an average of 13.5 µm higher than the corresponding 2D measurements (95% confidence interval: 12.0 - 15.0 µm; $p < 0.0001$).

The 3D measurements for the lingual marginal gap were an average of 13.4 µm higher than the corresponding 2D measurements (95% confidence interval: 10.9 - 15.8 µm; $p < 0.0001$).

When the buccal and lingual gaps were combined, the 3D measurements were an average of 13.4 µm higher than the corresponding 2D measurements (95% confidence interval: 11.7 - 15.1 µm; $p < 0.0001$).

Table 1. Summary of buccal and lingual marginal gap readings for all three materials and both luting spaces. Shading indicates the largest gaps in each measurement group of material and luting space combination.

Material	Luting space	2D/3D	Seating direction	Reading	Min µm	Max µm	Mean µm
Zirconia	100µm	2D	Buccal	Buccal MG	35.7	44.3	40.1
				Lingual MG	53	91.3	70.9
			Axial	Buccal MG	37.3	57	44.4
				Lingual MG	43.7	55.3	49.3
			Lingual	Buccal MG	66.7	87.3	73.9
				Lingual MG	35.3	44.3	40.9
		3D	Buccal	Buccal MG	47.3	59	55.4
				Lingual MG	70.3	101	88.3
			Axial	Buccal MG	48.7	65.7	58
				Lingual MG	45.7	59.7	53.1
			Lingual	Buccal MG	78	101	86.8
				Lingual MG	43	59	50.2
Enamic		2D	Buccal	Buccal MG	40.7	47.3	44.6
				Lingual MG	51	63	58.6
			Axial	Buccal MG	45.3	54.3	48.8
				Lingual MG	51.7	60.3	56.3
			Lingual	Buccal MG	63	65.7	64.3
				Lingual MG	33.7	45.7	37.9
		3D	Buccal	Buccal MG	53.7	62.3	57.1
				Lingual MG	70.7	91.7	81.3
			Axial	Buccal MG	55.3	61.7	57.5
				Lingual MG	57.7	62.3	60.6
			Lingual	Buccal MG	69.3	75	72.8
				Lingual MG	40.3	58	50.1
Brilliant Crios		2D	Buccal	Buccal MG	41.3	73	51.5
				Lingual MG	54.7	92.7	65.2
			Axial	Buccal MG	41	82.7	51.4
				Lingual MG	44.3	92.3	56.9
			Lingual	Buccal MG	58.7	102	70.7
				Lingual MG	34.7	39.3	36.2
		3D	Buccal	Buccal MG	50.7	81.7	61.9
				Lingual MG	68	109	85.1
			Axial	Buccal MG	46.7	86	56.3
				Lingual MG	45	95.3	59.7
			Lingual	Buccal MG	67.3	108	78.4
				Lingual MG	35	45.7	40.3
Zirconia	200µm	2D	Buccal	Buccal MG	57.3	62.7	60.5
				Lingual MG	58.7	89	69.9
			Axial	Buccal MG	30.7	56	46.8
				Lingual MG	66.3	87.7	82.1
			Lingual	Buccal MG	51.3	72.3	62.5
				Lingual MG	32	48	40.1
		3D	Buccal	Buccal MG	75	89	82.3
				Lingual MG	85.3	100	95.9
			Axial	Buccal MG	51	78	68.7
				Lingual MG	66.7	98.7	82.6
			Lingual	Buccal MG	69	81.7	76
				Lingual MG	47	59.3	51.6
Enamic		2D	Buccal	Buccal MG	43.3	50.3	47.4
				Lingual MG	66	77.3	71.8
			Axial	Buccal MG	40.3	54.3	47.1
				Lingual MG	49	68.3	60.7
			Lingual	Buccal MG	48.3	94.3	75
				Lingual MG	32.3	38	35.3
		3D	Buccal	Buccal MG	65	75.7	73.1
				Lingual MG	97.3	113	106.9
			Axial	Buccal MG	56.3	65	60.5
				Lingual MG	50	72.7	63.9
			Lingual	Buccal MG	71.3	103	88.5
				Lingual MG	40.7	48.7	44.1

Material	Luting space	2D/3D	Seating direction	Reading	Min µm	Max µm	Mean µm
Brilliant Crios		2D	Buccal	Buccal MG	47	54.3	50.9
				Lingual MG	69	75.7	72.7
			Axial	Buccal MG	44.3	53	48
				Lingual MG	52.3	69.3	63.1
			Lingual	Buccal MG	61.7	105	80.7
				Lingual MG	31	45	39.5
		3D	Buccal	Buccal MG	60	69.3	65.6
				Lingual MG	103	112	108.5
			Axial	Buccal MG	50	65	59.5
				Lingual MG	62.7	84	74.9
			Lingual	Buccal MG	71.3	117	92.6
				Lingual MG	40	58	50.9

Table 2. ANOVA results for the three-factor interaction of material, seating direction, and luting space.

Measurement	p-value
2D buccal	0.0039
2D lingual	0.0095
2D overall	0.0029
2D difference buccal / lingual	0.0028
3D buccal	0.0005
3D lingual	0.015
3D overall	0.0006
3D difference buccal / lingual	0.0003

Internal fit measurements

The effects of material, seating direction, and luting space, and their interaction, on each outcome were compared and the ANOVA source table is shown as Table 5.

The signifant interactions were between the material and the seating direction, and the material and luting space.

Table 3. Table comparing the buccal and lingual marginal gaps for different milled internal gaps; *denotes statistical significance.

Material	Luting space	Seating direction	n	Metric	Mean difference	95% CI for Mean		p-value
All materials	100 µm	Buccal	15	2D Buccal vs. Lingual	-19.6	-25.9	-13.3	0.82
	200 µm		15		-18.6	-24.9	-12.4	
All materials	100 µm	Lingual	15	2D Buccal vs. Lingual	31.4	23.7	39.0	0.58
	200 µm		15		34.3	26.7	41.9	
All materials	100 µm	Axial	15	2D Buccal vs. Lingual	-6.1	-11.9	-0.3	0.0007*
	200 µm		15		-21.4	-27.2	-15.6	
All materials	100 µm	Buccal	15	3D Buccal vs. Lingual	-26.9t	-33.4	-20.4	0.48
	200 µm		15		-30.2	-36.7	-23.6	
All materials	100 µm	Lingual	15	3D Buccal vs. Lingual	32.4	24.2	40.7	0.44
	200 µm		15		36.9	28.6	45.2	
All materials	100 µm	Axial	15	3D Buccal vs. Lingual	-0.7	-6.2	4.7	0.012*
	200 µm		15		-10.9	-16.3	-5.4	

Table 4. Mean of buccal and lingual measurements for axial seating direction.

Material	Luting space	Measurement	n	Mean buccal and lingual
Zirconia	100 µm	2D	15	46.9
		3D	15	55.6
	200 µm	2D	15	64.5
		3D	15	75.7
Enamic	100 µm	2D	15	52.6
		3D	15	59.1
	200 µm	2D	15	53.9
		3D	15	62.2
Crios	100 µm	2D	15	54.2
		3D	15	58.0
	200 µm	2D	15	55.6
		3D	15	67.2

Table 5. The effects of material, seating direction, and luting space, and their interaction on the internal fit; *significant differences.

Effect	Num DF	Den DF	F Value	p-value
Material	2	22	90.35	<0.0001*
Seating direction	2	21	7.26	0.004*
Luting space	1	22	2696.22	<0.0001*
Material* Seating direction	4	24.4	3.12	0.033*
Material* Luting space	2	22	36.52	<0.0001*
Pressure* Luting space	2	21	2.81	0.083
Material* Seating direction* Luting space	4	24.4	1.56	0.22

Post-hoc tests revealed the following significant differences:

- The mean internal fit was significantly higher for all Zirconia seating angles ($p < 0.0001$) compared with Enamic and Crios, but not within Zirconia.
- Within Enamic, the mean internal fit for lingual seating was greater than buccal ($p = 0.0088$) and axial ($p = 0.0052$).
- Within Crios, the mean internal fit for buccal seating was greater than for the occlusal ($p = 0.014$).

When comparing the luting spaces, Post-hoc tests revealed the following significant differences:

- The mean internal fit was significantly higher for all 200 µm experiments compared with all 100 µm experiments ($p < 0.0001$).
- Within the 100 µm experiments, the mean internal fit decreased in the order Zirconia > Enamic ($p < 0.0001$) > Crios ($p < 0.0078$).
- Within the 200 µm experiments, the mean internal fit decreased in the order Zirconia > Enamic ($p < 0.0055$) > Crios ($p < 0.0034$).

DISCUSSION

This is the first study to be carried out to measure and compare the effect of off-axis seating on the adaptation of full coverage crowns using the marginal gap and internal fit as excellent proxies for the clinical quality and success of a restoration.

Discrepancies in the marginal gap can lead to a variety of problems which could ultimately result in failure of the crown.[15-21] It is generally accepted that marginal gaps below 120 µm are clinically acceptable.[22-26,47,48]

With regards to the internal fit, it is clinically relevant to ensure that adequate space is created to allow an even thickness of dental cement. Theoretically, the space required for the cement to lute is 20-40 µm, as cement thickness ranges from 25-50 µm, and an acceptable practical guide was set between 50 µm and 100 µm.[49]

In CAD/CAM restorations, a luting space is used to allow for this, and several studies have linked luting space to marginal gap measurements.[3-7] In the literature, luting space recommendations have ranged from 10 µm to 100 µm. The larger spaces have produced the smaller marginal gaps both before and after actual or replicated cementation.[4-6,8-12]

In this study, it was decided to use luting spaces of 100 µm and 200 µm. In a pilot study it had been observed that, as finger pressure is used to cement a crown, it is possible that it may not seat evenly if seated at an angle to the occlusal. No studies have reported on the effect of non-axial seating discrepancies.

It was evident that seating the crown off-axis at just 5° did affect the marginal gap: there was a significant difference between the buccal and lingual marginal gap measurements in all cases when the crowns were seated off axis, but it was interesting to note that none of the marginal gaps measured exceeded 120 µm. However, the greatest discrepancies were observed in off-axis seating with a luting space of 200 µm for all materials, indicating that that luting space is proably too large and may produce more off-axis seating clinically.

There were statistically significant differences between the 100 µm and 200 µm spaces, for both the 2D and 3D measuremets, for the axial direction of seating, indicating that the luting space did affect the marginal gap. The smallest gaps were from the axial seating using the 100 µm luting space. Overall, for all materials these differences for the 2D measurements ranged from 10.4 µm – 20.1 µm, and for 3D measurements, from 3.5 µm – 9.4 µm.

Overall the 3D measurements were 13.4 µm greater, but not significantly different from the corresponding 2D measurements ($p = 0.92$). These measurements are to be expected, as the 3D gap is likely always to be higher than the 2D measurement, but they are nevertheless all extremely low, which is a testament to the accuracy of the milling of these crowns. As with the marginal gaps, within each material, axial seating yielded the smallest internal fit when compared with off-axis seating.

The internal fit of a crown is just as important as the marginal gap, as it enables the seating of the crown and expression of cement, while also aiding in retention and resistance.[31] The mean internal fit for all 200 µm crowns was significantly higher than the 100 µm crowns, which was expected.

This also shows that the CAD/CAM process is highly accurate, generating an internal fit for each crown which closely resembles the luting space chosen. Clinically the results obtained in this study have implications.

Irrespective of material used when seating a crown, a minor tilt of even 5 degrees can result in a larger marginal gap specifically on the opposite side to the pressure being applied.

Although this study did not find these measurements to be above 120 µm, some marginal gaps were still large, with one reaching 117µm.

Previous studies which measured the marginal gap of crowns found that they ranged from <70 µm[50], 52 µm to 74 µm[3], a median of 130.2 and 132.2 µm, 51 below 90 µm.[52] The marginal gaps measured in this study which more closely resemble those of other studies are the values measured for axial seating.

Should other studies have taken into consideration the tilt that may be found when seating off axis, they may have measured larger results. In this study the marginal gaps ranged from 36 µm – 117 µm with off-axis seating and 31 µm – 99 µm with axial seating.

The other factor not taken into consideration in other studies is measuring the marginal gap buccally and lingually separately. Gassino et al. (2004)[27] found that to obtain an accurate overall marginal gap measurement requires at least[18] points around the circumference of the tooth to be measured.

However, this again did not take into account the tilt and used an average of all measurements to arrive at a marginal gap. Considering that a larger marginal gap will be found on the opposite side to the pressure being applied it is necessary to measure the buccal and lingual sides separately, to yield an accurate result that resembles the correct fit of the crown.

CONCLUSION

Within the limitations of this study, it was found that, irrespective of the material, seating off-axis at 5 degrees buccally or lingually resulted in a marginal gap which was larger on the opposite side to which pressure was applied. The smallest marginal gaps and internal fit were obtained when seating axially, with a luting space of 100 µm.

All measurements made in three dimensions were larger than those derived for two-dimensional measurement, but the difference, average of 13.4 µm, was not significant. None of the measurements, whether cemented axially or off-axis were larger than 120 µm. However, when seating off axis, the largest gap was 117µm as opposed to seating axially which yielded a mean maximum marginal gap measurement of 76 µm.

It is recommended that future studies should measure the marginal gap both buccally and lingually separately and not just use an average to obtain an accurate measurement, and that a method needs to be devised to cement crowns axially in the clinical environment to provide the best fit possible and minimise complications.

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Declaration

The authors declare no conflict of interest.

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Perforation of the palate
- A report of two Syphilitic Gumma cases

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F Titinchi[1], N Behardien[2], J Morkel[3], J Opperman[4]

ABSTRACT

Syphilis has recently shown resurgence in its incidence especially in immune-compromised patients. We present two cases of tertiary syphilis in middle-aged males with large perforations in the hard and soft palates, one of which had Human Immunodeficiency Virus (HIV) co-infection. Diagnosis was initially difficult due to non-specific features mimicking other conditions such as perforation of cocaine abuse aetiology, neoplastic conditions, sarcoidosis, fungal infections, bacterial infections other than *Treponema pallidum* and Wegeners granulomatosis.

With special investigations including Anti-Treponema Immunohistochemistry and histology, however, a definitive diagnosis of syphilitic gumma was reached. Intravenous penicillin was the mainstay of management along with treatment of the underlying medical conditions.

A removable acrylic obturator was used to close the oro-nasal fistula to improve swallowing and speech. Syphilis should be included as a differential diagnosis in cases of palatal perforation.

Keywords

Orofacial syphilis, *Treponema pallidum*, gumma, oronasal fistula.

Author affiliations:

1. **Fadi Titinchi:** *BChD, PDD (Oral Surg), MSc,* Lecturer, Department of Maxillofacial and Oral Surgery, Faculty of Dentistry, University of the Western Cape, Cape Town, South Africa.
   ORCID Number: 0000-0003-3182-7038 (Young Author Under 35)
2. **Nashreen Behardien:** *BChD, MSc, PDD (Implantology),* Senior Lecturer, Department of Maxillofacial and Oral Surgery, Faculty of Dentistry, University of the Western Cape, Cape Town, South Africa.
   ORCID Number: 0000-0003-2881-7891
3. **Jean Morkel:** *BChD, MBChB, MChD, FCMFOS(SA),* Professor and Head of Department of Maxillofacial and Oral Surgery, Faculty of Dentistry, University of the Western Cape, Cape Town, South Africa.
   ORCID Number: 0000-0003-3089-4597
4. **Johan Opperman:** *BSc, BChD, PDD, MChD,* Consultant Oral and Maxillofacial Pathologist. National Health Laboratory Services (NHLS), Cape Town, South Africa.
   ORCID Number: 0000-0002-9684-6670

Corresponding author: Fadi Titinchi
Department of Maxillofacial and Oral Surgery, Faculty of Dentistry, University of the Western Cape, Tygerberg Oral Health Centre, Francie Van Zijl Drive, Cape Town, South Africa.
Email: ftitinchi@uwc.ac.za

Author contributions:

1. **Fadi Titinchi:** Identification of cases, literature review, manuscript preparation - 30%
2. **Nashreen Behardien:** Writing case reports and editing of discussion - 30%
3. **Jean Morkel:** Overall appraisal and final editing of manuscript - 20%
4. **Johan Opperman:** Histological sections and diagnosis - 20%

INTRODUCTION

Syphilis, a disease caused by the bacterium *Treponema pallidum*, is a sexually transmitted disease (STD). It may be acquired or congenital, with a variable clinical course.[1] The acquired form may present as primary, secondary, latent, or tertiary syphilis.[2] The various stages include presentations of ulceration (chancre) at the site of infection, lymphadenopathy, mucocutaneous rash, gummas, cardiosyphilis and neurosyphilis. All stages may present with oral lesions.[3]

Although the incidence of syphilis was significantly reduced after the introduction of penicillin in the 1940's, there has been a dramatic increase in its incidence recently.[4] The World Health Organisation (WHO) reported 6 million new cases of syphilis worldwide among individuals aged between 15 and 49 years in 2016.[5]

The resurgence of syphilis is a major concern to global public health, particularly due to the epidemiologic and biologic synergy of syphilis and Human Immunodeficiency Virus (HIV).[6-8] South Africa, with the largest HIV epidemic in the world, has 19% of the global number of people living with HIV, 15% of new infections, and 11% of Acquired Immuno-Deficiency Syndrome (AIDS)-related deaths.[9]

As a means to highlight the resurgence of this condition, we review the literature and present two explanatory cases of perforation of the palate resulting from syphilitic gumma, including the management thereof.

CASE 1

A 35-year-old male was referred to the Department of Maxillo-Facial and Oral Surgery at Tygerberg Oral Health Centre citing a four-month history of an ulcerative lesion of the hard palate, which had recently become painful (**Figure 1**). He also reported swallowing and speech difficulties. A medical history revealed that he was HIV-positive and had pulmonary tuberculosis (TB), both of which he had defaulted treatment of. He also reported a history of a genital chancre (diagnosed by his referring physician and managed by oral antibiotics).

Extra-orally, bilateral submandibular lymphadenopathy was noted. Intra-orally, a large, well-defined (20 mm x 20 mm), punched out, ulcerative lesion involving the hard palate was noted. A second ulcerative lesion of approximately (10 mm x 10 mm) was noted on the soft palate. Based on the history and examination the differential diagnosis included tuberculous ulceration, actinomycosis and tertiary syphilis.

On haematological study, the haemoglobin and platelet counts were low, while erythrocyte sedimentation rate was increased. The absolute CD4+ T-cell count was very low at 12 cells/μL and the HIV viral load was 10139 copies / ml.

All other routine haematological parameters were within normal range. The Venereal Disease Laboratory (VDRL) test detected titre of 1:32, highly suggestive for syphilis.

Both T pallidum antibodies FTA-ABS and Rapid Plasma Reagin (RPR) were reactive, while a bacterial swab culture for Actinomyces was negative.

A biopsy of the palatal mucosa was done at the peri-ulcer margins of the lesion in the hard palate. The histopathology showed non-specific features of fibrosis and plasma cells in adjacent margins as well as palisaded arrangement of fibroblasts and macrophages (**Figure 2**). This confirmed the clinical diagnosis of tertiary syphilis.

Medically, the patient was managed on intravenous penicillin (Pen G 2.4 million units 7-day interval). The gumma became necrotic and subsequently healed leaving a large oronasal fistula as seen on Computed Tomography (CT) (**Figure 3**). The fistula in the hard palate was obturated using a removable acrylic obturator, (**Figure 4**) while the ulcer on the soft palate did not require further management.

No surgical debridement was necessary. During the course of treatment at the Maxillo-Facial and Oral Surgery Department, the patient was referred to the Infectious Diseases Clinic for restart of the anti-retroviral and TB medication. Unfortunately, the patient demised 6 months later, and no further surgical treatment could be performed.

CASE 2

A 28-year-old male presented to the Oral Pathology Clinic at Tygerberg Hospital with a main complaint of a 'hole' in the palate. He reported experiencing a 'blocked nose' for five months prior, had a yellow discharge from the nose, and reported aspirating food particles into his nose. The patient had a history of genital chancres and weight loss as reported by his referring general - practitioner. No other medical history of note was reported.

Extra-orally, bilateral nasal crusting with a nasal septal perforation was noted on Ear Nose Throat (ENT) examination. Intra-orally, a small, round perforation of the hard palate (2 mm x 2 mm) was noted as well as a large perforation of the soft palate (10 mm x 15 mm) with marked erythema of the uvula (**Figure 5**). Initially, a clinical differential diagnosis of *Granulomatosis with Polyangiitis* (Wegener's granulomatosis) was made.

Special investigations included an incisional biopsy of the soft palate as it was more representative of the lesion; and the following haematological tests: full blood count; urea and electrolytes; HIV; rheumatoid factor; and Hepatitis B, and C. All test results were within normal range and hepatitis and HIV studies were negative.

Histopathological examination (**Figure 6**) demonstrated non-caseating granulomatous inflammation comprising of epithelioid histiocytes admixed with lymphocytes, plasma cells, and occasional multinucleated giant cells. Based on the histological findings along with the clinical picture, syphilitic ulcer and tuberculous ulcer were added to the list of differential diagnoses.

Special stains for fungal organisms and acid-fast bacilli were negative. Anti-Treponema immunohistochemistry however, was found to be positive for spirochetes (**Figure 7**).

An un-contrasted CT scan of the sinuses (Figure 8) displayed a destructive pattern centred on the hard palate and nasal cavity with septal perforation and erosion of the alveolar process .

The patient confirmed that he was managed previously with intravenous penicillin. Treatment included the construction of an acrylic obturator to improve phonetics and prevent food aspiration into the nose.

Figure 1. Intra-oral view showing ulcerative lesions in of the hard and soft palate post antibiotic treatment administered by referring physician.

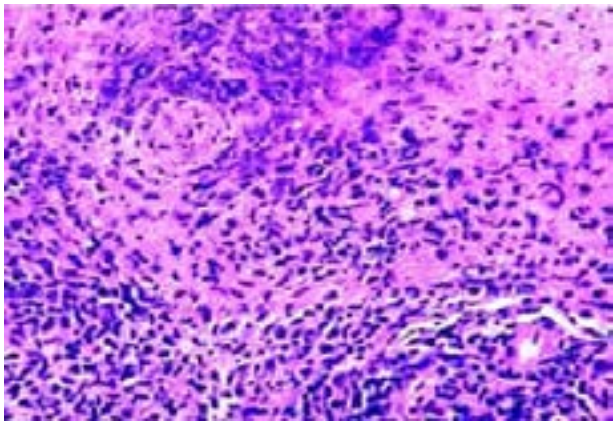

Figure 2. Histopathological specimen showing non-specific features of fibrosis and plasma cell infiltrate (H & E stain).

Figure 3. Coronal computed tomography (CT) slice at the level of the hard palate clearly demonstrates the extent of destruction in the midline of the palate.

Figure 4. Intra-oral view of the acrylic obturator in place.

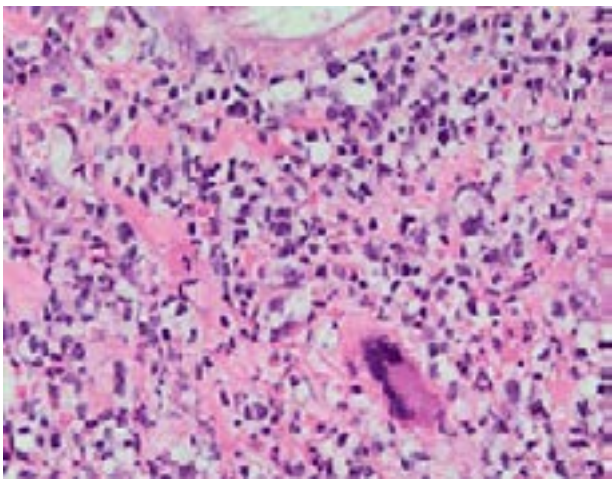

Figure 6. Non-caseating granulomatous inflammation showing multi-nucleated giant cells, lymphocytes and plasma cells obtained from the margins of the ulcerative lesion in the soft palate (H&E stain).

Figure 5. Intra-oral view showing ulcerative lesions in the hard palate.

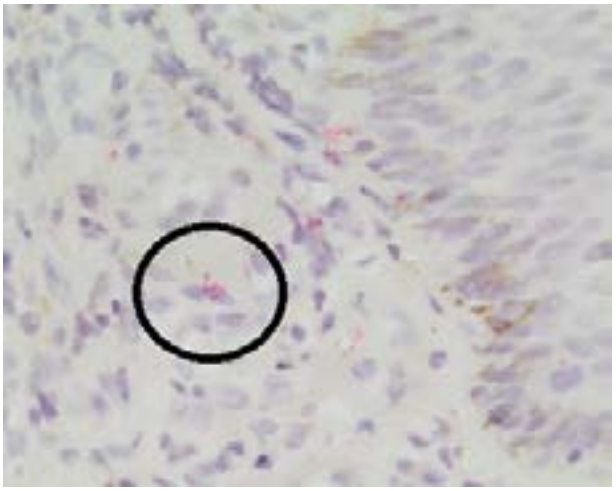

Figure 7. Anti-Treponema Immunohistochemistry showing clumps of spirochete organisms (circled).

Figure 8. CT showing destruction of the hard palate involving the inferior turbinates on the left as well as erosion of the nasal septum.

DISCUSSION

Syphilis, as a differential diagnosis for perforation of the hard and soft palates, should be included due to the re-emergence of this condition. Syphilis can present in a myriad of ways, hence the name the "great imitator"[10,11]. Oral health workers should consider this entity as a differential diagnosis and ensure appropriate diagnostic tests.

Despite advances in diagnosis and treatment, syphilis remains endemic in sub-Saharan Africa and Southeast Asia, and it has re-emerged in several developed countries in the form of sporadic outbreaks and widespread epidemics.[3] The resurgence of syphilis is a major concern to global public health, particularly due to the epidemiologic and biologic synergy of syphilis and HIV.[3,12]

Tertiary syphilis can be defined as the appearance of new lesions in untreated patients after one year of primary lesions.[13] The typical notorious lesion of this stage is the 'gumma'.[13] This is a granulomatous lesion, often found on the skin, bone, or liver.[14] Gummas can however involve any organ.[15] In the oral cavity, it is most commonly seen as a swelling on the tongue or hard palate, which eventually ulcerates.[16]

Gumma complications include bone erosion, palatal perforation, and oro-nasal fistulas.[14] Gummas of the oral mucosa usually affect the hard palate and typically start with a well-defined central ulcerative lesion, gradually increasing in size and later perforating the nasal cavity. Due to the risk of malignant change, biopsy is recommended biannually.

Gummas are often asymptomatic but very destructive if not managed timely. Perforation of underlying structures can lead to permanent deformity. Systemic complications can seriously affect the cardiovascular and nervous systems but are rarely seen.[14] Although oral tertiary syphilis lesions were described to be rare by Barrett in 2004,[16] its resurgence is evident by the presentation of cases in recent years.[2,11,17] The literature reports on eight cases of oral tertiary syphilis specifically relating to the hard palate (Table 1).[2,4,11,17-21]

All reported cases, including these two, presented in middle aged males (mean age 48.8 years). Three cases presented with HIV co-infection.[14,20,21] Six cases affected the hard palate,[2,4,11,17-19] while two cases affected the soft palate.[20,21] Unlike the two current cases, none of the cases in the literature simultaneously affected both hard and soft palate.

The clinical presentations ranged from sequestra formation, ulceration and clefting. This occurs as the lesion initially starts out as a painless ulceration and is commonly misdiagnosed.

The gumma is a highly destructive and rapidly expanding lesion that eventually leads to perforation of palate and the formation of a large oronasal fistula.[2]

The diagnosis for syphilis is dependent on non-treponemal tests, e.g. RPR, VDRL and treponemal anti-body specific tests e.g. Fluorescent Treponemal Anti-body Absorption (FTA-ABS), *Treponema Pallidum* Haemagglutination test (TPHA) and *Treponema Pallidum* Antibody test (TPAB), a chemiluminescent immunoassay.[22]

Non-treponemal tests uses antigens released during cellular damage caused by the organism, in serum and plasma e.g. lecithin, cholesterol and purified cardiolipin to detect antibodies against cardiolipin, which is present in many syphilis patients.[22] VDRL and RPR are flocculation tests used as initial screening for spirochete infection. These tests are relatively accurate but are not absolutely specific for syphilis and false positive reactions may occur in some cases.[23]

The National Health Laboratory Services (NHLS) at Tygerberg Hospital uses the reverse sequence algorithm testing for syphilis. These methods were employed in these cases. Whereas the traditional algorithm made use of a non-treponemal test (RPR) as a screening test, followed by a confirmatory treponemal test (FTA/TPHA), the reverse sequence algorithm starts with an automated treponemal screening test (TPAB) followed by, in those patients whose sera are reactive, a non-treponemal test (RPR) to determine disease activity.

The reverse algorithm offers increased sensitivity particularly in primary and tertiary syphilis but also in secondary syphilis where the prozone phenomenon may result in false negatives. It provides increased specificity at all stages of the infection due to fewer false positives.[23] Management of tertiary syphilis is summarized in Table 2. penicillin is the main treatment modality while obturators are a successful method of managing speech and masticatory problems. Reconstructive surgery is another option, but extensive scarring of syphilitic lesions renders surgical repair using local and regional flaps a challenge as ischaemia and necrosis render the tissues more likely to breakdown following surgical repair.[17] Free vascularised flaps in the form of a radial forearm flap is then often the optimal surgical solution.[4]

Table 1. Summary of previous cases published in literature on tertiary syphilis.

Author	Gender	Age	Site	Clinical presentation	Diagnosis	Treatment	Management of defect	HIV status
Huebsch (1955)[18]	M	33	Hard Palate	Sequestrum	N/A	N/A	N/A	N/A
Taylor and Hipple (1961)[19]	M	43	Hard Palate	Ulceration	N/A	Penicillin	N/A	N/A
Ramstad and Traaholt (1980)[20]	M	63	Soft Palate	Cleft	N/A	Penicillin	N/A	N/A
Kearns et al. (1993)[21]	M	43	Soft Palate	Ulceration	Biopsy	Penicillin	Surgical	Positive
Bains and Hosseini-Ardehali (2005)[4]	M	70	Hard Palate	Cleft	Serology	Penicillin	Palatal obturator	Positive
Murthy et al. (2014)[11]	M	48	Hard Palate	Cleft	Serology	N/A	Palatal obturator	Negative
Singh et al. (2015)[2]	M	55	Hard Palate	Cleft	Serology	Penicillin	Palatal obturator	Negative
Sharma and Sharma (2016)[17]	M	36	Hard Palate	Ulceration	Serology	N/A	N/A	Positive

Table 2. Management of palatal perforation due to tertiary syphilis.[4]

Initial phase	Antibiotics (Penicillin, Tetracylines, etc.)
	Preventative advice and education
	Management of underlying medical condition
Conservative/ Non- surgical phase	Palatal obturators
	Speech therapy
Surgical/Reconstructive phase	Local flaps
	Regional flaps e.g. Tongue flaps
	Free flaps where the radial forearm flap is the most widely used
	Osseodistraction
Combination of Surgery and Prosthodontics	Implant supported obturators

CONCLUSION

Tertiary syphilis presents with destructive gummatous lesions that can cause severe destruction to the orofacial regions. It is important to diagnose these lesions early with the aid of clinical and laboratory investigations. Management is aimed at eliminating the bacterial organisms with antibiotics and subsequent reconstruction of the defect.

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Calcific Metamorphosis
- A review of literature and clinical management

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PJ van der Vyver[1], M Vorster[2], CH Jonker[3], N Potgieter[4]

INTRODUCTION

Calcific metamorphosis (CM) or pulp canal obliteration (Fig. 1A-C) is a common occurrence following concussion and subluxation injuries.[1,2] Although the exact mechanism by which the canal obliterates is unknown, it is believed to be related to neurovascular damage and deposition of hard tissue within the canal.[3,4]

This calcification of the pulp canal space results in a loss of translucency leaving the crown with a yellow discolouration (Fig. 2 and 3).[5] CM can be clinically detected as early as three months after injury but remains undetected in most cases for up to a year after trauma.[6-8]

Asymptomatic teeth presenting with CM do not initially require treatment other than annual review.[1,9] However, the pulp status within partially obliterated canals may eventually lead to apical pathology requiring treatment.[10-14]

Treatment protocols and exact intervention times for the treatment of CM remains controversial and a challenge for even the skilled clinician.[15-17]

Aetiology and Incidence

CM is a common outcome of trauma frequently associated with anterior teeth of young adults and is characterised by partial or total obliteration of the root canal.[6,8,15]

Author affiliations:
1. **Peet J van der Vyver:** *BChD, PG Dip Dent (Endo), PG Dip Dent (Aesthet Dent), MSc, PhD (Pret),* Department of Odontology, School of Dentistry, University of Pretoria, Pretoria, South Africa.
   ORCID Number: 0000-0003-1951-6042
2. **Martin Vorster:** *BChD, PG Dip Dent (Endo), MSc (Pret),* Department of Odontology, School of Dentistry, University of Pretoria, Pretoria, South Africa.
   ORCID Number: 0000-0003-4470-1530
3. **Casper H Jonker:** *BChD (Pret), Dip Odont (Endo), MSc (Pret),* Department of Operative Dentistry, Sefako Magatho Health Sciences University, Ga-Rankuwa, South Africa.
   ORCID Number: 0000-0002-9110-5208
4. **Nicoline Potgieter:** *BChD, PG Dip Dent (Endo), MSc (Pret),* Department of Odontology, School of Dentistry, University of Pretoria, Pretoria, South Africa.
   ORCID Number: 0000-0003-4061-3322

Corresponding author: Martin Vorster
Department of Odontology, School of Dentistry, University of Pretoria, Gauteng, South Africa.
Email: martin.vorster@up.co.za

Author contributions:
1. **Peet J van der Vyver:** Treated patients, followed-up with patients, scientific writing and proofreading of the manuscript - 25%
2. **Martin Vorster:** Scientific writing and proofreading of the manuscript - 25%
3. **Casper H Jonker:** Scientific writing and proofreading of the manuscript - 25%
4. **Nicoline Potgieter:** Scientific writing and proofreading of the manuscript - 25%

In a study by Holcomb and Gregory,[15] 881 participants were investigated for the presence of CM. Initial periapical radiographs were taken of the participant and repeated four years later.

The survey revealed an incidence of partial or complete canal obliteration of 3.86% with initial examination. Only three (7.3%) of the 41 teeth developed periradicular rarefactions after the four-year follow-up. Over 79% of the participants could recall a traumatic dental injury between the age of 10 and 16 years of age. The authors of this study concluded that a significant correlation exists between a prior traumatic dental injury and the incidence of CM. They also commented that associated periapical rarefaction is uncommon and that endodontic intervention should only be considered in rare circumstances.

In a follow-up study by Andreasen,[6] where 189 teeth with history of dental luxation were examined, the authors described CM as an accelerated deposition of dentine and did not advocate early endodontic intervention. Pulp canal obliteration was observed in 22% of luxated teeth over a mean observation period of 3.4 years. Only 7% of teeth became necrotic over the follow up time. A relationship was found between the incidence of pulp obliteration and the stage of root development. The incidence of CM was higher in teeth with incomplete root development.

Another study by Andreason et al.,[18] showed a 5% incidence of CM in 637 permanent incisors after luxation injuries. Only 1% of these teeth developed pulpal necrosis when evaluated over a five-year period.

Stalhane and Hedegard[19] conducted a long-term study on 76 teeth that showed CM following traumatic injuries. Follow-up examinations were done 3-21 years after injuries. Of the 76 teeth, 12 teeth (16%) developed periapical rarefaction over this examination period.

The stage of root development, time of trauma as well as type of traumatic injury were also recorded. The authors commented on the fact that the success of modern endodontic treatment should be weighed against the incidence of developing periapical pathology when deciding on clinical treatment options.

A study by Jacobsen and Kerekes,[20] followed up on radiographic hard tissue changes of 122 teeth, 10-23 years post injury. Of the 36% of cases with partial and 64% of cases with complete canal obliteration, none of the partially obliterated canals became necrotic with

peri-apical rarefactions and only 13% of the complete obliterations eventually developed pulpal necrosis. The findings of this study strengthen the rationale behind performing endodontic treatment only when periradicular rarefactions develop.

In a study by Robertson et al.,[21] 82 permanent incisors with a history of trauma were followed up over a period of 7-22 years. Frequent yellow discolouration was seen and by evaluating periradicular bone loss, the authors reported that 8.5% of cases developed pulpal necrosis over this time.

The survival rate was found to be 84% after 20-years and it was reported that caries, new trauma, orthodontic treatment as well as crown coverage did not increase the frequency of pulpal necrosis.

Rock and Grundy[7] suggested a different approach to the previous studies and did a retrospective study in which 517 traumatised teeth were evaluated for the development of CM. They found that 16% of teeth developed CM. Although not statistically significant, CM was seen in the younger age groups (<9 years) while root resorption was seen in the older age group (>9 years).

Clinical, radiographic and histological findings

Most teeth presenting with canal obliteration are asymptomatic[1,9,21] including the absence of sensitivity to percussion.[10] CM is therefore often an incidental finding during clinical or radiographic investigations.[1,9]

CM is usually characterized by a dark yellow discolouration of the tooth.[9,10] This distinct discolouration of the crown has been reported in 79% of 122 teeth with pulpal obliteration[9,20] and may be attributed to the deposition of dark tertiary dentine.[8,10,13,14]

Oginni et al.[1] reported that out of 276 teeth with partial canal obliteration, 186 (67%) had yellow discoloration and a further 34 (12%) teeth were grey in colour.

Interestingly, the incidence of pulp or periapical pathology were greater in the teeth with a grey discoloration compared to those with yellow discoloration.[1] It is important to note that teeth with radiographic signs of pulpal obliteration may also present without any colour change,[9] and although colour change may indicate CM, it is not a necessarily an indication of pulpal or periapical pathosis.[1,9,20,21]

In the presence of partial canal obliteration, it is generally accepted that vitality tests are unreliable.[1,9,21,22] These teeth show a delayed or completely absent response to vitality tests.[10,11,23] The response to vitality tests also tend to decrease as pulpal obliteration progresses.[1,5,9,16]

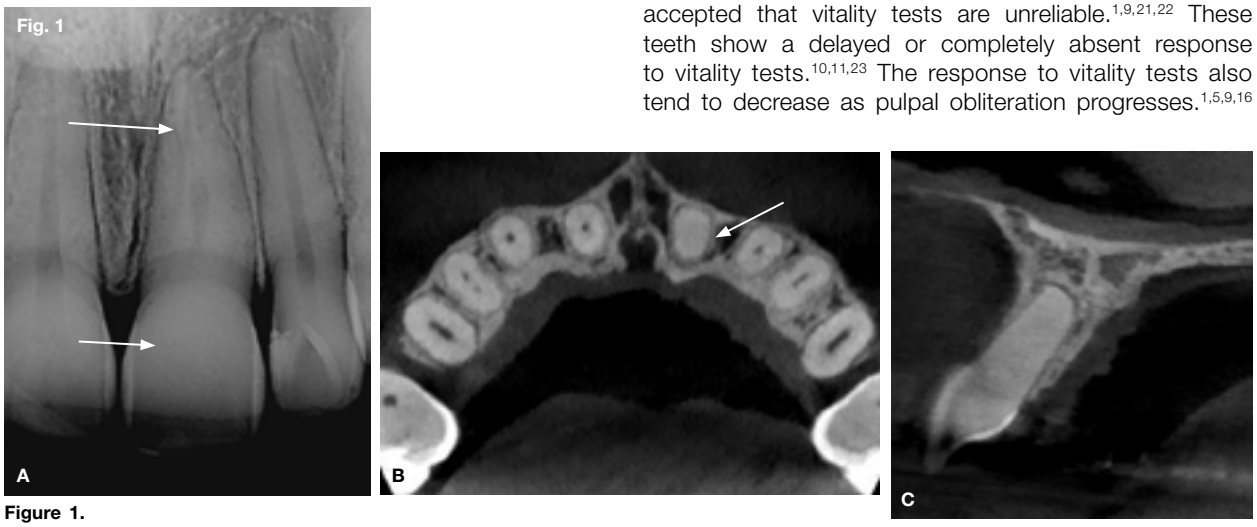


Figure 1.
A. Periapical radiograph of a left maxillary central incisor of a 27-year-old female patient that suffered a concussion injury at the age of 14 years. Note the canal obliteration in the coronal and apical third of the root canal (arrows), leaving a small amount of pulp tissue in the mid-root region.
B. Axial slice of CBCT at the level of CEJ showing complete canal obliteration of the left maxillary central incisor (arrow) compared to the other teeth in maxillary arch.
C. Sagittal slice of CBCT showing complete canal obliteration of the left maxillary central incisor.

Figure 2. Clinical view of the discoloured left maxillary central incisor.

Figure 3. Clinical view of the discoloured left maxillary central incisor taken with cross polarization photography resulting in no specular reflection. Note the severe change in hue and value of the affected tooth.

Generally, canal obliteration progresses in a corono-apical direction.[10] A decrease in the pulp chamber volume is often the first radiographic sign, followed by a gradual narrowing of the complete root canal.[10,23]

Obliteration can be classified as either partial (coronal), or complete (extending radicular) obliteration of the pulp canal space.[9,10] CM usually presents with a normal periodontal ligament space and intact lamina dura.[11,14,23,24]

Thickening of the periodontal ligament space or periradicula pathology may however be visible in the presence of infection.[9,10,14,24]

Cone beam Computed Tomography (CBCT) may prove helpful in locating the root canals.[10,24-26] The option to view canals in multiplanar reconstructions provides the clinician with valuable information in the diagnosis and management of CM.[10,27]

The absence of a root canal on conventional radiographs does not necessarily mean total absence of that canal.[5,8,9,16] Histologic evaluation of pulp canals, radiographically diagnosed as being obliterated, almost always confirm the existence of a narrow pulp canal containing pulpal tissue.[10,12,14,23] Canal mineralization has therefore been suggested as a more accurate term as opposed to canal obliteration.[10,23,28]

Pulp canal obliteration was initially described as an irregular tertiary dentine deposition, but more recently as multifocal, dystrophic calcifications composed of ill-defined secondary dentine.[8,29-31] Calcifications have also been described by some authors as dentine-like, bone-like and fibrotic.[10,32,33] Holan[24] described calcificationsas tube-like osteo-dentine structures extending along the entire length of the pulp canal, surrounded by pulp tissue only connected to the root dentine at some areas.

In a study by Lundberg and Cvek,[32] no micro-organisms were found in any of the specimens investigated. Inflammatory components, indicative of a pathologic process, are usually absent in teeth with CM.[5,8,10,13,4,32,34] Based on these histopathological studies, asymptomatic CM does not indicate the necessity for root canal treatment.[10,14,18,32]

Treatment options

The dark appearance of teeth affected by CM is not only a huge aesthetic concern but also presents the clinician with a great treatment challenge. Recently, West[35] suggested four potential treatment options for the restoration of aesthetics in discoloured teeth affected by sclerosis of the root canal complex. The four treatment options with an example of a case report on option one and two are described below.

1. Vital bleaching/External bleaching

Due to its conservative nature, several authors advocate that external or vital bleaching should be considered as a first treatment option.[35-38] Greenwall[37] described a vital tooth whitening technique for affected single teeth. The author advocated the use of 20% carbamide peroxide gel in a modified conventional vital bleaching tray where windows are created adjacent to the discoloured tooth, on either side.

This modification will prevent the overflow of bleaching liquid to adjacent teeth which might result in uneven whitening. The disadvantage of this particular technique is that progress can be slow due to the nature of discoloration and the final result might not be acceptable. An advantage of this treatment option is that patients experience limited or no sensitivity during the whitening procedure.[37]

Joiner[39] suggested that using a low con-centration for a longer treatment time will reduce the negative effects (as a result of rapid diffusion of free radicals) of bleaching. Additionally, the prolonged use of bleaching products with a low concentration (for example 10-20% carbamide peroxide) provides greater stability.[39]

Haywood and DiAngelis[40] discussed two approaches when considering external bleaching as a treatment option to improve aesthetics:

Tray bleaching: the authors advocated a horseshoe-shaped cast on which the tray is manufactured with no vestibule to allow proper adaptation of bleaching solution.

Single tooth bleaching tray: a non-scalloped, non-reservoir tray modified and trimmed to fit a single discoloured tooth. Patients are provided with a single syringe bleaching solution.

CASE REPORT

A 29-year-old female presented with a history of trauma to her maxillary anterior teeth at the age of 13 and agenesis of her maxillary left and right lateral incisors (Fig. 4). Historically, orthodontic treatment was attempted to move the canines into the position of the laterals. Following orthodontic treatment the patient relapsed with a resultant non-aesthetic appearance.

The main concern was a yellow discoloration of both the maxillary canines and left central incisor (Fig. 4). The patient sought an immediate aesthetic solution as she was getting married in four weeks' time. Radiographic examination revealed complete canal obliteration of the asymptomatic maxillary left central incisor (Fig. 5A), with vital and visible root canal systems on the canines (Fig. 5B).

It was decided to manage the case using the vital bleaching technique with 16% carbamide peroxide (Flash Take Home Whitening System, Whitesmile GmbH, Germany) for three weeks. The patient was instructed to bleach the discoloured teeth every day for 45 minutes and the rest of the arch was bleached every third day.

Figure 6 shows the result after vital bleaching and Figure 7 the immediate postoperative result after minimally invasive direct composite restorations to modify the anatomical shape of the teeth and to close the diastema between the 21 and 23.

Figure 4. Yellow discoloration of the left central incisor and both maxillary canines, in the position of the laterals.

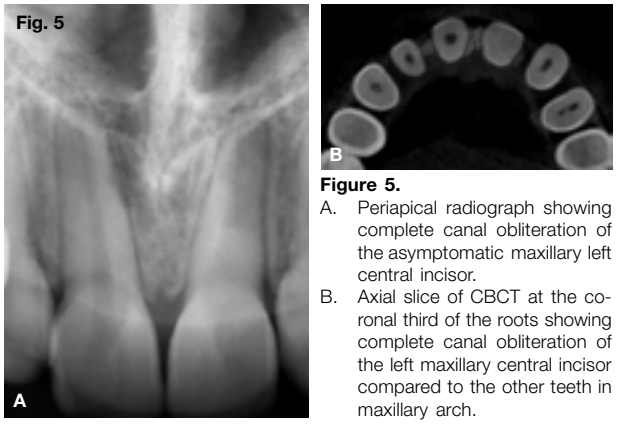


Figure 5.
A. Periapical radiograph showing complete canal obliteration of the asymptomatic maxillary left central incisor.
B. Axial slice of CBCT at the coronal third of the roots showing complete canal obliteration of the left maxillary central incisor compared to the other teeth in maxillary arch.

Figure 6. Postoperative result after vital bleaching.

Figure 7. Postoperative result after direct composite restorations on the left central incisor and two canines.

2. Intentional root canal treatment followed by intra-coronal/non-vital bleaching

Rock and Grundy[7] recommended root canal treatment as soon as evidence of narrowing of the pulp chamber was seen radiographically.

The rationale was based on two clinical considerations: firstly, once access to the canal is lost there is an increased risk of root perforation and secondly, a loss of coronal access to the root canal might result in surgical intervention should the remainder of the canal become necrotic.

De Cleen[11] recommended a more invasive approach by creating a fully extended access cavity similar to a healthy unaffected tooth with normal chamber size.

The author was convinced that by following this approach, the majority of tertiary dentine will be removed and ultimately create a translucency within the crown.

Rotstein & Walton[41] concluded that an acceptable aesthetic result could be obtained on CM affected teeth by means of intra-coronal bleaching, once root canal treatment has been completed successfully. However, the disadvantage of the non-vital bleaching technique is the increased possibility of colour regression over time.

The exact mechanism responsible for this colour regression is not yet defined although micro leakage through the final covering restoration could play a role.[42]

Friedman et al.[43] observed endodontically treated teeth with non-vital bleaching and found that on recall periods of one to eight years, 79% of these teeth illustrated improved colour and aesthetics compared to their initial appearance. It should however be stated that the introduction of bleaching solution into the pulp chamber may increase the risk of external cervical resorption.[44] Bleaching procedure for endodontically treated anterior teeth can be approached internally, externally or a combination of both depending on a proper assessment and diagnosis. Haywood and DiAngelis[40] discussed different approaches when considering bleaching as a treatment option in non-vital teeth:

In-office bleaching: the classic in-office non-vital bleaching technique involves the use of a high concentration hydrogen peroxide (35%) which is placed in the prepared pulp chamber and activated with a light or heat source.

Walking bleach technique: a classic technique where gutta-percha is removed 2mm below the cemento-enamel junction, sealed off using a lining material (such as glass ionomer) with bleaching solution placed and sealed in. The patient is instructed to return for subsequent visits and follow-ups.

Internal-external closed bleaching: bleaching is executed from within the affected tooth as well as the external surface. The pulp chamber is prepared and the walking bleach technique is used as described above. Additionally, a single tooth tray is manufactured to allow bleaching externally and patient follows the instructions as advocated above.

According to Haywood and DiAngelis and other authors, this approach is considered as most effective and proves most beneficial.[40,45,46]

Internal-external open bleaching: the technique is similar to the internal-external closed technique accept that the affected tooth is left open and the patient is instructed to fill the tooth and tray with bleaching solution. The technique is highly reliant on the patient's understanding and co-operation.

For all approaches it is crucial to remove any remnants of pulp horns before the internal bleaching procedure is conducted. Very often proper cleaning of the pulp chamber and pulp horns will result in an improved appearance.

CASE REPORT

A 27-year-old female presented with percussion sensitivity on her maxillary left central incisor. She was also concerned about a yellow-brown discoloration of this

tooth (Fig. 8) and expressed the desire to have her teeth "bleached". A peri-apical radiograph and CBCT scan revealed that the canal was almost completely obliterated (Fig. 9).

The tooth was isolated with rubber dam using a Brinker Tissue Retractor (Hygenic) clamp (Fig. 10) to ensure retention of the clamp because of the lack of an adequate cingulum area on the palatal aspect of the tooth.

Figure 9. Pre-operative peri-apical radiograph of maxillary left central incisor with obliterated root canal system.

Figure 8. Pre-operative clinical view of the discoloured maxillary left central incisor.

Figure 10. Rubber dam isolation using the Brinker Tissue Retractor B5 (Hygenic).

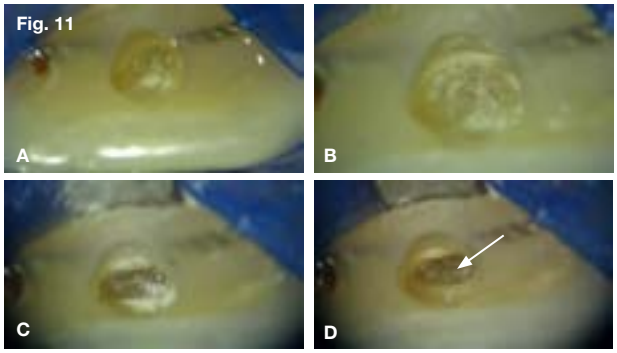
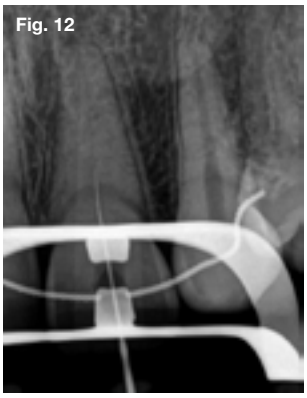


Figure 11. High magnification views of the pulp chamber floor.

A. Initial view after access cavity preparation. Note the darker yellow discoloration outlining the position of the original pulp chamber.
B. Selective removal of the darker dentine with a small long-shank bur (Dentsply Sirona). Clearly visible is the outline of the tertiary dentine formation and calcification of the original root canal system.
C. Troughing to a deeper level revealed narrow band of darker discoloured dentine directly related to the smaller diameter of the original root canal system at this level.
D. After troughing to a deeper level with a Start.X ultrasonic tip (Dentsply Sirona) a narrow band of reactionary dentine was revealed with a collection of white dentine debris in one spot (arrow), indicating the remaining canal space.

After access cavity preparation, the darker dentine discoloration of the pulp floor was followed with small long-shank burs (Dentsply Sirona) and a Start.X ultrasonic tip (Dentsply Sirona) until a rather calcified canal orifice was located (Fig. 11A-D). The coronal aspect of the canal was negotiated with a size 08 C+ file (Dentsply Sirona) (Fig. 12) followed by a 08 K-file. This sequence was repeated until canal patency and full working length (Fig. 13) were achieved.

A size 10 K-file was used to create a reproducible micro glide path before the macro glide path was completed using the TruNatomy Glider (Dentsply Sirona) in 8–12 back-stroke brushing motions. Canal preparation was done with the TruNatomy Prime (Dentsply Sirona) file followed by canal irrigation with 17% EDTA (Vista Dental) and 3.5% sodium hypochlorite.



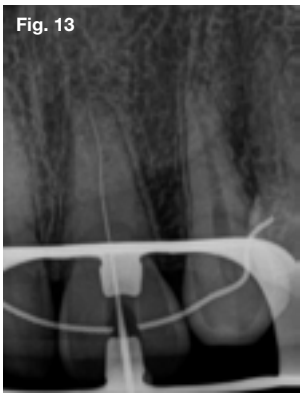


Figure 12. Coronal aspect of the root canal negotiated with a 08 C+ file.
Figure 13. Length determination on peri-apical radiograph.

Figure 14. Conefit peri-apical radiograph confirming the fit of a TruNatomy Prime Gutta Percha Point (Dentsply Sirona).

Figure 15. Postoperative peri-apical radiograph after root canal obturation.

Figure 16. Result after bleaching technique for 48 hours using 35% hydrogen peroxide until a lighter value was obtained and the uneven gingival contour of the tooth was corrected using a Sirolase Blue (Dentsply Sirona).

Figure 17. Final aesthetic result that was obtained after the treatment.

Figure 18. Side view illustrating the aesthetic outcome of the treatment resulting in a very happy patient.

A TruNatomy Prime Gutta Percha Point (Dentsply Sirona) was placed in the prepared root canal system and the fit verified radiographically (Fig. 14). Finally, the root canal system was obturated with a TruNatomy Prime Gutta Percha Point, AH Plus sealer (Dentsply Sirona) and the Gutta Smart Obturation System (Dentsply Sirona) (Fig. 15).

The tooth was bleached utilising the walking bleach technique for 48 hours using 35% hydrogen peroxide (Opal Endo, Ultradent) until a lighter value was obtained compared to the other maxillary teeth. The uneven gingival contour of the tooth was corrected using a Sirolase Blue (Dentsply Sirona) (Fig. 16).

This was followed by home bleaching of the other maxillary teeth using 10% hydrogen peroxide (Flash Take Home Whitening System). The palatal access cavity was cleaned with air polishing before it was restored with SDR (Dentsply Sirona) and composite resin.
Figure 17 and 18 shows the final aesthetic result that was obtained after the treatment.

3. Internal and external bleaching without root canal treatment

Pedorella, Meyer and Woollard[47] described a technique where the access cavity is prepared by removing the sclerotic dentine in the coronal portion of the affected tooth followed by the placement of a suitable base/liner on the floor of the prepared cavity. The approach is aimed at addressing the aesthetic concerns with internal and external bleaching without attempting the root canal procedure.

Whilst considering this approach as a suitable treatment option, the technique is not well supported in literature and does not have widespread support. Various studies have concluded that in the majority of cases a pulp space with pulp tissue is present.

Conventional radiographs fail to capture the presence of a microscopic root canal system, therefore being interpreted as a completely sclerotic tooth with no root canal and pulp chamber.[5,8,16] Once the cavity preparation for intra-coronal bleaching is attempted and a microscopic root canal system in unknowingly penetrated, the pulp tissue is exposed to possible infection that might result in periradicular pathology.[9]

4. Extra-coronal full or partial coverage

Traditionally, various invasive treatment approaches were followed in an effort to improve the appearance of teeth affected by CM. Direct or indirect veneers, ceramic crowns or removal of part of the palatal dentine (similar to traditional endodontic access) are among the treatment approaches attempted to restore aesthetics.

The disadvantage of these invasive approaches is the removal of healthy tooth structure and weakening of the remaining tooth structure.[44] Recent reports have suggested external bleaching as the first treatment option. This treatment is non-invasive, relatively cost effective and simple with predictable outcomes.[48]

West[35] suggested a more invasive treatment option by considering a full coverage restoration. Considering the fact that most teeth affected by CM are intact and have no structural damage, the preparation and placement of a full or partial covering restoration should be carefully considered only when more conservative approaches have failed. Malhotra[10] also suggested the preparation and placement of veneers on teeth with large existing restorations, fractures or defects. A combination of treatment options can also be considered.

CONCLUSION

Treatment of CM, both endodontically and aesthetically, remain challenging for even the skilled clinician. In this paper the authors provide an overview of CM and some clinical advice on the management this condition both endodontically and aesthetically. An accurate diagnosis, based on clinical and radiographic findings, will guide the practitioner to select the appropriate treatment approach or combination of approaches for each individualised case.

Declaration

The authors have no conflict of interest to declare.

Clinical significance

This review article aims to give the reader an in depth oversight on the aetiology and clinical presentation of calcific metamorphosis. The authors also provide some insight on the clinical management of these, often complexed and difficult to manage clinically, cases.

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Visual assessment is no substitute for radiographic analysis
- A forensic case report

SADJ July 2020, Vol. 75 No. 6 p323 - p325

L Robinson[1], C Nel[2], H Bernitz[3]

CASE REPORT

The details of this case have been omitted in order to maintain anonymity.

While preparing the foundations for a new house, a builder happened to find a small mandible buried just below the surface. Human skeletal remains in the form of a mandible were submitted to the forensic odontology unit at the University of Pretoria for age assessment.

On initial macroscopic examination, all mandibular deciduous teeth were present and fully erupted. Both mandibular permanent first molars were visible, due to the exposed overlying alveolar bone, but were still fully submerged with no evidence of eruption. At this stage, a dental age estimation of approximately 4-5 years was proposed based on the presence of all mandibular deciduous teeth and the exposure of the mandibular permanent first molars.

A radiographic analysis followed (Figure 1), whereby it was noted that the mandible was less mature than initially suspected from the visual examination (Figures 2-4). The developmental stages of the relevant teeth were analysed according to the methods of AlQahtani et al., London Atlas of Human Tooth Development and Eruption, 2010[1], and the Developmental Atlas of the Human Dentition (Oral Anatomy, Histology and Embryology), 4th Edition, 2009.[2]

Author affiliations:
1. **Liam Robinson:** *BChD, PDD (Maxillofacial Radiology), PDD (Forensic Odontology),* Department of Oral Pathology and Oral Biology, School of Dentistry, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa.
   ORCID Number: 0000-0002-0549-7824
2. **Chané Nel:** *BChD, MSc (Maxillo-facial and Oral Radiology),* Department of Oral Pathology and Oral Biology, School of Dentistry, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa.
   ORCID Number: 0000-0003-4047-6356
3. **Herman Bernitz:** *BChD, Dip (Odont), MSc, PhD,* Department of Oral Pathology and Oral Biology, School of Dentistry, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa.
   ORCID Number: 0000-0003-1361-1225

Corresponding author: Herman Bernitz
Department of Oral Pathology and Oral Biology, University of Pretoria, Pretoria, South Africa.
Email: bernitz@iafrica.com

Author contributions:
1. **Liam Robinson:** Principle author - 50%
2. **Chané Nel:** Radiographic acquisition and analysis - 20%
3. **Herman Bernitz:** Forensic report and advisor - 30%

Figure 1. Photograph illustrating periapical radiographic technique.

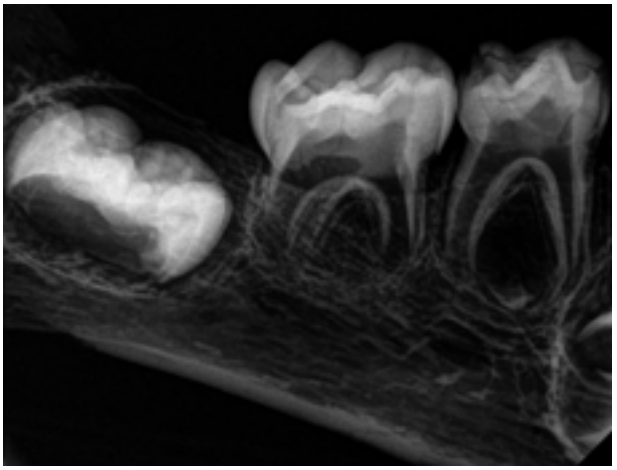

Figure 2. Periapical radiograph depicting the right mandibular deciduous molars and an unerupted permanent first molar.

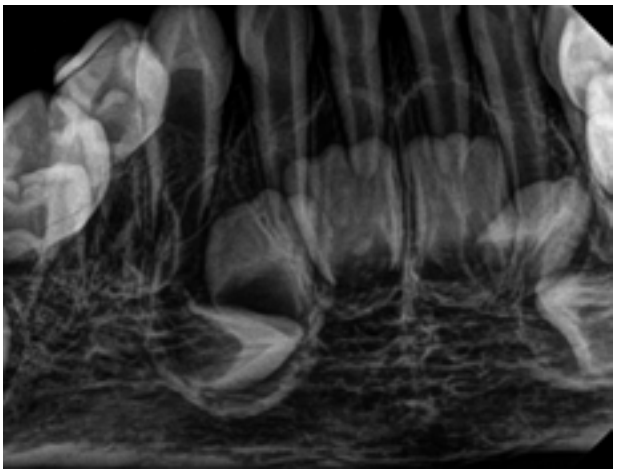

Figure 3. Periapical radiograph depicting the developing mandibular permanent anterior teeth.

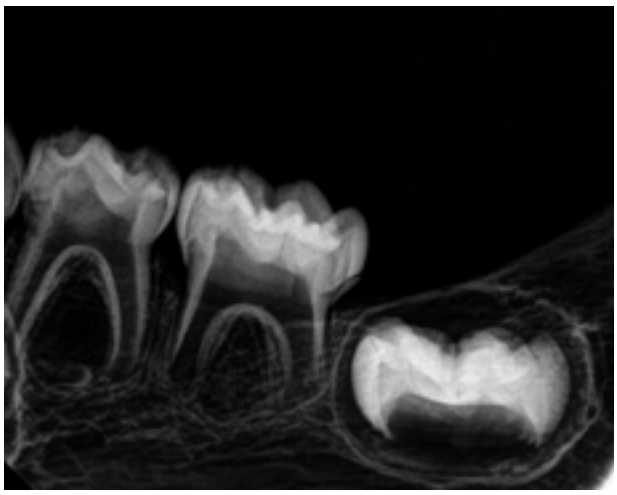

Figure 4. Periapical radiograph depicting the left mandibular deciduous molars and an unerupted permanent first molar.

AlQahtani et al, London Atlas of Human Tooth Development and Eruption (2010)[1] (Figure 5)

The development of the teeth 36, 75, 74, 33, 32 and 31 correspond closest to the development seen at age >1.5 years and <2.5 years. It must be stated that the development stages are only given in yearly intervals. It is important to note that the radiographs taken of the mandibular teeth showed no initial crypt development of teeth 34 and 35. This strongly indicates an age of less than 2.5 years. An age of >1.5 but <2.5 years can therefore be considered reliable.

Developmental Atlas of the Human Dentition, Oral Anatomy, Histology and Embryology, 4th Edition (2009)[2]

The development of the teeth 36, 75, 74, 33, 32 and 31 correspond closest to the development seen at age >2 years and < 3 years. An age of 2.5 years with a 6-month dispersion can therefore be considered reliable using this method. This method was used as a quality control understanding its limitations.

It was therefore concluded, that according to both methods, an age of < 2.5 years with a 6-month dispersion could be considered reliable for the mandibular remains.

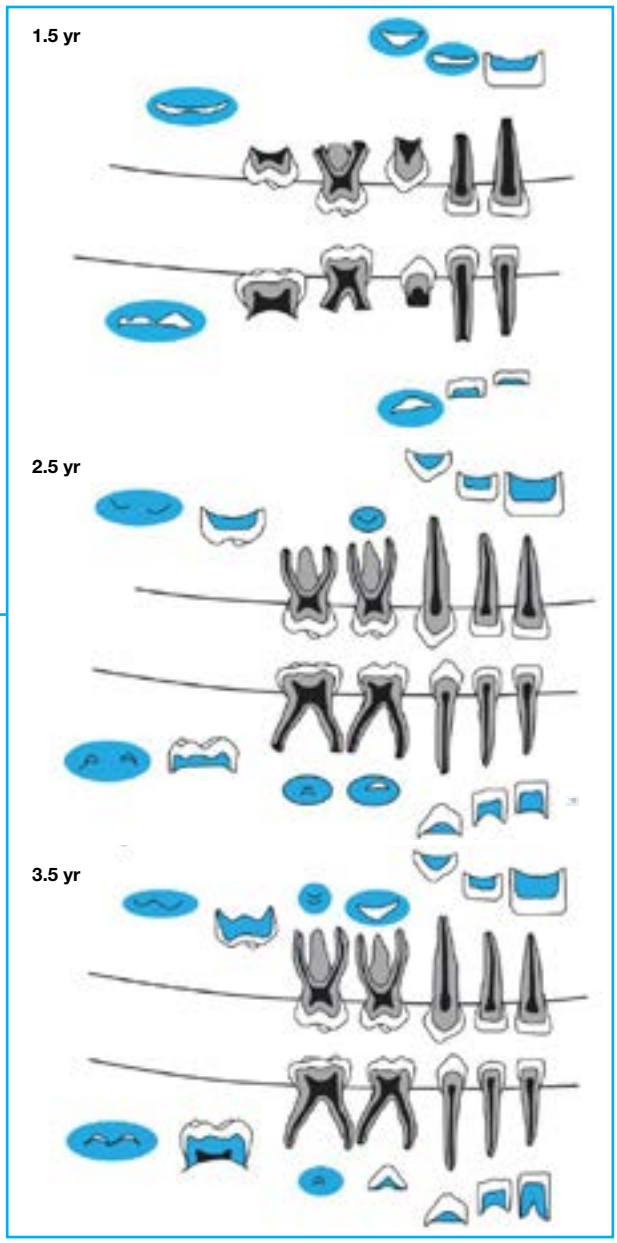

Figure 5. Schematic chart illustrating developmental age of 1.5 to 3.5 years. Adapted from: London Atlas of Human Tooth Development and Eruption, AlQahtani et al. (2010).[1]

DISCUSSION

Dental age estimation of living and deceased individuals has been the subject of extensive research worldwide. In recent years, population specific standards have been sought to assist in meeting rigorous legal requirements.[3]

Calculation of the biological age of an individual has many applications in the field of dentistry. It can be used to determine appropriate timing of orthodontic treatment, to analyse the developmental stage of an individual relative to the general population in cases of disturbed growth; and to estimate the age of a living or deceased individual for forensic purposes.[1,4-5]

Teeth are often used for identification purposes as well as age estimation as they survive inhumation well and show less variability than bones used in skeletal age estimation. Hence, the developing dentition is considered superior to other developmental indicators for age estimation up to maturity.[1] Accurate estimation of age at the time of death may be a crucial component in the identification of human remains, and can significantly narrow the field of possibilities in establishing a positive identification.[6]

Over the years, many authors have recognised the use of systems of age estimation based on dental development. As early as 1935, Schour and Hoffman found that the pattern of calcification of dentition under normal conditions followed a reliable sequence of growth, allowing for age estimation.[3,6] This led to the widespread use of dental development-based age-estimation systems. While accurate, many of the techniques require additional training and experience to ensure precision.[3-4] Some methods are destructive to tooth tissue and are therefore considered inappropriate in many instances.

Schour and Massler later published an important study that summarised the development of the human dentition in an atlas-style chart consisting of 21 diagrams with an age range from 5 months in utero to 35 years.[1] This method involved comparison of a radiograph of the maxillary and mandibular dentitions against diagrams depicting the stage of development. This system was simple to follow, required no major specialised training, and made use of readily available diagnostic aids, i.e periapical radiographs.[4] The drawbacks of using an atlas-based system are that they are based on the premise of 'one size fits all'.

Clinicians are required to make a qualitative assessment of the case at hand and match it to the closest suitable diagram, thus a high risk of error exists. Moorrees et al. published research providing norms of formation of ten permanent teeth, namely, the maxillary incisors and all eight mandibular teeth. The findings provided ages of attainment for fourteen selected stages of tooth development, taking into account crown, root and apex development.[7]

Demirjian et al., in 1973, developed a method using panoramic radiographs for estimating dental maturity based on the stage of development of each tooth present in the jaws. The data was based on measurements obtained from a sample of boys and girls of French Canadian parentage.[5] Their method referenced eight tooth developmental stages (A-H) in a chart format, and was considered significantly less complicated than the approach previously published by Moorrees et al.[5,8] Unfortunately, this method, although simple in ts application, has been shown by subsequent studies to be inaccurate on population samples of different ethnic heritage.[6,9] However, the well-defined stages and objective evaluation still makes Demirjian's method one of the most suitable for forensic purposes.[9]

Ubelaker's dental chart was produced in 1978 and attempted to modify and improve upon the original chart produced by Schour and Massler.[1,10] Again, this method is not without its limitations, as owing to issues with identification of sex, no differentiation was made between males and females.[4] Ubelaker's charts have since been modified for modern Australians, with separate charts created for males and females by adjusting the age of each drawing.[4]

More recently, work published by AlQahtani et al., based on cases taken from a range of sources, assessed for stages of development using the system devised by Moorrees et al.[1] The main advantage of this work over previous methods is the availability of diagrams for each year of development from ages 1 to 23. Each developmental stage is illustrated radiographically and clarified by the addition of written descriptions.[1]

As with any categorical system of assessment, the larger number of diagrams results in more accurate estimations of age. This work culminated in the establishment of the so-called 'London Atlas of Human Tooth Development and Eruption', which has subsequently been validated using predominately modern samples with accurate results.[3]

A recent study compared results from older charts with the more modern London Atlas. Age was estimated more accurately with greater precision, and the percentage correctly aged was higher for the London Atlas compared with Schour and Massler and Ubelaker.[10] In spite of these findings, one major limitation with the London Atlas is that age is expressed as a midpoint of an age category and not a point estimate with no measure of dispersion provided in the atlas.

CONCLUSION

Age estimation charts are useful tools to estimate age at time of death. The datasets on which these charts were developed are based upon significant sample sizes and are in many instances sex specific.

In spite of the inherent limitations of the atlas style, these charts are recommended for use as an initial screening tool, especially in a mortuary setting or mass disaster situation. More precise and detailed age estimation analysis should be undertaken when time and other pressures of the forensic environment have subsided.[4] This case report highlights an example where the initial visual impression of skeletal remains could have clouded the judgment of the investigators, leading to a miscarriage of justice.

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What's new for the clinician?
- Excerpts from and summaries of recently published papers

SADJ July 2020, Vol. 75 No. 6 p328 - p332

Compiled and edited by V Yengopal

1. Evaluation of postoperative sensitivity in restorations with self-adhesive resin - a randomized split-mouth design controlled study

NG de Oliveira, ASLC Lima, MT da Silveira, et al. Evaluation of postoperative sensitivity in restorations with self-adhesive resin: a randomized split-mouth design controlled study. Clin Oral Invest. 2020; 24: 1829-35.

ABSTRACT

Self-adhesive restorative materials have been developed to simplify the restorative procedure by reducing the number of operative procedures and thus decreasing the number of possible errors from multiple steps such as inadequate acid etching in dentin, moisture contamination, etc.

The type of adhesive system used in the bonding of restorative material can contribute to marginal microleakage and sensitivity. To obtain adequate bonding, the smear layer, which is formed during cavity preparation, must be treated or removed by adhesives.[1] However, the effects of different adhesive systems vary widely both on the smear layer and in bonding quality. Biologically and technically, bonding mechanisms are different in etch-and-rinse and self-etch systems.[1]

In etch-and-rinse systems, the bonding mechanism is micromechanical and is based on the formation of a hybrid layer. In addition to micromechanical adhesion, diffusion and infiltration of resin within etched collagen fibrils are also effective in bonding to dentin.[1] In self-etch systems that are easy to use, the bonding mechanism occurs by dissolving the smear layer and through penetration of acidic monomers into dentin to create a hybrid layer.[1]

The self-adhesive resin composite (SAC) acts simultaneously as a self-etching adhesive and a flowable resin, thus eliminating the acid etching step and separate application of a bonding agent. de Oliveira and colleagues (2020)[1] reported on a split mouth trial that sought to evaluate the post-operative sensitivity of restorations with self-adhesive resin composite (Vertise Flow) compared with conventional resin composite with self-etching adhesive (Filtek Z250 and Clearfil SE Bond).

The null hypothesis tested was that no difference would be found regarding the postoperative sensitivity between restorative techniques.

MATERIALS AND METHODS

This study was a randomized, controlled, double-blind, split-mouth, two-arm clinical trial conducted in Brazil. Twenty-seven volunteers, aged between 18 and 40 years (mean 25.92 years) and of both sexes were recruited into this trial. A total of fifty-four third molars with an indication of extraction were included.

The study inclusion criteria were (1) two third molars indicated for extraction for orthodontic reasons; (2) healthy teeth without caries, score "0" according to the International Caries and Assessment System (ICDAS); (3) complete root development; and (4) fully erupted teeth.

Teeth without pulpal vitality or with altered pulpal vitality demonstrated using cold sensitivity tests, percussion, or palpation; the presence of pulpal calcification; and the impossibility of isolation with rubber dam were excluded.

A total of 54 restorations in 27 volunteers were performed by the same operator. Each participant received two restorations according – one was the test/experimental material and the other the control. The treatment allocation was done by the toss of a coin – "tails" meant that the tooth received a SAC whilst "heads" meant that the tooth restored using the conventional tech-

Veerasamy Yengopal: *BChD, BScHons, MChD, PhD*, Community Dentistry Department, School of Oral Health Sciences, University of Witwatersrand, Medical School, no. 7 York Road, Parktown 2193, South Africa.
ORCID Number: 0000-0003-4284-3367
Email: veerasamy.yengopal@wits.ac.za

nique with prior bonding procedure. Patients and evaluators were not aware of the type of material used for each tooth.

One previously calibrated operator performed all restorations. The cavity preparation was standardized. The restorative materials were applied according to the manufacturers' instructions. All photoactivation procedures were performed with halogen light (Ultralux) at a power density of 800 mW/cm2, previously measured with a radiometer.

After restoration placement, the occlusal contacts were evaluated with marking paper. The finishing and polishing were performed in the same session. Both restorations were done during the same clinical appointment.

Postoperative sensitivity was evaluated at 24 h and 15 and 30 days after the restorative procedure. Information on the presence of pain was collected (present or absent). If present, the characteristics of the pain were recorded: the localization of pain (localized or diffuse), the type of stimulus (triggered or spontaneous), the duration of pain (short or prolonged), its frequency (intermittent or continuous), and intensity of pain (mild, moderate or severe). Thermal stimulation (refrigerant spray Endo-Ice) was used to evaluate the type of stimulus. The pain intensity was recorded with the visual analog scale (VAS). The VAS consists of a 100 mm line divided into equal intervals of 10 mm, where 0 represents "absence of pain" and 100 "severe pain." The results of VAS were classified as mild (0-30 mm), moderate (40-70 mm), or severe pain (>70 mm).

After each evaluation period, the patients had the tooth extracted as previously recommended.

RESULTS

Two patients with 4 third molars were excluded after enrolment because of lost to follow-up. The remaining 50 third molars of 25 patients (56% male vs. 44% female) were included. Regardless of the time intervals, postoperative sensitivity was observed in 52% and 48% of the conventional and self-adhesive resin composite (SAC) groups, respectively. No differences were observed between the postoperative sensitivity of the studied groups ($p = 1.000$) regardless of the time intervals.

None of the characteristics related to pain sensitivity, localization, type of stimulus, duration, frequency, and intensity demonstrated statistical differences between groups. Regarding the type of stimulus, triggered pain corresponded to 92.3% of the conventional group and 91.7% of the self-adhesive resin composite (SAC) group.

As for pain intensity, most was considered mild for both self-adhesive resin composite (SAC) group (75%) and conventional treatment group (76.9%). Moderate pain was observed in the conventional treatment group (23.1%), and severe pain (8.3%) was only observed in self-adhesive resin composite (SAC) group. No statistical differences were observed between groups.

All patients who had postoperative sensitivity reported that the pain was localized and of short duration with both materials.

When the evaluation period was considered for both groups, the 15-day time point presented the highest pain occurrence (87.5%) of mild intensity.

CONCLUSION

The authors found that Self-adhesive resin composite and conventional resin composite with a self-etching bonding agent showed similar responses regarding postoperative sensitivity in deep class I cavities. When postoperative sensitivity was present, mild pain was observed in about half the participants; this decreased over time.

Implications for practice

This study provides evidence that the self-adhesive resin composite performed similarly to the conventional resin composite with a self-etching bonding agent for the main outcome of postoperative sensitivity.

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A Puisys, M Schlee, T Linkevicius, P Petrakakis, A Tjaden. Photo-activated implants: a triple-blinded, split-mouth, randomized controlled clinical trial on the resistance to removal torque at various healing intervals. Clinical oral investigations. 2019 Sep; 11: 1-11.

ABSTRACT

The success rates for implant therapy has been reported to be well above 95% after a 10 year observation period in a number of published studies.[1] The term "osseointegration" was coined to describe the osseous bonding of the bone to implant and more recently this process has been referred to as "encapsulation" resulting from a foreign body reaction". The quality and stability of the osseointegration (OI) or osseoencapsulation (OE) enables the implant to bear chewing forces.[1]

Implant stability is achieved at two levels—primary and secondary stability. Primary stability is mechanically obtained immediately after implant insertion as a result of friction between implant and bone, whereas secondary stability is achieved by deposition of mineral on the implant surface, beginning 2 weeks after surgery.[1]

Factors affecting primary stability are numerous and include bone quality and quantity, different drilling protocols depending on bone density, surgical technique and surgeon's skills, and implant and surface characteristics.[1] The quality and timeline of secondary implant stability are influenced by surgical technique; surface characteristics of the implant such as roughness, hydrophilicity, and chemical modifications; and general health of the patient.[1] Surfaces that attract water are termed hydrophilic, whereas surfaces that repel water are termed **hydrophobic**. The degree to which a surface either attracts or repels water can be termed, respectively, the **hydrophilicity** or the **hydrophobicity** of that surface.

In vitro studies have demonstrated that cell differentiation and growth factor expression increase on hydrophilic implant surfaces. Moreover, animal studies indicated improved early soft and hard tissue integration of hydrophilic titanium implants. Some authors have demonstrated that titanium surfaces will be contaminated within 4 weeks and lose initial hydrophilicity.[1]

This effect is associated with the progressive deposition of hydrocarbons and a change of electrostatic charge from positive to negative. These effects have a negative impact on protein absorption capacity, osteoblast migration, attachment, spread, and proliferation. Mineralization also decreases on 4-week-old titanium surfaces.

Application of ultraviolet (UV) light can regain hydrophilicity of titanium dioxide.[1] *In vitro* and animal models investigated the effect of photo-activation (PA) on fresh, aged, and photo-activation treated implant surfaces. PA was found to increase hydrophilicity, turns the electrostatic charge to positive, and removed hydrocarbons from the surface.[1]

PA was also reported to have positive effects on alkaline phosphatase activity, calcium deposition spreading of human stem cells, protein absorption capacity, osteoblast migration, attachment, spread, and proliferation.

Kumar and colleagues (2020)[1] reported on a randomized controlled clinical trial that sought to investigate the influence of photo-activation (PA) on implant stability using Removal torque (RT) at different time points as a surrogate outcome. RT is defined as the force which is necessary to detach an implant from the bone, thus indirectly providing information on the degree of bone-implant contact (BIC).

The null hypothesis stated that surface-treated implants (test group) will show the same deliberation force at specific time points as implants without surface treatment (control group).

MATERIALS AND METHODS

In this single-center study, 180 partially edentulous patients requiring two implants were selected and the position of test and control implant was randomly assigned. Both implant locations had to be in the same jaw. Furthermore, the patients were randomly allocated to six groups. Randomization was performed using computer-generated random numbers, sealed in sequentially numbered opaque envelopes.

One hundred eighty test implants and 180 control implants (N = 360) with a tapered design, a micro-textured surface morphology in the neck area, and an internal connection (BioHorizons® Tapered Plus) were inserted epicrestally in single-stage surgery. Each patient received one test and one control implant of the same diameter and length. The implants used had a diameter of 3.8, 4.6, or 5.8 mm and a length of 9.0, 10.5, 12.0, or 15.0 mm, respectively.

Patients, surgeon, and outcome assessors were blinded to the type of implant (test or control). Patients in good systemic health requiring (at least) two dental implants were included in the study.

Exclusion criteria were:

- Patients unable to commit to the follow-up period.
- Patients needing bone augmentation at implant placement.
- Post-extractive sites (implants were intended to be inserted after a healing period of at least 3 months).
- Patients with an acute infection or suppuration at the site intended for implant placement.

- Patients with acute or untreated periodontal disease (BOP >15%); General contraindications to implant surgery.
- Immune-suppressed/immune-compromised patients.
- Patients irradiated in the head and/or neck area.
- Patients with poorly controlled diabetes, pregnancy, poor oral hygiene and motivation, addicted to alcohol or drugs or those with psychiatric problems and/or unrealistic expectations were excluded.

Surfaces of the test implants were treated by UV irradiation (180-300 nm) with a processing time of 12 min, using the TheraBeam® SuperOsseo Device immediately prior to implant placement. Implant stability quotient was measured by the Osstell ISQ Device using resonance frequency analysis (RFA). A Smart Peg® (Osstell) was attached to the implant in order to be used in combination with the abovementioned meter. Resonance frequency was calculated as an ISQ value, on a scale from 0 to 100.

Cone beam computed tomography (CBCT) scans were used to evaluate available bone volumes and to determine a patient's eligibility for study participation. Patients who met the inclusion/exclusion criteria and signed the informed consent form took 2.0-g Augmentin (in case of allergy, 600 mg clindamycin) 1 h before surgery for antibiotic prophylaxis.

Prior to the surgical intervention, patients rinsed with 0.2% chlorhexidine for 1 min to reduce microbial count. Local anesthesia was applied at the discretion of the dental surgeon. All implants were inserted by a single surgeon using exactly the same surgical procedure. Drilling protocols and surgery followed manufacturer's recommendations and were the same for each implant, irrespective of the particular bone quality or location (800 rpm, no taping). No augmentation procedures were performed.

After a crestal incision, a mucoperiosteal flap was elevated. Implants were inserted with a calibrated drilling device combined with a calibrated contra-angle handpiece with an automatic torque control and integrated RFA module. To avoid any calibration problem, the same handpiece was used for all patients. The same staff member recycled and sterilized the handpiece using the identical process. Implants were placed epicrestally with the appropriate insertion tool.

The same tool was used with the Implantmed contra-angle handpiece for Removal Torque (RT) assessment. The RT was limited to a maximum torque of 80 Ncm to avoid mechanical alteration of the implants. Immediately after implant placement at time point one (T1), ISQ and peak RT were gauged.

Test and control implants were of identical diameter and length in each patient and were placed in the same jaw to minimize the risk of bias due to different bone density in maxilla and mandible. After RT testing, the implant was returned to its former position and a healing abutment was placed. Finally, healing abutments were inserted and the mucoperiosteal flap was repositioned and sutured.

Patients were instructed about postsurgical care (1.0 g of amoxicillin or 300 mg clindamycin respectively as antibiotics of second choice twice a day for 1 week, a soft diet was recommended for 1 week, rinsing twice a day with chlorhexidine for a period of 14 days, ibuprofen 400 mg twice a day in case of pain). To ensure healing without any functional load, occlusion was checked.

After a certain healing time (time point T2), the healing abutments were removed; ISQ and RT values of test and control implants were recorded at 1 week (group 1), 2 weeks (group 2), 3 weeks (group 3), 4 weeks (group 4), 6 weeks (group 5), and 8 weeks (group 6). The force to retrieve the implants was limited to 80 Ncm as described above. After RT assessment, the implants were returned to their original position and left for open healing.

RESULTS

Postoperative healing was uneventful in all patients; all implants finally osseointegrated and no implant was lost. No mechanical damage to implant components was observed.

Twenty patients had to be excluded from the analysis due to protocol deviations (test and control implants placed in different jaws). The mean age of the whole patient sample was 50.65 years. One hundred eleven patients were female and 69 patients were male.

There was no significant difference between the six groups with regard to age and gender. The majority of the patients were non-smokers ($n = 128$, 71.1%); 50 (27.8%) patients declared consumption of ≤ 10 cigarettes per day, whereas only two patients (1.1%) consumed more than ten cigarettes per day.

There was no statistically significant difference concerning the smoking habits between all groups (chi-square test, $p = 0.894$). Forty-eight participants from the female group (43.2%) had premenopausal status, whereas 63 female patients (56.8%) were in a postmenopausal state. No statistically significant difference was recorded between all the groups (chi-square test, $p = 0.786$).

The total number of fixtures was 360, out of which 142 implants (71 test and 71 control implants) were inserted in the maxilla (39.4%) and 218 (109 test and control) were placed in the mandible (60.6%). In both the test and control group, the majority of the implants were inserted in the posterior part of the dental arch. The machine used in this clinical study was set at 80 Ncm reverse torque as a maximum to prevent mechanical damage to the implants (RTmax).

The frequency of occurrence of reaching RTmax was calculated for each group and point in time. At time point T1, there were no significant differences between the test and control implant for all groups (McNemar test, $p \geq 0.05$). At T2, however, a significant difference was seen in group 3 (McNemar test, $p = 0.008$). The limit of 80 Ncm was reached, a total of 63 times in the test group and 43 in the control group.

Comparing the amount of measurements above 80 Ncm between T1 and T2 for the test implant, there was a significant change for the test implant in groups 1, 2, and 4 ($p < 0.05$). In groups 3, 5, and 6, however, there was no significant change ($p \geq 0.05$).

Comparing the amount of RTmax values for the control implants T1 versus T2, the statistical test was not applicable in groups 1, 2, and 5 as the tables were non-symmetrical. For groups 3 and 4, no significant changes were revealed. However, the amount of measurements above 80 Ncm was significant for group 6 ($p < 0.001$).

The statistical analysis showed that there is a strong correlation between the insertion torque and the removal torque at time point T1 for all groups and equally for test and control implants At the later time point (T2), there was only a small correlation between the original insertion torque (at T1) and the removal torque applied at T2 ($R = 0.2$, $p < 0.05$).

CONCLUSION

The authors concluded that Photo-activating (PA) the surface of titanium implants leads to higher resistance to RT forces compared with that of non-treated implants, showing higher implant stability especially in the early healing phase. Additionally, they found that Photo-activation results in an increased speed of osseointegration.

Implications for practice

This trial has provided evidence that the use of PA leads to greater implant stability. The RT test seems to be a suitable method for the measurement of implant stability during the healing phase in humans.

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1. Puisys A, Schlee M, Linkevicius T, Petrakakis P, Tjaden A. Photo-activated implants: a triple-blinded, split-mouth, randomized controlled clinical trial on the resistance to removal torque at various healing intervals. Clinical oral investigations. 2019; Sep 11: 1-11.

Do the CPD questionnaire on page 339

The Continuous Professional Development (CPD) section provides for twenty general questions and five ethics questions. The section provides members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure continuing education. The importance of continuing professional development should not be underestimated, it is a career-long obligation for practicing professionals.

Online CPD in 6 Easy Steps

1 Go to the SADA website www.sada.co.za.
2 Log into the 'member only' section with your unique SADA username and password.
3 Select the CPD navigation tab.
4 Select the questionnaire that you wish to complete.
5 Enter your multiple choice answers. Please note that you have two attempts to obtain at least 70%.
6 View and print your CPD certificate.

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Maxillofacial Radiology 182

SADJ July 2020, Vol. 75 No. 6 p333

CJ Nortjé

This eighteen year old female presented at the department with the main complaint of a swelling in the lower right mandible which developed over a period of twelve months (Fig. 1 & 2). She did not experience much pain but felt uncomfortable sleeping on her right side. What are the important radiographic features and what is your provisional diagnosis. An appointment was made for her to return so that a biopsy could be done but she only returned twelve months later.

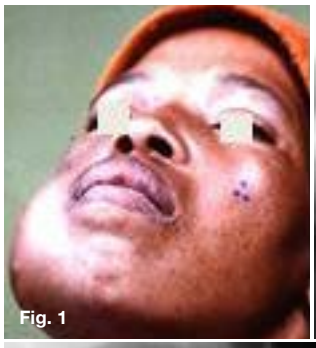
Fig. 1

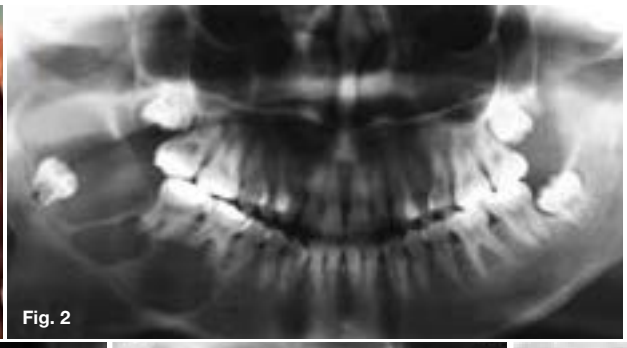
Fig. 2

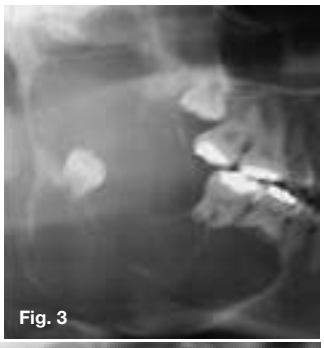
Fig. 3


Fig. 4

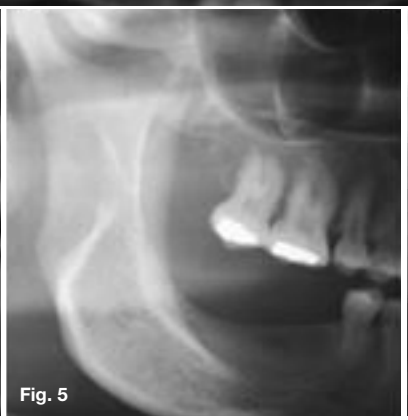
Fig. 5


Fig. 6

INTERPRETATION

Figure 3, is a pantomograph of the same lesion 24 months after lesion originally presented showing an increase in size. The Images of the lesion (Fig. 2&3) also changed dramatically from a classical multilocular appearance to a more expansive lesion with advanced resorption of the roots of 46 & 47. Extra oral examination revealed a diffuse hard swelling measuring approximately 4 cm × 3 cm. On intraoral palpation there was expansion of buccal and lingual cortical plates. A biopsy was done and multiple sections of the biopsy specimens were studied histologically. The clinical and radiological features especially the presence of root resorption indicated the possibility of an ameloblastoma; however the histological features was not pathognomonic. The other problem was that the patient belonged to a religious group which do not allow any form of blood transfusion. Many ameloblastomas can only be successfully treated by resection which normally would mean that a blood transfusion would be part of surgery protocol. In this specific case it was decided that an exceptional conservative treatment approach would be applied under the circumstances. Decompression and packing with BIPP paste were done to prevent pathological fracture (Fig. 4) After 6 months enucleation with curettage was done and an incisional biopsy revealed the presence of a unicystic ameloblastoma. Regular follow up were carried out on a yearly basis, Figure 5 is a cropped pantomograph two years after the enucleation showing normal healing and no signs of recurrence of the lesion. The cropped pantomograph (Fig. 6) was taken fifteen years after she presented at the department showing complete healing and remodelling of the unicystic ameloblastoma. Unicystic ameloblastoma refers to those cystic lesions that show clinical, radiographic or gross features of a jaw cyst but on histologic examination show a typical ameloblastomatous epithelium lining the cyst cavity, with or without luminal and/or mural tumour proliferation unicystic ameloblastoma is a less encountered variant of the ameloblastoma and believed to be less aggressive. Moreover, recurrence of unicystic ameloblastoma may be long delayed and a long-term post-operative follow up is essential for proper management of these patients.

Christoffel J Nortjé: *BChD, PhD, ABOMR, DSc.* Faculty of Dentistry, University of the Western Cape.
ORCID Number: 0000-0002-9717-5514
Email: cnortje@uwc.ac.za

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The renaissance of virtue ethics and its application in dentistry

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HD Miniggio[1], PD Motloba[2], CS Wareham[3]

ABSTRACT

Virtue ethics, an ethical theory that focuses on concepts of how to live a good life and the characteristic traits or virtues of individuals, has enjoyed increasing popularity and considerable re-emergence in ethical assessment in various healthcare disciplines.

This popularity is, in part, attributable to its contrasting approach to the more formalized rule-based approaches to ethical assessment in healthcare practice.

The formalization of ethical healthcare practice (presented as the four principles of autonomy, beneficence, non-maleficence and justice) coupled with various codes of ethics, has led to a considerable focus and reliance on rules and obligations.

A significant limitation of this type of approach arises from the difficulty in choosing which principle takes greater priority, in cases in which two or more principles are in conflict. What is more, in this rule-oriented approach, motivations of individuals, characteristic traits and relationships, which are important aspects in ethical deliberations, have taken a back seat.

Against this background we describe and propose the incorporation of a virtue ethics approach, with a focus on the character and motivations of the individual or agent, as part of ethical deliberations in the practice of dentistry.

Author affiliations:
1. **Hilde D Miniggio:** *BDS (UMF, Cluj-Napoca), MScMed (Bioethics and Health Law) (Wits), PGDip (Health Sciences Education) (Wits)* Senior Lecturer, Department of Oral Pathology and Oral Biology, Sefako Makgatho Health Sciences University, South Africa.
2. **Pagollang D Motloba:** *BDS, MPH (Epid), MDent (Comm. Dent), MBL,* Head, Department of Community Dentistry, School of Oral Health Sciences, Sefako Makgatho Health Sciences University, South Africa.
   ORCID Number: 0000-0003-1379-7576
3. **Christopher S Wareham:** *BA Hons (Rhodes), MA (Rhodes), PhD (Milan),* Senior Lecturer, Steve Biko Centre for Bioethics, School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand, South Africa.

Corresponding author: Hilde D Miniggio
Department of Oral Pathology and Oral Biology
Sefako Makgatho Health Sciences University, South Africa
Email:hilde.miniggio@smu.ac.za

Author contributions:
1. **Hilde D Miniggio:** Conceptualization, first draft, revision, final write-up and final approval - 60%
2. **Pagollang D Motloba:** First draft, revision, final write-up and final approval - 20%
3. **Christopher S Wareham:** First draft, revision, final write-up and final approval - 20%

INTRODUCTION

Traditionally, ethical analysis in the practice of medicine has been approached from a rule-based viewpoint. This has encouraged an action-oriented ethical analysis, often to the detriment of character, professional conduct and judgement of healthcare practitioners.

> *It is now widely acknowledged that not everything that is important in professional life can be captured by codes of conduct and that professionalism goes beyond ethical principles.*[1]

Similarly, the prevailing approach in discussions pertaining to ethical issues that arise in the context of dental practice is principle-based, otherwise known as rule-based.

The principle-based approach guides ethical reasoning by focusing on what actions a moral agent should take. Aspects of internal motivations, character of the healthcare practitioner and professional judgement do not form part of this rule-based approach.

This is a shortcoming since these aspects assist the healthcare practitioner to "[interpret] the principles, [select] the ones to apply or ignore, [put] them in order of priority, and [shape] them in accord to his life history and current life situation".[2] Furthermore, virtue ethics also makes room for the incorporation of emotions as an "integral and important part of our moral perception".[3]

Given the essential role of these aspects in the moral decision-making process, it is surprising that so little attention focuses on these in dental ethics literature. We propose the incorporation of virtue ethics, as part of ethical reflections in the practice of dentistry in conjunction with the four principles. Dental practitioners would, in this way, be better equipped to address ethical issues pertinent to dental practice.

For the purpose of this article, we limit our discussion to aspects of virtue ethics advanced by Aristotle, Alasdair MacIntyre and Edmund Pellegrino. Similarly, from the several virtues which have been proposed as being important in the healthcare context, we restrict our focus to the virtues advanced by Beauchamp and Childress; we argue that these virtues have significant application to the dentist-patient relationship and assist in furthering the goals of the practice of dentistry.

We begin with an exploration of Aristotle's notions of virtue ethics and Alasdair MacIntyre's concept of a practice with goods specific to it. We then briefly explore how virtues are linked to those goods. We also evaluate Edmund Pellegrino's concepts of a morality that is inherent to healthcare practice with a focus on the goals specific to healthcare practice. An exploration of these concepts is significant in understanding virtue ethics theory as it was originally intended, and understanding how these original concepts have subsequently been applied in ethical deliberations in healthcare.

Virtue ethics

"When it comes to moral theories, virtue ethics is the old new kid on the block".[4] Our exploration of virtue ethics begins with the 'old' or original concepts of *eudaimonia*, doctrine of the mean and *phronésis*. For Aristotle, all human beings have a final purpose; not only, do all human beings have a final purpose but in fact, all human beings strive to achieve this final purpose.[5] For Aristotle, this final purpose is to achieve a state of *eudaimonia*, generally translated as happiness or fulfillment.[5]

Aristotle proposes that *eudaimonia* or fulfillment is the highest good for human beings, and as such, it is chosen as an end in itself.[5] He further considers that living a fulfilled life requires specific human excellences which he differentiates into intellectual excellences or wisdom (*sophia*) and practical excellences or wisdom (*phronésis*).[5]

A fulfilled life, in turn, is achieved by habitually exercising certain moral virtues. A moral virtue is an "acquired habit or disposition to do what is morally right or praiseworthy".[6]

Aristotle suggests that virtues can be taught and that exercising a virtue occasionally does not make a virtuous agent, thus virtues must be exercised routinely throughout one's life.[5] For Aristotle, a moral virtue is a praiseworthy character trait that is found between two extremes which can be explained by his concept of the doctrine of the mean.[5] If we apply the doctrine of the mean to, for example the virtue of courage, we see that the virtue can be found between the two extremes; that of rashness (too much courage) and that of cowardice (too little courage).[5] Practical wisdom (*phronésis*) then, is the virtue which assists the moral agent in choosing the appropriate action at the appropriate time.[5] This virtue is often translated as prudence.

But how can a virtue theory developed 2400 years ago, have applicability in ethical assessment in modern day dentistry? We will attempt to answer this question by exploring notions of virtue ethics related to the practice of medicine as advanced by a couple of contemporary ethicists writing on the topic in the field.

Virtue in practice

A virtue in the context of a practice, such as the practice of medicine, can be described as an "acquired human quality, the possession and exercise of which tends to enable us to achieve those goods which are internal to practices and the lack of which effectively prevents us from achieving any such goods".[7]

According to MacIntyre, a practice can be defined as "any coherent and complex form of socially established cooperative human activity, through which goods internal to that form of activity are realised in the course of trying to achieve those standards of excellence which are appropriate to, and partially definitive of, that form of activity, with the result that human powers to achieve excellence (virtue) and human conceptions of the ends and goods involved, are systematically extended".[7]

Internal goods are in turn "defined by each particular practice and recognized by the experience of participating in the practice in question".[7,8] The concept of internal goods, refers to those goods which can only be achieved as part of being directly involved in that particular practice; the concept of external goods, refers to those goods that can be achieved within the practice as well as outside of the practice or in many other types of practices or activities.[7]

Examples of external goods, are financial benefit and a certain standing in society.[7] The internal goods in the practice of medicine are considered to be the doctor-patient relationship and technical competence.[7] MacIntyre considers that the internal goods in a practice can only be achieved through the exercise of certain virtues which lead to the attainment of those internal goods, specific to the practice.[7]

Pellegrino similarly applies the concept of practices to medicine in the particular sense that MacIntyre proposes, and considers that the practice of medicine is guided by specific goals that are particular to the practice. Pellegrino deems both principled-based ethics and virtue-based ethics as being inadequate, on their own, for ethical deliberations in healthcare and advances the integration of both principles and character in such deliberations.[2]

Furthermore, he considers that the doctor-patient relationship is unique as it "centres on a vulnerable, anxious, dependent, often suffering individual person".[2] This relationship embodies a certain inherent morality to the practice of medicine and through this unique relationship the goals of medical practice are determined and achieved.[2] For Pellegrino, the practice of medicine is a moral practice due to the "nature of illness, the non-proprietary nature of medical knowledge, and the nature and circumstances of a professional oath".[2] Pellegrino suggests that the goal of medical practice is "the good of the patient" and considers that both the doctor and the patient must jointly work towards this goal and that virtues lead to the realization of that goal.[2]

> *The practice of medicine, thus, flourishes most when virtue is pursued by a community of practitioners.*[2]

Amongst the chief virtues, which date back to the time of Socrates, Aristotle and Plato and traditional Christian theology are temperance, courage, justice and prudence.

From these virtues, of particular relevance is the virtue of prudence which "emphasizes long term goals, good judgement in the face of uncertainty, and overcoming shortsighted choices" which "not only provides order for the principles, but also provides order for other virtues".[9]

While there is no specific nor exhaustive list of virtues applicable in healthcare practice, and several virtues have been proposed, the virtues that have particular relevance in healthcare practice have been designated by Beauchamp and Childress as, **compassion**, **trustworthiness**, **integrity**, **discernment** and **conscientiousness**.[10]

The continuous exercise of these virtues in the relationship with patients leads to the development of a virtuous character; a virtuous character is characterized by Meara et al. as one who:

- *is motivated to do what is good.*
- *possesses vision and discernment.*
- *realizes the role of affect or emotion in assessing or judging proper conduct.*
- *has a high degree of self-understanding and awareness.*
- *is connected with and understands the mores of his or her community and the importance of community in moral decision making.*[11]

Importantly, "virtuous agents are motivated to do what is right and have developed traits or dispositions or motivations to act in accordance with high ethical standards or ideals".[11] Virtue ethics thus teaches us that we are all capable of becoming virtuous, by learning and routinely practicing virtues, which will ultimately define our moral character.

We now apply MacIntyre's concept of a practice and Pellegrino's view of medical practice, which aims at a specific goal, in the context of dentistry. We also propose that the virtues identified by Beauchamp and Childress as being essential in medical practice, are valuable in ethical decision making in dentistry.

Virtue ethics in dentistry

At this point we would like to point out that certain characteristic traits, or virtues, such as compassion and integrity, are mentioned in the ethics literature as being "core values of dentistry" and these are considered to "serve as the foundation of dental ethics".[12] However, these virtues are not presented, nor discussed within the broader context of a virtue ethics theory and as such, lose their intended meaning and application.

We now turn our attention to discuss dentistry as a practice as advanced by MacIntyre. Dentistry corresponds well with MacIntyre's definition of a practice, namely "a coherent and complex form of socially established cooperative human activity" which leads to the attainment of certain goods internal to the practice.[7]

If we consider dentistry as a practice in the sense defined by MacIntyre and the goal of dental practice as being in line with the goal of medical practice, then the goal of dental practice can be considered as *the good of the patient in relation to promoting, maintaining and restoring oral health*. Furthermore, as a practice, dentistry has internal goods, through which the goals of the practice are achieved. We suggest that the internal goods in the practice of dentistry in the sense that MacIntyre proposes, are technical competence and the dentist-patient relationship.

Patients are dependent on the technical expertise of dental practitioners for reasons ranging from pain relief to oral health rehabilitation and disease prevention.[12] The dentist-patient relationship is a significant internal good of dental practice which hinges on trust. Trust is essential in this relationship, as patients accept certain physical intrusions by having portions of their bodies examined and treated by dental practitioners.[12]

They allow such intrusion "because they trust their dentists to act in their best interests".[12] In other words, they trust the motivations of dental practitioners. Furthermore, as part of the consultation process, patients often disclose personal and private information to the dental practitioner, and trust that this sensitive information will not be divulged to others.[12]

All these aspects render patients vulnerable and dependent on the character and motivations of the dental practitioners. Additionally, trust is important in the patient-dentist relationship as dentists usually make use of their technical skills to earn a livelihood, thus there can be a "potential tension" between the commercial interest of dentists and the best interest of the patient.[12] The character of the dental practitioner safeguards against the possible exploitation of vulnerable patients.

We argue that a **compassionate** and **trustworthy** dental practitioner, who displays high levels of **integrity**, **discernment** and **conscientiousness**, will safeguard the trust that patients place in the dental practitioner as well as in the dental profession, and advance *the good of the patient in relation to promoting, maintaining and restoring oral health.*

In the sections to follow we explore these virtues in more detail and provide an overview of certain contexts in which these virtues can assist dental practitioners in the decision-making process.

Let us now consider how virtue ethics, could assist dental practitioners when faced with ethical challenges that arise in those cases where patients make inappropriate treatment choices; choices which are clearly not in their best interest. Such inappropriate treatment choices may be less costly and less procedurally cumbersome in the short term, to the detriment of the oral health of the patient and increase in cost in the long term.

This can cause a difficult ethical dilemma and considerable frustration for the dental practitioner. In such cases, the application of the principle-based approach offers insufficient guidance. In trying to apply the principled-approach to this scenario, we remark that the principle of autonomy (in this case, the right of the patient to make informed decisions regarding their oral healthcare) is in conflict with the principle of beneficence (in this case, acting for the good of the patient). The question arises, should the dental practitioner choose to respect the patient's autonomy or are considerations of beneficence more important? We note that, when faced with ethical dilemmas that arise from the conflict of two or more principles, the principle-based approach does not offer clear guidance as to how the conflict should

be solved. In such cases, the dental practitioner is then further required to make use of either intuition or reach out to other ethical theories in order to come to a resolution.

In such an ethical dilemma, in which principles are at odds and the dental practitioner is uncertain which principle has greater importance, virtue ethics is helpful by encouraging a broader and more flexible evaluation of the situation.

From a virtue ethics standpoint, the virtue of **compassion** is one which refers to "an active regard for another's welfare with an imaginative awareness and emotional response of deep sympathy, tenderness and discomfort at another's misfortune or suffering".[10] In this scenario, the dental practitioner has an emotional response to the situation, seeing that the inappropriate treatment choice might negatively affect the oral health of the patient in the long term. Applying the virtue of compassion in this case assists the dental practitioner to respond with sympathy and active regard for the particular circumstances of this case.

The virtue of **compassion** compels the dental practitioner to understand that, while it is ultimately the right of the patient to make informed decisions regarding their oral treatment, the patient may at times have difficulty with the treatment decision. Such treatment decisions might be, for example, based on irrational fears regarding certain procedures or previous bad experiences with similar procedures, or misconceptions regarding the consequences thereof. If the inappropriate treatment decisions are made due to such external factors, the dental practitioner is in a position to help in alleviating such fears and misconceptions.

On the other hand, if the treatment choice is based solely on financial concerns, the virtue of compassion would compel the dental practitioner to have regard for the welfare of the patient and attempt to find creative solutions to balance the financial constraints with the good of the patient.

Compassion thus compels the dental practitioner to create a conducive environment in which a comprehensive discussion and collaboration can take place. A compassionate response to this dilemma would also entail affording the patient time to reflect on his or her decision regarding treatment options. Such a compassionate response leads to a holistic interaction between the dental practitioner and the patient, in which the collaborative decision can be made and the goals of the practice achieved.

The virtue of **trustworthiness** is also valuable in this scenario. Trustworthiness is considered the "cornerstone of the doctor-patient relationship".[12] In this case building trust with the patient allows for meaningful collaboration in regards to common decision making that serves in the best interest of the patient.

Integrity refers to the "quality of being honest and fair".[13] Honesty and fairness represent essential components of the dental practitioner-patient relationship as patients are dependent on the dental practitioner and in this vulnerable position, patients become easily exploitable.

Honesty in this case would go a long way in managing patient expectations and being forthright about the outcomes and possible complications of the various treatment options.

The virtue of **conscientiousness** is "governed by or conforming to the dictates of conscience".[13] In this case, conscientiousness leads to a concern regarding the consequences to the oral health of the patient as treatment options chosen by the patient might not in his or her best interest.

Discernment is the virtue that "brings sensitive insight, understanding and wise judgement to the situation".[13] Wise judgement and sensitive insight are important aspects that sensitizes the dental practitioner to the predicament that some patients might find themselves in when their oral healthcare choices are influenced by external factors.

The virtues of compassion, trustworthiness, integrity, discernment and conscientiousness in this case can assist the dental practitioner in solving the conflict between the principles of autonomy and beneficence. Once the dilemma is viewed from a holistic standpoint which takes into account the individual needs of the patient coupled with the motivation to improve the oral health of the patient, a decision can be made in regards to which principle is more significant.

For instance, if the treatment decision is made out of fear of the treatment procedure, the compassionate dental practitioner can take steps to alleviate any unfounded fears, thereby acting in the interest of beneficence. If, however, the treatment option is chosen in the absence of external influences, and after ensuring that the patient understands the consequences thereof, the principle of autonomy takes preference.

The application of these aforementioned virtues can similarly be of value when, for example, dealing with ethical issues that may arise from patient non-compliance and difficult patients, which can negatively impact on the oral health of these patients and thus on the goal of dental practice.

The development and continued exercise of these virtues advances the goals of dental practice and encourages professional judgement in the moral decision making process. Furthermore, these virtues can assist in balancing and choosing between competing principles in ethical issues that arise in dental practice. These virtues are significant in understanding the needs of individual patients and making use of sensible judgement when faced with conflicting ethical interests in dental practice.

A virtuous dental practitioner is able to identify and be sensitive to the various oral healthcare needs and circumstances of individual patients, which goes a long way in improving patient satisfaction and treatment compliance thereby advancing the goals of dental practice.

In sum, virtue ethics is helpful in providing a more holistic and varied approach to ethical dilemmas encountered in dental practice. This is because the whole character of the dental practitioner takes center stage in this type of approach including the internal motivations.

Such an approach means that the dental practitioner "is not simply an inanimate observer in the process of ethical deliberation" but rather the "living body of ethical practice".[4] Ultimately it is the character and motivations of the dental practitioner that guides the ethical decision-making process.

Virtue ethics provides dental practitioners with an additional tool that assists them when solving ethical dilemmas for which the principle-based ethical approach canot provide an answer.

CONCLUSION

"Virtue ethics calls upon individuals to aspire towards ideals and to develop virtues or traits of character that enable them to achieve these ideals".[10] Virtue ethics recognizes the importance of the development of healthcare practitioners' character, which provides the foundation for professional judgement and ethical behavior.

Through an effective dentist-patient relationship based on trust and mutual collaboration, coupled with competence in technical expertise, the goals of the practice of dentistry can be achieved. The incorporation of a virtue ethics approach provides dental practitioners an additional tool for solving ethical issues in dentistry in conjunction with the four principles.

When faced with ethical dilemmas, dental practitioners can make use of the virtue ethics approach which highlights the importance of character in the decision making process and incorporates the question, what type of dental practitioner should I be, as part of the ethical assessment. Such an approach makes room for the incorporation of virtues as part of the ethical assessment of issues pertaining to dental practice, which has, for many years been overlooked.

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CPD questionnaire

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GENERAL

Throughputs of two cohorts of dental students at Sefako Makgatho Health Sciences University: A comparison

1. Identify the CORRECT answer. The following is/are determinants of university dropout and delayed graduation:
   A. Students' characteristics, abilities and behaviour
   B. Parental background and family networks
   C. Characteristics of tertiary education system and institutions
   D. Labour market conditions
   E. All of the above

2. Identify the CORRECT answer. In what year was Sefako Makgatho Health Sciences University (SMU) founded?
   A. 2004
   B. 2005
   C. 2006
   D. 2010
   E. None of the above

3. Identify the CORRECT answer. By what percentage did the number of dentists registered with HPCSA increase during the period 2002 to 2015?
   A. 1%
   B. 2%
   C. 5%
   D. 7%
   E. 10%

Comparison of three different instruments for orthodontic study model analysis

4. Identify the CORRECT answer. What were the instruments used to conduct the study?
   A. Boley Gauge
   B. Vernier Calliper
   C. Carestream CS 3600
   D. None of the above
   E. All of the above

5. Identify the CORRECT answer. The standardised reference points used during the measuring process of the intermolar width were made on the?
   A. Mesiopalatal cusp
   B. Mesiobuccal cusp
   C. Distopalatal cusp
   D. Distobuccal cusp
   E. None of the above

6. Identify the CORRECT answer. A statistically significant difference was found when the measurements of the three instruments were evaluated for?
   A. Maxillary intercanine width (tooth 13 – 23)
   B. Maxillary intermolar width (tooth 16 – 26)
   C. Mesio-distal width of tooth 11
   D. Mesio-distal width of tooth 46
   E. Mesio-distal width of tooth 41

The effect of off-axis seating on the marginal adaptation of full coverage all ceramic crowns

7. Identify the CORRECT statement. The luting space in a milled crown is:
   A. the space between the margin of the crown and the margin of the tooth after cementation
   B. automatically created by the milling machine
   C. a space created on the inner surface of a full crown for the luting cement
   D. added to the virtual preparation before designing the crown

8. Identify the CORRECT statement The marginal gap in a full crown:
   A. should not occur after cementation
   B. can be up to 200µm in size
   C. is larger when measured in three dimensions rather than in two
   D. is the gap between the crown and the tooth before cementation

9. Identify the CORRECT statement. If a crown is seated off-axis when cementing by seating it with a tilt to the buccal:
   A. There will be no effect on the marginal gap
   B. There are likely to be occlusal interferences after cementing
   C. The marginal gap will be greater on the buccal side
   D. None of the above

Perforation of the palate - A report of two Syphilitic Gumma cases

10. Identify the CORRECT answer. Which of the following stages of Syphilis may present in the oral cavity?
    A. Primary Syphilis
    B. Secondary Syphilis
    C. Latent Syphilis
    D. Tertiary Syphilis
    E. All of the above

11. Identify the CORRECT answer.
Clinical signs of Syphilis may include:
A. presentations of ulceration (chancre) at the site of infection,
B. lymphadenopathy
C. mucocutaneous rash
D. Pathological fracture
E. A, B and C only

12. Identify the CORRECT answer. Management of tertiary syphilis may include:
A. Penicillin and tetracycline
B. Palatal obturators
C. Preventative advice and education
D. Management of underlying medical condition
E. All of the above

Calcific Metamorphosis: A review of literature and clinical management

13. Identify the CORRECT answer. Teeth with Calcific Metamorphosis usually present with which of the following clinical or radiographic appearance?
A. Full or partial canal obliteration
B. Percussion sensitivity
C. Acute apical periodontitis
D. No clinical or radiographic abnormalities
E. All of the above

14. Identify the CORRECT answer. In which of the cases presenting with calcific metamorphosis is the incidence of periapical pathology higher?
A. Cases with a dark yellow discoloration
B. Cases with a grey discoloration
C. Cases with no colour change
D. Colour presentation has no influence on incidence of periapical pathology

15. Identify the CORRECT answer. In which direction does calcification of root canal systems usually progress?
A. From the largest part of canal to the canal extremities
B. From apical to coronal
C. Simultaneously from both sides
D. From coronal to apical

Visual assessment is no substitute for radiographic analysis - A forensic case report

16. Identify the CORRECT answer. Biological age estimation utilising the developing dentition has the following application(s) in dentistry.
A. To determine the appropriate timing of orthodontic treatment
B. Forensic identification of deceased individuals
C. To analyse disturbed growth relative to the general population
D. All of the above

17. Identify the CORRECT answer. At what age do the first permanent molars emerge in the oral cavity?
A. 4 years of age
B. 5 years of age
C. 6 years of age
D. 7 years of age

18. Identify the CORRECT statement.
The following factor(s) can have an influence on the dental developmental stage:
A. Sex
B. Ethnicity
C. Developmental disturbances
D. Age
E. All of the above

Clinical Window: What's new for the clinician?

19. Identify the CORRECT answer. In the de Oliveira et al. trial, for the outcome postoperative sensitivity:
A. The Self-adhesive resin composite group performed better
B. Conventional resin composite group with a self-etching bonding agent has less sensitivity
C. Both groups had similar sensitivity scores
D. None of the above

20. Identify the CORRECT statement. In the The Puisys et al. trial, Photo-activating (PA) the surface of titanium implants led to:
A. higher resistance to Removal Torque forces compared with that of non-treated implants
B. hower resistance to Removal Torque forces compared with that of non-treated implants
C. higher resistance to Removal Torque forces compared with that of PA treated implants
D. lower resistance to Removal Torque forces compared with that of PA treated implants

ETHICS

The renaissance of virtue ethics and its application in dentistry

21. Identify the CORRECT statement.
Identification using dental records:
A. cannot be used for badly burnt bodies
B. cannot be used in mass disaster situations
C. cannot be used for murder victims
D. may make use of hand written notes

22. Identify the CORRECT statement. Internal goods in healthcare refers to:
A. financial benefit
B. a high standing in society
C. the doctor-patient relationship
D. prestige

23. Identify the CORRECT statement. The concept of *eudaimonia*, proposed by Aristotle refers to:
    A. practical wisdom
    B. courage
    C. compassion
    D. fulfillment

24. Identify the CORRECT statement. One of the virtues identified by Beauchamp and Childress as being essential in medical practice is:
    A. compassion
    B. courage
    C. humility
    D. open mindedness

25. Identify the CORRECT statement.
    The principle-based approach focuses on:
    A. the character of the moral agent
    B. the actions of the moral agent
    C. the internal motivations of the moral agent
    D. the virtues of the moral agent

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Does the paper adhere to the format requested in Instructions to Author?	☐
Are the references quoted according to Journal policy, both in the text and in the list of references?	☐
Have all authors signed the Letter of Submission?	☐

Smalls advertising and placement procedure

- All smalls advertisements are restricted to a **maximum 100 words** per advertisement.
- All advertisement requests are required in writing, **submit to abayman@sada.co.za**, with full contact details of the advertiser which should include:
  - the wording of the advertisement as you require it to be published;
  - the members professional number; (will not be published);
  - the members contact details (will not be published).
- Advertisement **lifespan is two weeks** from the date of upload.
- Advertisements to be **repeated follow the same process** as the original placement request.
- All advertisements which **exceed a word count of 100** words will be forwarded to our **publishers E-Doc** for further processing as a potential advertisement to be placed in the SADJ electronically or as website advertising. E-Doc will contact you thereafter regarding your requirements.
- **SADA Members** may place advertisements at no cost providing their annual membership fees are either paid in full at the time of their request of a debit order request has been lodged.
- **Non-SADA Member** advertisers will be charged R25 per word for placement of their advertisements.
- Advertisement must be paid in full prior to uploading on the web platform.
- Invoice may be settled telephonically with the use of a credit card to prevent delay of placement.
- **Telephonically processed** payments will result in uploading of advertisement within **24 hours** of settlement.
- Advertiser remains liable for placement costs should payment be dishonoured and invoice remains unpaid.

Contact details:
Ann Bayman
South African Dental Association
Tel: +27 (0)11 484 5288
Email: abayman@sada.co.za

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THE SOUTH AFRICAN DENTAL ASSOCIATION

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