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- Liquid-Supported Dentures: A Soft Option—A Case Report
- Fractographic Analysis of a Dental Zirconia Framework: a Case Study on Design Issues
- Comparison of immediate complete denture, tooth and implant-supported overdenture on vertical dimension and muscle activity

SADTJ

The Southern African Dental Technology Journal

CEU

Invitation to write articles and case presentations

The Southern African Dental Technology Journal invites all dental technicians/technologists and dentists, who have original articles or case presentations to submit their work. The SADTJ is a peer review publication, and all original articles will be reviewed by our Associate Editors. Do not let this scare you off, you will receive constructive criticism and suggestions on how to improve your writing, should your article not be published the first time round.

Length of Manuscripts:

- Technical Article: 1500-2000 words and 15-20 photos or diagrams. These articles should be up-to-date accounts of interesting and noteworthy developments in techniques. They should be case specific and engage the intermediate and advanced-level technologies as well as new techniques. Articles should give step by step information on how to do something, but also provide insight on the why and how of a particular technique or product. Please include a 10 question, multiple choice quiz, about the contents of the article, when submitting a technical article. All technical articles submitted to the journal must be written or co-written by a Certified Dental Technician, a foreign technician with a SADTC approval to work in South Africa, or a dentist.
- Photo Technical Article (Case presentation): 1000 words maximum and 10-26 photos. These articles should be up-to-date accounts of interesting and noteworthy developments in techniques. This kind of article is usually a case presentation sharing tips or a quick technique with others. The photos should be accompanied by a written explanation (maximum 1000 words) of how the final results were accomplished.
- Research Article: 6000 words. Here the criteria of intelligibility and wider interest are strictly applied.
- Review Articles: up to 6000 words long. These articles should be up-to-date surveys of important current developments in dentistry.
- News Articles: 250-700 words, photos optional. We are interested in all news-worthy events that involved or impact dental technicians, or their laboratories. Please keep us up to date so we can share the news.

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- Include a photograph of the authors as well as a short biography.
- Include copies of the completed authors release form, conflict of interest and photo release forms with the submission, of your article.
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Presentation of Content:

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- Number each page clearly.
- No footnotes will be allowed.
- Keep your presentation clear and simple.
- Tables, figures and images (including photographs), should be presented on a separate page at the end of the document, separate from other documents.
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STATEMENT OF INTENT

The Southern African Dental Technology Journal is published 3 times a year. The main objective of the Journal is to provide the professional with the opportunity to earn CEU's through completing the questionnaires, or writing articles. All papers in English, on any aspect of dental laboratory science or related disciplines, will be considered on merit and subject to the review of the editorial board and the CEU accreditation committee.

EDITORIAL, ADVERTISING AND COPYRIGHT POLICY

Axel Grabowski

APRIL 2013

Incredible, the New Year is already three months old and winter is on its way.

It has been a busy time for us, as the arrangements for the upcoming DENTASA Summit and AGM are well underway. As you are hopefully aware by now, the dates to mark on your calendar are the 1st and 2nd August 2014. The venue, Birchwood Hotel in Boksburg lends itself perfectly to this occasion. There is a free shuttle from O.R. Tambo International Airport to and fro from the Hotel. This cuts costs as the delegates that fly in, do not have to rent any transport.

It is very exiting that the keynote speaker is none other than the well known Mr. Mark Jackson from the U.S.A. He is very involved in the dental politics in America, and a renowned speaker. It will be of great interest to hear how they are dealing with the same problems that we are currently experiencing in South Africa, i.e. dentists owning milling machines and unregistered milling centres.

The interest shown by the supply houses to give their unequivocal support was heart-warming to say the least. It took all of two hours to rent out all available booths. Fantastic, and we want to thank them.

Good news too, over and above the McCarthy Group offer, is the fact that all graduates with a B-Tech degree can now join PPS.

All registered dental technicians who are paid up members of DENTASA, irrelevant of qualification, have the option of joining Prof-med Medical Scheme.

The SADTC elections are done and dusted, and we, the profession wish them well for their term of office. I will make this promise to DENTASA members, I will be very actively involved to ensure that all matters raised by you to Council, will not be swept under the carped, but will be addressed appropriately. I will attend each Council meeting in person, and keep an ear to the ground to ensure that you stay informed.
May this year be a profitable one for all, and may you enjoy reading this edition of the SADTJ as much as I did editing it.

Editorially yours,
Axel

POPI (The Protection of Personal Information Act) – How Will it Affect You and Your Business?

" This article first appeared in CA (SA) Dot News and is produced with the authority from Dot News and Du Toit Mook, Registered Accountants and Auditors ''

Technology has unleashed enormous power which has altered the way we live and do business. It brings with it concentration of data which is easily accessible. When this data affects private information, protections need to be built in. POPI (which was gazetted in November) is aimed at codifying the use of and the safeguarding of such information. This has substantial implications for business, particularly in the area of staff records. The fact that the Act imposes penalties of up to a R10 million fine or ten years imprisonment should further focus business.

- The Act in a nutshell Firstly, what is personal information? POPI defines this as including - a person'sname (including a juristic person e.g. a company), contact details, religion, sexual orientation, personal views, private correspondence, health records, employment records, financial records, biometrics (DNA, fingerprints) etc.

- Eight self-explanatory principles govern the Act:

1. Accountability
2. Processing limitation
3. Purpose
4. Further processing limitation
5. Information quality
6. Openness
7. Security
8. Right of access

- Further restrictions apply for the use of "special pe sonal information" like political affiliation or sexual orientation.
- A regulatory body known as the Info mation Regulator is to be established with the following powers and duties:-

  ¤ Search and seizure powers
  ¤ May impose administrative fines
  ¤ May sue on behalf of the subject
  ¤ Can decide if the law is being complied with
  ¤ Receives and acts on complaints
  ¤ May issue notices

Note that it is a criminal offence to make false statements to, or to not comply with notices from, the Regulator.

- POPI makes provision for cross-border uses of personal information
- In terms of direct marketing, there is a clause requiring opt-in. This is contrary to current laws where the norm is to require opt-out. This means permission must be sought from people whose information will be used, prior to direct marketing taking place. The only exception is in respect of existing customers/clients.
- Twelve month transition period – businesses have twelve months from commencement (whilst POPI has been passed into law, the President is still to determine a date from which it commences and becomes effective) to comply.

This transition period is going to be onerous on businesses. They need to determine what information falls into the Act, how it is used, protected, stored, who has access to it. Businesses will also need to get the relevant consents from staff and other stakeholders. What privacy statements do you need to make, what protocols do you need to put in place over your information and website?

As there are onerous penalties and these requirements concern the safety of your staff's (amongst other) information, it is well worth investing time and taking advice to get the right procedures in place now.

NOTE FOR ACCOUNTANTS: The Act is available via a link on SAICA's website.

Suggested Reading, see -
"Promulgation of Protection of Personal Informtion Act 4 OF 2013" on the DLA

Cliffe Dekker Hofmeyr website and "Overview of the Regulatory Framework" on the Bowman Gilfillan website.

RECORD RETENTION: PLENTY TO KEEP TRACK OF!

There are many statutory requirements to comply with. Each has its own period for keeping records. We have tried to simplify the most important ones in table format.

The following tables (largely adapted from tables obtained from SAICA and from CIPC) show record retention for:

- Companies and Close Corporations,
- Tax records,
- Staff records.

1. Companies/Close Corporations

COMPANIES/CLOSE CORPORATIONS			
No	Description	Retention Period Companies	Retention Period CCs
1	Accounting records, including supporting schedules and documentation relating to all accounting records	7 years	15 years
2	Registration Certificate/Founding Statement (CK1)	Indefinite	Indefinite
3	Memorandum of Incorporation and amendments/alterations. Amendments to Founding Statements (CK2, CK2A)	Indefinite	Indefinite
4	Annual financial statements	7 years	15 years
5	Minutes and resolutions of directors' (members') meetings and sub-committees	7 years	Indefinite
6	Rules	7 years	Indefinite*
7	Register of company secretary and auditors	Indefinite	Indefinite*
8	Microfilm of original record	7 years*	Indefinite
9	Shareholder meetings (including annual general meeting), resolutions and all communication with shareholders	7 years	See point 5 for CCs
10	Share register	Indefinite	CK2 above - indefinite
11	Regulated companies (subject to Takeover Regulations)	Indefinite	Indefinite*
12	Directors and past directors	7 years	Indefinite*
* = Not explicitly stated but makes sense as shown			

2. Tax

TAX - Part 1			
No	**Act**	**Description**	**Retention Period**
1	Income Tax	**Employer to keep employee records**: Remuneration paid Tax deducted Employee tax number Any other prescribed information EMP 501 (half yearly PAYE reconciliation)	5 years
2	Income Tax	**Micro Business to retain records of:** Annual turnover Dividends declared Every fixed asset with a cost in excess of R10,000 Liabilities at year end greater than R10,000	5 years
3	Tax Administration	**Income tax submission – Individuals and Businesses** If submission late	5 years 5 years from submission date
4	Tax Administration	If advised by SARS of a tax audit or if taxpayer lodges an objection	5 years, plus keep all records until audit/objection is finalised

TAX - Part 2			
No	**Act**	**Description**	**Retention Period**
5	Value Added Tax	**Vendors are obliged to retain the following:** Record of all goods and services The rate of tax applicable to the supply and the suppliers or their agents Invoices Tax invoices Credit notes Debit notes Bank statements Deposit slips Stock lists Paid cheques	5 years
6	Value Added Tax	Evidence of zero rating	5 years
7	Value Added Tax	**Importation of goods and services:** Bill of entry Substantiation that VAT paid Any other prescribed records	5 years
8	Value Added Tax	**Change in basis of accounting:** Records of debtors and creditors in month prior to change	5 years
9	Value Added Tax	Agents to maintain documentation in terms of Customs and Excise Act to ascertain VAT number, address and name of principal	5 years

3. Staff Matters

STAFF MATTERS			
No	Act	Description	Retention Period
1	Basic Conditions of Employment	**Employers to keep**: Employee details after termination Employee's name plus occupation Salary paid to staff member Period worked If employee less than 18, date of birth	3 years
2	Labour Relations	**Employers to keep:** Records for each employee detailing The nature of any disciplinary offences What action was taken by the employer and The reasons for the actions	Indefinite
3	Labour Relations	**Employer to keep documentation of:** Collective agreements Arbitration awards	3 years
4	Labour Relations	**Employer to keep:** Documentation of any strike, lock-out or protest by staff	Indefinite

"NOTE FOR ACCOUNTANTS: For more information see SAICA's "Guide on the Retention of Records" on its website.

Also see the Close Corporations Administrative Regulations on the CIPC website.

Tax Ombud Appointed and Gearing up to Hear Your Complaints

The position of Tax Ombudsman was created by the Tax Administration Act, Act 28 of 2011. Retired Judge Bernard Ngoepe was appointed as the first Ombudsman which effectively means the Office of Tax Ombudsman can begin to operate. A website is now being set up, the Office is being staffed (by transferring SARS officials to the Office) and it expects to be operating at full capacity in the first quarter of 2014.

Role of the Tax Ombud

The Office has no jurisdiction over tax law, tax po icy, SARS practices and policies. Structures already exist for such matters, namely objections, ADR (alternative dispute resolution), Tax Boards (for simple and lower value cases), Tax Courts (appeals from Tax Boards and more complex higher value cases) and finally the civil Courts themselves.

Simply put the Ombud deals with service problems and administrative and procedural complaints. Taxpayers need to have exhausted existing channels before contacting the Tax Ombudsman. These are –

- Contacting the SARS call centre to register a co plaint,
- Working through the closest SARS branch,
- Escalating the complaint to the SARS Service Mo itoring Office,
- And only then to the Tax Ombudsman.

It should also be borne in mind that findings of the Ombudsman are not binding on SARS or the taxpayer.

However the Office of the Tax Ombudsman will be independent of SARS and its annual report will be tabled in Parliament. Judge Ngoepe has got off to a good start by setting a target of 15 business days to resolve complaints. He has the background and experience to make this a meaningful Office.

Whilst it will be cumbersome to register a complaint, the fact that the Office is independent and that its work will be visible to Parliament means it is worth giving the Tax Ombud's Office a chance to prove that it can be effective.

NOTE FOR ACCOUNTANTS: For the parts of the Act applying to the Tax Ombudsman go to Chapter 2, Part F of the Tax Administration Act, available on ActsOnline.

For suggested reading, see -

- "Tax Ombud aims to resolve disputes within 15 days" on Moneyweb Tax
- "Ngoepe appointed as new tax ombudsman" on the Mail & Guardian website
- "Briefing Note: Tax Ombud: Clauses 14 – 21" on the SARS website.

Business 101: Less Red Tape and More Incentives for Small Business?

Johann Rupert recently said he does not know how people start companies, considering, amongst other things, the amount of red tape in South Africa. A recent study found that only 14% of South Africans plan to open a business which is barely half the global norm. Ongoing compliance requirements from SARS plus new and revised laws are placing a heavy burden on small business.

There could be an upside

In his budget speech this year, Minister Pravin Gordhan set up a panel to review how to use tax revenues to best grow employment, promote economic growth and sustainable development. The panel, known as the Davis Tax Committee (DTC), was also required to work within the framework of the National Development Plan.

Judge Davis has made it a priority to focus on finding ways to stimulate the growth of small businesses. The DTC is also studying the amount of onerous red tape placed on small business.

In addition, the Employment Tax Incentive Act came into effect on 1 January 2014 (except section 10 which deals with reimbursements, commencement date still to be gazetted). You may, with a few exceptions, claim up to 50% of the cost of the wages of youths employed from ages 18 - 29 with a South African ID. The incentive will be in the form of a reduction of PAYE paid to SARS. Many businesses would like to employ more people but are put off by, amongst other things, the high cost of labour – this will certainly help reduce it for them.

What these two bits of information add up to is that government is aware of the difficulties faced by business, particularly small business, and is beginning to take steps which could stimulate the growth of small usinesses which are the prime creator of jobs.

Artcles sourced from: CA[SA].News

3Shape Releases CAD Solution for Post and Core Restorations

Posted by JDTUnbound on August 12, 2013 in Industry News

3Shape, the provider of 3D scanners and CAD/CAM software solutions for the dental industry, announces the launch of its CAD solution for Post and Core restorations – which includes dedicated Post and Core intraoral scanning with 3Shape TRIOS® and unique CAD design workflows in Dental System™ 2013. 3Shape's Post and Core solution utilizes special scanning capabilities, 3Shape Scan Posts™ , and sophisticated software tools for reliable capture and optimally shaped and functional Post and Core designs. The solution saves time by allowing lab technicians to design all layers in a single digital workflow.

3Shape Scan Posts™ – for use in clinics and labs

3Shape has developed special Scan Posts™ to facilitate accurate capture of the Post and Core restorations' positions and depths. Scan Posts™ are approved for both intraoral use in the clinic and for model scanning in the lab. Scan Posts™ are autoclavable, and they come in various shapes and sizes to support drill systems from major suppliers. Patent Pending.

Flexible input – takes scans from TRIOS® and from dental lab scanners

3Shape's Post and Core solution can be used with 3Shape TRIOS® digital impressions and 3D scans of gypsum models. Dentists with 3Shape TRIOS® can kick start Post and Core cases in the clinic by capturing and sending highly reliable input to the lab for direct designing. A special dual-scan workflow using 3Shape Scan Posts™ ensures accurate capture of true depths and positions of the root canal. If gypsum models are the input source, lab technicians simply insert Scan Posts™ in the model before scanning.

Sophisticated design tools

In the lab, technicians align the captured Scan Posts™ and let the software calculate positions and depths automatically. By first designing the anatomy layer and applying dedicated Post and Core modeling tools, technicians can create optimally shaped and functional Post and Core designs that are matched to the clinical case and ready for manufacturing through wax print & cast, milling, or laser sintering.

Frederic Rapp, Director of Crown Ceram dental laboratory in France says: "In combination with TRIOS®, 3Shape's Post & Core design software gives us a fast and easy way to model optimally shaped and robust Post and Core restorations. The full digital workflow makes it very easy to design parallel post and cores, or work with cases involving multiple posts."

All types of Post and Core cases

Labs can design Post and Core cases for standard crowns, single-piece retained crowns, and anatomical single-piece retained crowns that are cut back for veneering.

3Shape's Post and Core design solution is fully functional in the released Dental System™ 2013 software, and with 3Shape TRIOS®. 3Shape Scan Posts™ are available for both dental clinics and labs through 3Shape distributors. Please contact your local 3Shape representative for details and purchase information.

Article sourced from: JDT Unnound, www.jdtunbound.com

Shane Palm

Differentiation

by Shane Palm

Posted by JDTUnbound on March 2, 2014 in Unbound Columnists

In a market where every lab produces the same types of products, how do you make yourself stand out? What makes you different from the lab down the street, on the other side of town, or across the country? The purpose of differentiation is to make your products/lab stand out amongst all the others to the point of retaining and gaining new clientele. But, how do you do that when everyone is capable of fabricating the same prosthesis? Michael Porter developed three generic strategies to gain a competitive advantage: cost advantage, differentiation, and focus.

A cost advantage strategy is the method of reducing all production costs to a level where the lab can offer an extremely low priced product. The goal is to become the low price leader and make a profit based on economies of scale. There can only be one low price leader. If cost is the biggest motivator for a customer to choose a lab, why would they send it to the second or third low price leader? This strategy is mainly used by larger labs that have a large customer base and volume.

A focus strategy targets a narrow market, a niche market. Within this niche, the strategy is to gain market share through differentiation or cost advantage. Typically there is less volume with this strategy. However, focus strategy is able to create strong brand loyalty within the market. This brand loyalty can be a deterrent for others to compete in the market.

Differentiation strategy is used to make your products more attractive than a competitor. The lab uses creativity and their knowledge of their market to offer built in value for their targeted customers. This can be accomplished through customer service, technology, expert knowledge, problem solving, accessibility, branding, etc. Laboratories utilizing this strategy are able to charge more for their work and customers are willing to pay for the built in value. This is the strategy of choice for most labs.

How do you determine which way you can differentiate your lab from another? Start by grabbing a pen and paper. Draw a line down the center of the paper from top to bottom. The left column is for your lab and the right is for the other labs. In your column, list all the products/services offered and anything else that differentiates you from the other labs. Some examples would be, excellent customer service, “x” amount years of experience, fabricates “x”, “y”, and “z” products, education, technology used. Try to stay away from opinion based statements such as “high quality”. 1. They are subjective and everyone has a different definition/standard of quality. 2. Honestly, who is going to boast they produce exceptionally mediocre or low quality work? Everyone thinks their work is high quality. In the column for the other labs, do the same. Next, cross out anything that is the same in both columns. What’s left on your side is the potential areas that can make you stand out. What’s left on the other labs side is how they are setting themselves apart. Once you know what areas you can exploit as strengths and the areas that are weaknesses, you can develop a strategy to maintain and gain market share. For help with strategy formulation, read my article, What’s your Strategy for your dental lab? Lastly, create a marketing plan that integrates your strategy and will communicate why you are the lab to use.

In a market where the products are essentially the same, you must differentiate amongst the others if you want to survive. Take some time and discover what can make your lab stand out!

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Rapid Tooling Method for Soft Customized Removable Oral Appliances

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Abstract: Traditionally oral appliances i.e. removable orthodontic appliances, bite splints and snoring / sleep apnea appliances are made with alginate impressions and wax registrations. Our aim was to describe the process of manufacturing customized oral appliances with a new technique i.e. rapid tooling method. The appliance should ideally be custom made to match the teeth. An orthodontic patient, scheduled for conventional orthodontic treatment, served as a study subject. After a precise clinical and radiographic examination, the approach was to digitize the patient's dental arches and then to correct them virtually by computer. Additive manufacturing was then used to fabricate a mould for a soft customized appliance. The mould was manufactured using stereolithography from Somos ProtoGen O-XT 18420 material. Casting material for the mould to obtain the final appliance was silicone. As a result we managed to create a customized soft orthodontic appliance. Also, the accuracy of the method was found to be adequate. Two versions of the described device were manufactured: one with small and one with moderate orthodontic force. The study person also gave information on the subjective patient adaptation aspects of the oral appliance.

Keywords: Additive manufacturing, computer-aided design (CAD), computer-aided manufacturing (CAM), rapid prototyping, oral appliance, orthodontics.

INTRODUCTION

Traditionally the protocol to fabricate oral appliances i.e. removable orthodontic appliances, bite splints and snoring / sleep apnea appliances, includes alginate impressions and wax registrations taken by the dentist and the appliance made by the dental technician. Three-dimensional computeraided design (3D-CAD) creates new possibilities in this field allowing greater use of industrially manufactured appliances while respecting the biological tissue reaction in the dental tissues [1]. Computer-aided graphical 3D-reconstruction has been used to trace the prenatal development of the human temporomandibular joint [2]. The first and still best known CAD / Computer Aided Manufacturing (CAM) technology in odontology was Cerec (Siemens, Germany) to manufacture ceramic inlays [3]. Clear orthodontic aligners provide a way to move the teeth with an aesthetic removable appliance in patients with only minor orthodontic problems or the aligner can also be used as a finishing or retention appliance.

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Lin [4] introduced a method where a clear and hard tooth aligner is first manufactured by digitizing teeth, and then straightening them virtually by computer, and further additive manufacturing of a corrected pattern for a vacuumheat process. Lee et al. [5] used a combination of computed tomography and rapid prototyping to manufacture a physical copy of unusual tooth root anatomy. Lauren et al. [6] used a computer-assisted method for design and fabrication of hard occlusal splints. They scanned teeth from stone casts and virtually adjusted them. Splints were manufactured by milling. Joffe [7] used 60 commercially available hard clear appliances, which were made by the following method: digitalizing tooth, virtual straightening, additive manufacturing a mould, pressure forming and finishing. Keski-Nisula et al. [8] investigated a soft eruption guidance appliance for children and found it as an effective method to restore normal occlusion and eliminate the need for further orthodontic treatment.

Kohorst et al. [9] measured the accuracy of different CAM systems and the best mean value was 58 μm and the worst ones 183 and 206 μm. Germani et al. [10] investigated the accuracy of a scanning plaster model and additive manufactured plaster replica. They tested four different digitizing systems and eight different combinations of additive manufacturing technology with various materials. Metzger et al. [11] combined computerized tomography imaging and optical plaster model scanning to obtain a virtual model with accurate teeth and jaws for occlusal control. They also undertook virtual repositioning of the jaws and then printed physical models

Table 1. Requirements for Method

Requirements for the used Approach	Requirements for Virtual Correction
• Sufficient accuracy	• Segmentation of teeth
• Correct geometry	• Moving and positioning teeth
• Good occlusion	• Controlling occlusion
• Easy and fast enough	• Modeling mould
• Cost efficient	

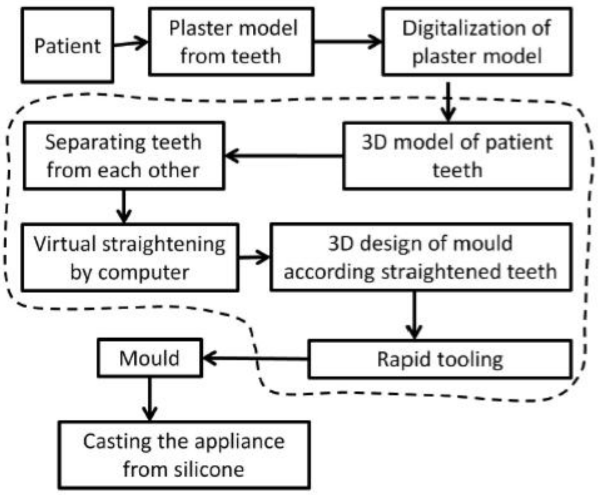

Fig. (1). Process for planning and manufacturing of customized orthodontic appliances. The dashed line defines the digital steps of the process.

of the splint with a 3D printer.

The aim of the present study was to generate a cutommade oral appliance with a new technique i.e. a rapid tooling method. It is a process using additive manufacturing to directly fabricate a mould quickly and economically. A patient, planning to start conventional orthodontic treatment, was asked to give information regarding their adaptation, convenience and tolerance to the oral appliance made by this technique. After a precise clinical and radiographic examination, the approach was used to digitize the patient's dental arches and then to correct them virtually by computer to develop a custom made removable oral appliance. Silicone was used as the casting material for the mould. Two versions of the device were manufactured: one with small and another with moderate correcting force.

MATERIALS AND METHODS

Several methods to create an unfixed, customized and soft oral appliance were investigated and used. Our approach was to use 3D digitizing to create a 3D model for virtual orthodontic correction. The established requirements for the used study design are presented in Table 1.

Using ideal virtual teeth positioning a mould for silicon casting was designed and additive manufacturing was used to create it. The mould was then used to cast the appliance from silicone. A flow chart of the process is demonstrated in Fig. (1).

Fig. (2). The plaster model.

EXPERIMENTAL PATIENT FOR APPLIANCE TESTING

The study patient, who was asked to test the convenience of the appliance use, was a 46-year-old healthy female, with no medication or allergies. The patient had no previous orthodontic treatment. The dental and periodontal tissues were healthy, as assessed by careful clinical and radiological examination. Due to temporary pain in the temporomandibular joints and bruxism, the patient used a bite splint nightly. In the orthodontic examination, the convexity of the profile was normal, mesiodistal molar relationship was ideal (Angle class I) on the right and cusp-cusp on the left side, horizontal overjet was 4 mm and vertical overbite 1/3 of the crown height. Upper and lower right first premolars had been extracted earlier. There was minor crowding of the upper canine area. The canines were palatally inclined, on both right and left sides as well as on the lower incisor area, which were labially inclined (Fig. 2). According to the clinical and radiological examination, the patient was suitable for the experimental use of the appliances. Each appliance was tested for two minutes.

Digitization of Teeth

The teeth digitizing can be either direct or indirect. The direct method comprises imaging or scanning of the dental arches straight from the patient's mouth and generating the 3D model from these data. In the indirect method a plaster model is first made from the teeth and then digitized by using a scanner or other imaging techniques. At imaging the slice thickness should be as small as possible and the patient should not move during the imaging. Additional artefacts can cause errors. These error sources can ruin the 3D model and therefore, a direct method with imaging is not suitable for all patients. Imaging allows for including the roots of the teeth into the 3D model and segmenting the teeth one by one, assuming that sufficient accuracy exists.

The teeth were digitized by first taking a plaster model from the patient's teeth and used the GOM ATOS 3D scanner (GOM GmbH, Germany) to obtain a virtual 3D model from the plaster model. It is important to use software that is able to fix small holes and errors in the obtained scanned image, be-

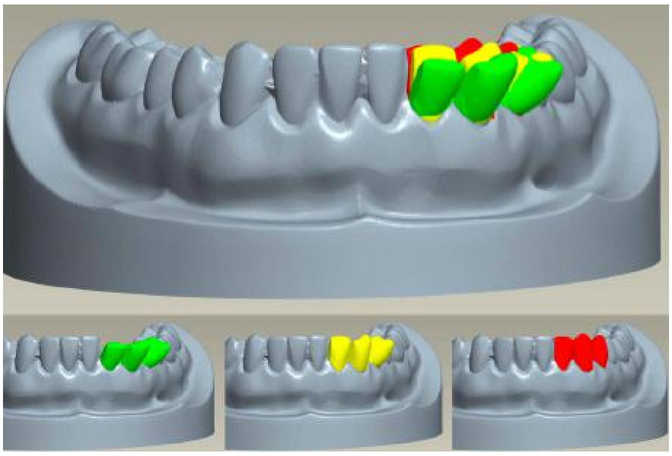

Fig. (3). Digital moving and repositioning of teeth in green, the moderate correction in yellow and the high force correction in red.

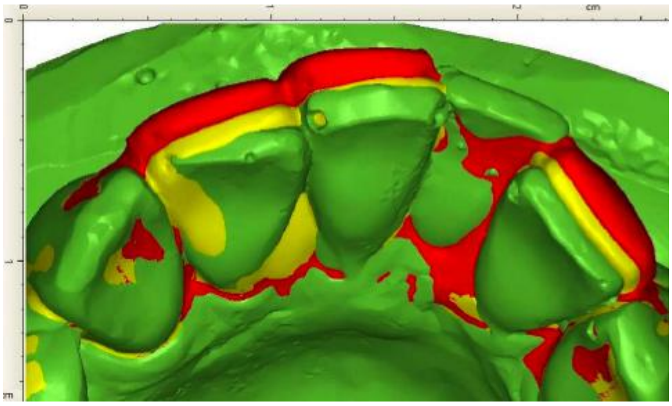

Fig. (5). Current lower jaw with teeth in green, the moderate correction in yellow and the high force correction in red.

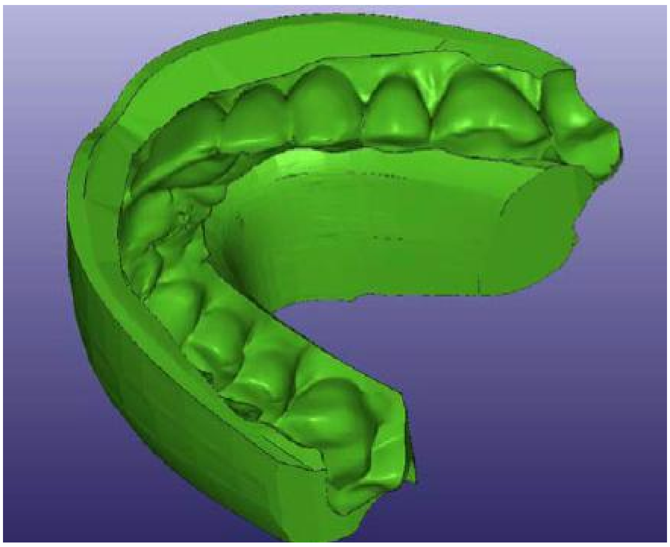

Fig. (4). 3D-model of orthodontic appliance.

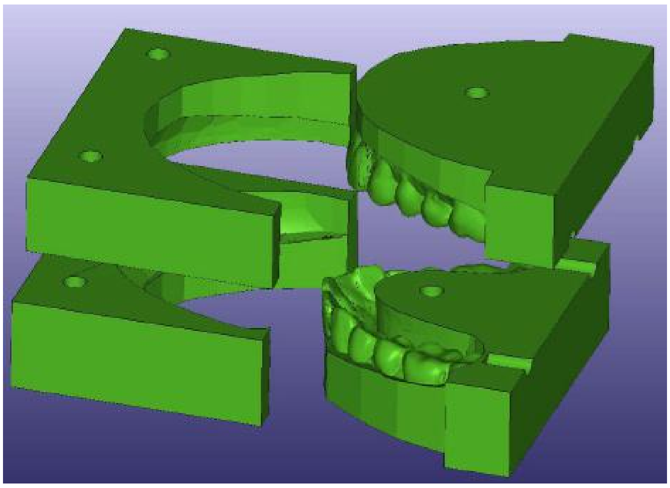

Fig. (6). Four-piece mould for the appliance.

cause these can cause interference with the Boolean operations in the 3D design of mould. We separated teeth from each other by using the basic cutting tools in the Viscam RP 4.0 software (Marcam Engineering GmbH, Germany).

Virtual Alignment

The digital data of the separated teeth were imported into Pro Engineer Wildfire 4.0 software (Parametric Technology Corp, USA). Each corrected tooth was a separate data set and these were combined in an assembly mode. The software allowed the teeth to be movedto get an optimal dental arch form. Fig. (3) demonstrates removing and repositioning of the

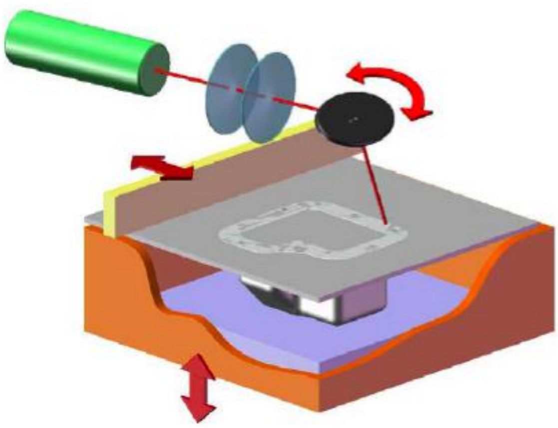

Fig. (7). A schematic drawing of the stereolithography.

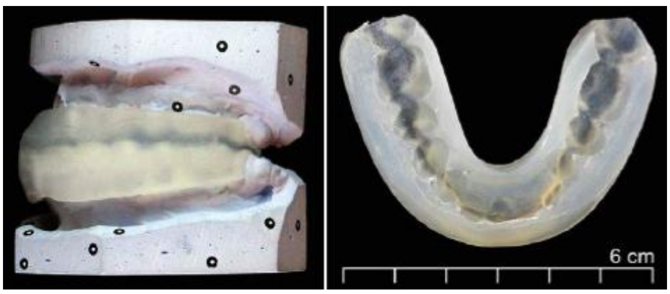

Fig. (8). Appliance between plaster models and the finished orthodontic appliance.

teeth. The red colour represents an oblique position, the yellow the intermediate, and the green the final ideal position.

3D Design of the Mould

Viscam RP 4.0 software was used for the mould design. A previous 3D model of an orthodontic appliance with no geometry data of the teeth was used as a starting point. This formed the geometry for the outer shape of the appliance. The inner geometry to the appliance was achieved by using Boolean cutting operation with aligned upper and lower teeth and this produced the final geometry for the appliance. The 3D model of the orthodontic appliance is shown in Fig. (4). As a slab for the mould a rectangular prism was used. The mould´s actual final form was obtained by a Boolean cutting operation and using the shape of the appliance.

Guide pins were placed to align parts of the mould to each other and a channel was constructed for squeezing silicon into the mould, but these were not used during the actual manufacturing phase. The modelling could also have been done by making a parametric model which allows an adjustment of the mould geometry according to the imported corrected 3D model.

In the second version the teeth were adjusted more to get more force applied to them from the appliance. Over correction was 1 - 3 mm and this seemed to produce too much force. The current lower dental arch with corrections is presented in Fig. (5).

Also, the two-piece mould was changed to a four-piece mould because of difficulties in removing the appliance from the mould due to undercuts. With the four-piece mould (Fig. 6) removing the appliance from the mould was relatively easy.

Manufacturing

The mould was manufactured by using stereolithography, which is an additive manufacturing technology, where parts are built layer by layer by curing photopolymer with ultraviolet laser. The laser beam traces a part cross-section pattern on the surface of the liquid resin on each layer and between layers the building platform descends by a single layerthickness. A schematic figure of the stereolithography process is shown in Fig. (7). Used machine was SLA 350 (3D Systems, USA). For the material Somos ProtoGen O-XT 18420 (DSM Functional Materials, USA) was chosen because it has a very low material shrinkage and it can stand the temperatures needed in the casting phase. The layer thickness used was 0.05 mm. After manufacturing the mould was placed in

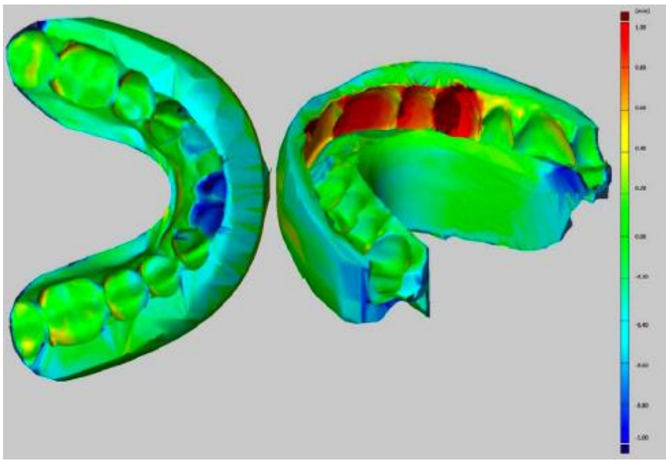

Fig. (9). Accuracy of appliance compared with the designed 3D model. Scale: red + 1.0 mm to blue -1.0mm.

a post-cure apparatus for 60 minutes. Silicone was used as casting material.

Inspection

After manufacturing we used GOM ATOS II 3D scanner (GOM mbH, Germany) to capture virtual 3D model from manufactured appliance. Before measuring the silicone was sprayed with mixture of titanium oxide and alcohol to gain better response for optical scanner. Comparison was performed using GOM Inspect V7 SR2 (GOM mbH, Germany).

RESULTS

Fig. (8) depicts the appliance between plaster models and a finished appliance. Both manufactured customized soft oral appliances were tested in the patient's mouth repeatedly for two minutes each to get some subjective feedback of various aspects regarding its use (ease, comfort and convenience). The device with moderate force was subjectively more efficient but also caused a slightly unpleasant sensation. The small force version did not create that much force sensation but was more comfortable to use. Furthermore, an exact fit and a user-friendly surface quality were other attributes for both versions reported by the patient. The true movement of teeth was not investigated since this effect was not the focus of the present study.

The accuracy of the system is visualized in Fig. (9). Maximum dimensional errors of approximately 1mm were found at thin walls and sharp corners when comparing the physical model to the 3D design.

DISCUSSION

Custom-made brackets for orthodontic purposes are an ideal target for additive manufacturing techniques. In the present study scanned data of the patient's teeth were used to virtually design a mould for silicon casting. Furthermore, additive manufacturing was used to create the physical mould. The final appliance was made of silicone by a casting method using this mould.

While performing the digitization phase, the jaws must be in the same position as they would be when using the appliance. This is to prevent possible unwanted pain in the temporomandibular joint or the bite muscles or changes in the occlusion. It also makes the 3D modeling easier because the modeler does not have to reset the jaws or to consider any forces due to biting. An alternative option is to combine three scans: upper and lower jaw as well as occlusion. These appliances have a limited ability to align teeth due to their inability to create tooth rotations, intrusion or root movement. The appliance might also be useful in finishing orthodontic treatment after fixed appliances. At present only a sparse literature regarding this issue exists. Thus, the complex force delivery properties of the appliance system have to be systematically investigated and studied until commercial use can be considered.

The advantage of these removable oral appliances made by the rapid tooling method compared to conventional appliance production protocol might be a faster production technique, as well as more inexpensive and more precise oral appliances. The geometric dimensions of the custom-made appliance were found to be accurate compared to the 3D model. In soft appliances, though, the accuracy of the geometric dimensions is not that crucial since the material is pliable compared to hard appliances. The need for cheaper oral appliances is greater among snorers or in patients with sleep apnea.

One method for manufacturing is to use a soft slab that is for example thermally formed over rapid manufactured straightened teeth. However, tipping movements are predictable with thermoplastic appliances and it is much more difficult to establish a comparable amount of root control [12]. Also the thickness of the appliance as well as the material used for the appliance may have a significant influence on the amount and type of the orthodontic tooth movement [13- 15].

The aim of the present study was to describe the multidisciplinary process that is needed to additive manufacture a custom-made soft orthodontic appliance. Evidence of clinical applicability of this created appliance is needed before further commercial production. However, production of a physical prototype usually leads to further developing phases of the product before any clinical experience can be obtained.

Selection of the patients to the orthodontic treatment demands accurate diagnosis, and the number of suitable patients might be fewer due to a multitude of orthodontic problems in many patients, i.e. skeletal problems, hypodontia, etc. In the future, during the use of the oral appliance manufactured by rapid tooling method for either orthodontic, sleep apnea, temporomandibular joint or bruxism problems, a careful follow-up of the effects of the appliance as well as the changes in the occlusion should be investigated in a controlled manner.

CONCLUSIONS

The customized soft orthodontic appliance made from silicone could be manufactured by making a mould with stereolithography from Somos ProtoGen O-XT 18420 material. The appliance with moderate force was more efficient but caused a slightly unpleasant sensation. The small force version did not create that much force but was more comfortable to use. Both appliances were well tolerated and convenient to use.

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CONFLICT OF INTEREST
None declared.

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Liquid-Supported Dentures: A Soft Option—A Case Report

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Liquid-supported denture technique allows continued adaptation of denture to the mucosa both at resting and functional state. A complete denture prosthesis is unacceptable if it violates the foundation on which it rests. In this case, a technique for fabrication of a complete denture prosthesis that eliminates the disadvantages of tissue conditioners and soft liners (i.e., poor bond strength to acrylic, candidal colonization, etc.) and preserves the remaining tissues is described. Liquid-supported denture can be a permanent solution to some patients with problematic conditions like diabetes, xerostomia, atrophied ridge, and so forth.

1. Introduction

Flabby ridge is a superficial area of mobile soft tissue affecting the maxillary or mandibular alveolar ridges. It can be developed when soft tissue replaces the alveolar bone and it is a common finding, particularly in long term denture wearers [1]. These soft tissue changes and bone resorption occurs because ofmuscle dynamics or tissue irritation, which ultimately affects the residual ridge dimensions [2]. Thus, complete denture seldom remain in close adaptation to the adjacent mucosa. However, it also has to support the teeth during function and thus should be rigid. An ideal denture base should be flexible, as it has to continuously adapt to the mucosa. However, it also has to be rigid so as to support the teeth during function. These properties cannot be combined in one material, but are possible by using combination of materials [3].

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Several techniques have been tried on the tissue surface of the dentures. In 1961, Chase introduced the use of elastic impression material to relieve traumatized tissue. But this can be only a temporary provision. Moreover, it might easily derive candidal growth. Since then a variety of tissue conditioning materials has been introduced. Another group of materials called soft liners has been used to relieve "denture soremouth" problems. But soft liners are also only temporary provisions because due to loss of plasticizer over a period of time, they lose their plastic properties. In a flabby ridge condition, an ideal denture should be able to withstand masticatory forces and have flexible tissue surface to reduce stress concentration and trauma on the underlying tissues [4]. A Liquid-supported denture can hence be a solution for this problem. This paper describes the fabrication of a mandibular complete denture with its base covered with a preshaped, close fitting, and flexible sheet containing a thin film of viscous liquid, which fulfills the aforementioned requirements.

2. Case Report

A 56-year-old male patient reported to HKE'S S N Institute of Dental sciences & Research, Gulbarga, Karnataka, India, for replacement of missing teeth. The patient had a history of wearing maxillary and

Figure 1: Patient's old denture.

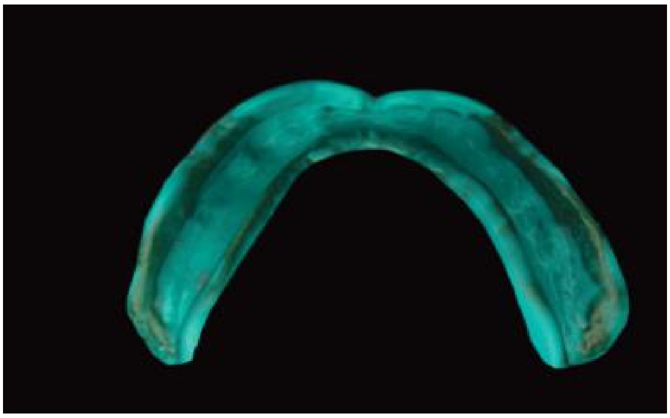

Figure 2: Final impression made with elastomeric impression material.

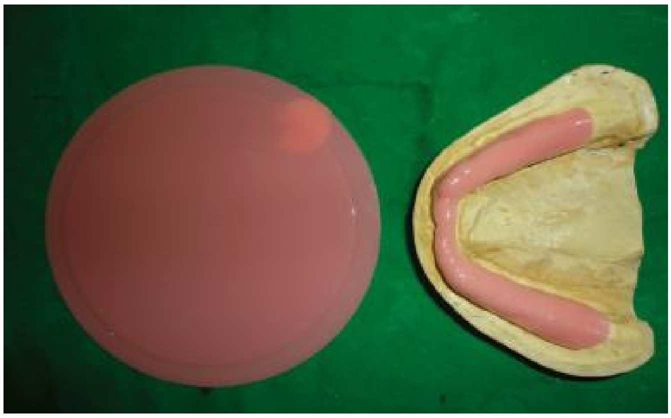

Figure 3: Vacuum heat-pressed polyethylene sheet (1.5mm thick).

Figure 4: Vacuum heat-pressed polyethylene sheet (1.5mm thick) incorporated at the time of packing.

mandibular complete dentures since the past 6 years (Figure 1). His chief complaint was the poor fit of the denture, and it felt loose while eating. Patient had a history of diabetes and hypertension since last 9 years. The patient was wearing complete dentures even at the night. He was also using denture adhesive. By intraoral examination, a completely edentulous mandibular arch with flabby tissue existing in the mandibular anterior region was observed. It was decided to give a conventional maxillary complete denture opposing a Liquid-supported mandibular complete denture because of flabby soft tissues in anterior mandibular region. Primary impressions were made with alginate (Prime Dental products pvt. Ltd., Mumbai, India). Full complete double spacer was applied in the mandibular anterior region because of flabby soft tissues in the anterior region. Border molding was performed by using low fusing impression compound (DPI pinnacle tracing sticks, Dental products of India), and final impression was made with light body additional silicone impression material (Aquasil, Dentsply/caulk) (Figure 2). Denture base of 3mm thickness was fabricated for mandibular denture base and 2mm for maxillary 3 denture base. Jaw relations record and trial of waxed up denture was done by conventional method. The mandibular denture design was modified to make a Liquid-supported denture. Maxillary complete denture was acrylised using conventional procedure.

Steps in fabricating a Liquid-supported denture.

(1) Vacuum heat-pressed polyethylene sheet (Biostar vacuum forming machine, Scheu-dental, Germany) of 1.5mm thickness was adapted on the mandibular master cast. The sheet acted as a temporary spacer, and it was made 2mm short of the sulcus (Figure 3).

(2) After dewaxing, 1.5mm temporary polyethylene sheet was adapted on the mandibular cast, and vaseline was applied over it so that this temporary sheet can be retrieved easily (Figure 4). Now, the denture was acrylised using heat cure resin along with the sheet. The mandibular denture with this 1.5mm thick temporary polyethylene sheet was then finished and

Figure 5: Polished denture with 1.5mm thick temporary polyethylene sheet.

Figure 6: Intraoral view of maxillary and mandibular complete dentures.

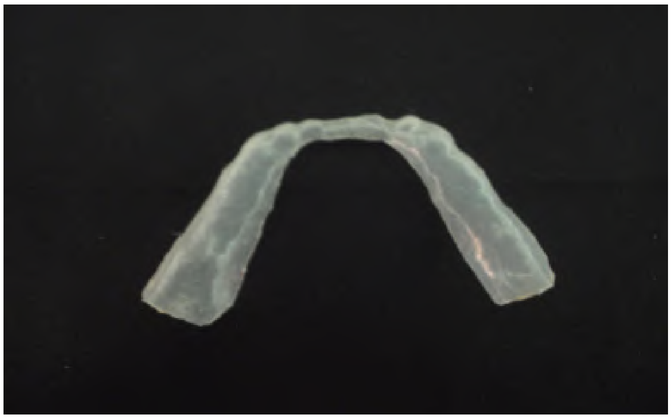

Figure 7: Vacuum heat-pressed 0.5 thick final polyethylene sheet.

Figure 8: Liquid-supported mandibular denture with 0.5mm thick final polyethylene sheet filled with glycerine (tissue surface).

polished in conventional manner (Figure 5).

(3) The mandibular denture was inserted in to the patient's mouth to check for retention, support, stability, and border extension.The patient was asked to wear the denture for two weeks to get adjusted to it (Figure 6).

(4) After two weeks, the patient was recalled to convert the mandibular denture into a Liquid-supported one. Temporary polyethylene 1.5mm thick spacer sheet was removed from the mandibular denture.

(5) An additional silicone putty impression was made of the tissue surface of the denture, and the cast was made of it.This was done to record the exact junction of the sheet to the denture. The impression was poured with dental stone, which will form negative replica of the ridge. Now, again the cast was poured upon the negative replica to produce positive replica of the ridge. On this cast, a 0.5mm thick final polyethylene sheet was vacuum heat pressed which was used in place of 1.5mm thick sheet creating a 1mm space between tissue surface of the denture and permanent polyethylene sheet (Figure 7).

(6) The polyethylene sheet was cut using the putty index as guide. The borders of the 0.5mm thick sheet were placed in the crevice formed due to removal of 1.5mm thick sheet. Cyanoacrylate adhesive and autopolymerizing acrylic resin were used to seal the borders and prevent escape of liquid (Figure 8).

(7) The space created due to the replacement of a 1.5mm thick sheet with a 0.5mm thick sheet was filled with viscous liquid, that is, glycerine. This was done by making two holes drilled on the buccal flange in the molar area of the denture by round bur and injecting viscous liquid, that is, glycerine through these holes, and one hole was sealed with autopolymerizing cure acrylic resin.

(8) The occlusal vertical dimension was adjusted by fitting the denture in the patient's mouth, and the other holewas sealed using the autopolymerizing cure acrylic resin.Then, the mandibular Liquid-sup-

ported denture was delivered (Figure 9).

(9) Denture care instructions were given to the p tient. The patient was told to clean the tissue surface using cotton.The patient was recalled for followup.

3. Discussion

In this case where the presence of flabby tissue in-mandibular arch (anterior portion) was treated by a

Figure 9: Final mandibular denture (Polished surface).

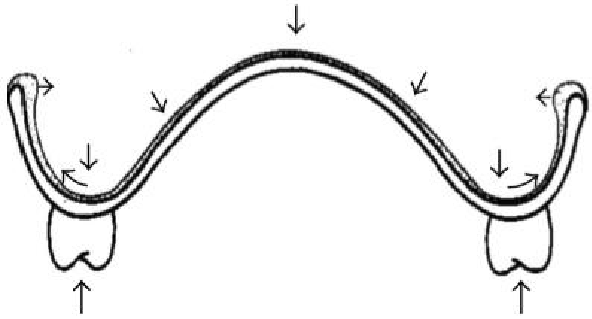

Figure 10: Unidirectional loading of denture resulting in multidirectional distribution of hydrodynamic pressure throughout fluid and clasping pressure at border of denture.

modified design, that is, Liquid-supported denture. The principle of this design was that a Liquid-supported denture is flexible and continuously adapts itself to themucosa.However, it is also rigid enough to support the teeth during actual use.Thus, the denture base is covered with a close-fitting flexible foil to keep a thin film of liquid in its place.This design will act as a continuous reliner for the denture and thus has an advantage over the existing denture designs. When no forces are applied, the foil remains in the resting position and act as a soft liner, and when the dentures are in use, vertically directed loads are distributed in all directions by the liquid resulting in optimal stress distribution (Figure 10).Thus, Liquid-supported denture provides benefits of both tissue conditioners and soft liners. This helps in long-term the preservation of bone and soft tissues. Apart from the combined benefits of tissue conditioners and soft liners, the load from biting forces and even bruxism will be distributed over a larger surface [5].

The Precautions are as follows (see [6]):

(i) thickness of denture base should be at least 3 mm;
(ii) The seal should be perfect and should be checked for microleakage;
(iii) denture care instructions should be given to the patient;
(iv) in case the liquid leaks out, the patient should inform the dentist, and the denture should be refilled;
(v) repair is possible if the sheet gets ruptured and can be replaced over preserved stone cast.

For a liquid cushion, glycerine was used, which is clear, colorless, and odourless with a good pharmaceutical action. To prevent the liquid from leakage, a dense foil must be used

[7]. The problem faced in fabrication of complete denture is the difficulty in a achieving complete seal at the junction of polyethylene sheet and denture base. The main drawback of liquid-supported denture is the relining procedure, which is not possible with this liquid supported denture [8].

4. Conclusion

Days and nights change, men, tissues, so do our treatments. Ultimately, Devan's dictum holds true "Our objective should be perpetual preservation of what remains, rather than meticulous reconstruction of what is lost." The seeds of success or failure of the prosthesis lies in the hands of the dentist. Liquid-supported denture by acting as a continuous reline provides solution to some problematic prosthodontic situations like patients with bruxism or clenching habits, in xerostomia patients, or those patients with atrophic ridge, superficial mental nerve, and so forth. Liquid-supported denture with its shock absorbing effect thus fulfills a valuable role in prosthetic dentistry.

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LIQUID-SUPPORTED DENTURES

1. Liquid-supported dentures can be a permanent solution to some patients with conditions like:
   - a) Diabetes
   - b) Xerostomia
   - c) Atropheid ridge
   - d) All of the above

2. Soft liners in dentures are considered temporary in this article because:
   - a) Loss of plasticizer over time
   - b) Cost too much to maintain
   - c) Detach from the denture acrylic
   - d) All of the above

3. What was used to seal the borders of the polyethylene sheet to the denture and to prevent escape of liquid:
   - a) Cyanoacrylate adhesive
   - b) Super glue
   - c) Autopolymerizing acrylic resin
   - d) a & c

4. What viscous liquid was used in the liquid-supported denture:
   - a) Petroleum jelly
   - b) H^2O
   - c) Vaseline
   - d) Glycerine

5. The denture base should be at least how thick:
   - a) 1.5 mm
   - b) 2 mm
   - c) 3 mm
   - d) 4 mm

CEU

Fractographic Analysis of a Dental Zirconia Framework: a Case Study on Design Issues

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Abstract: Fractographic analysis of clinically failed dental ceramics can provide insights as to the failure origin and related mechanisms. One anterior 6-unit all-ceramic zirconia fixed partial denture (FPD) (Cercon®) has been clinically recovered and examined using qualitative fractography. The purpose was to identify the fracture origin and to state the reasons for failure. The recovered parts of the zirconia FPD were microscopically examined to identify classic fractographic patterns such as arrest lines, hackle, twist hackle and wake hackle. The direction of crack propagation was mapped and interpreted back to the origin of failure at the interface of the occlusalpalatal tip of the core and the veneering ceramic. An inappropriate core drop design favoring localized stress concentration combined with a pore cluster in the veneering ceramic at the core tip interface were the reasons for this premature through-the-core thickness failure.

Keywords: Fractography; failure analysis; ceramic restoration; zirconia; fixed partial denture; dental ceramic

1. Introduction

An increasing number of all-ceramic materials are being used in prosthetic dentistry. Allceramic prostheses, the so-called fixed partial dentures (FPDs) in most cases consist of a supporting, high strength zirconia framework structure and an esthetic veneering ceramic (Raigrodski, 2004).

Clinical studies in an academic environment using zirconia supported FPDs reported promising results for an observation time of two to five years (Raigrodski et al., 2006; Tinschert et al., 2008; Sailer et al., 2007; Vult van Steyern et al., 2005; Molin and Karlsson, 2008; Beuer et al., 2009). The zirconia frameworks showed excellent mechanical stability as only one fracture occurred in each of two studies on FPDs (Sailer et al., 2007; Beuer et al., 2009). However, several authors reported up to 15% of the frameworks had minor chipping of the veneering ceramic (Raigrodski et al., 2006; Tinschert et al., 2008; Sailer et al., 2007; Vult van Steyern et al., 2005). Nevertheless, when using anatomically designed frameworks, Molin et al. observed no veneer chipping after five years of observation time. A five year follow-up in three dental private practices (Kerschbaum et al., 2009), regrouping 259 bridges and 957 crowns (Cercon® system), reported 8 % veneer and framework fractures. The authors suspected the early framework fractures in the connector area were caused by an inadequate connector cross-section and subsequent grinding without water cooling of the zirconia frameworks as well as a learning curve of the laboratories working with CAD-CAM technology. Connector areas are at increased risk of failure if the radius of curvature is reduced (Plengsombut et al., 2009; Oh and Annusavice, 2002). The gingival embrasures of connectors are shown to be the site of highest stress concentration when using finite element (FE) modeling (Dittmer et al., 2009). Insufficient connector dimensions, framework grinding damage while making shape adjustments, positioning of the connector outside the arch of occlusion, all

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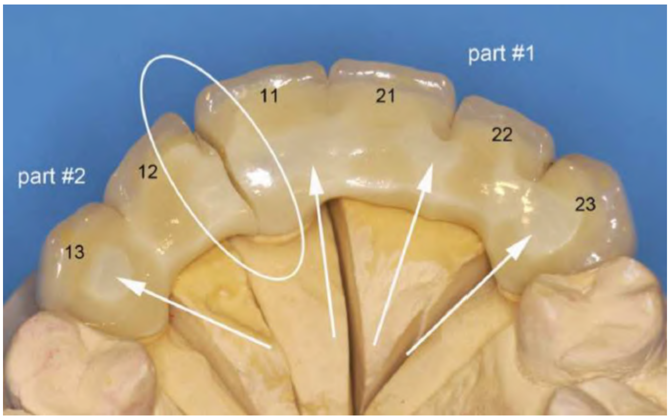

Figure 1. Cercon® veneered six-unit anterior zirconia bridge, fractured between the upper teeth 11 and 12 in the maxillary arch (FDI numbers for each relevant tooth are labelled). The fracture surface distal of tooth #11 is labelled part #1, the fracture surface mesial of tooth #12 is labelled part #2. The region of fracture and exposed zirconia core structure are indicated by the arrows and the loading direction is indicated in red.

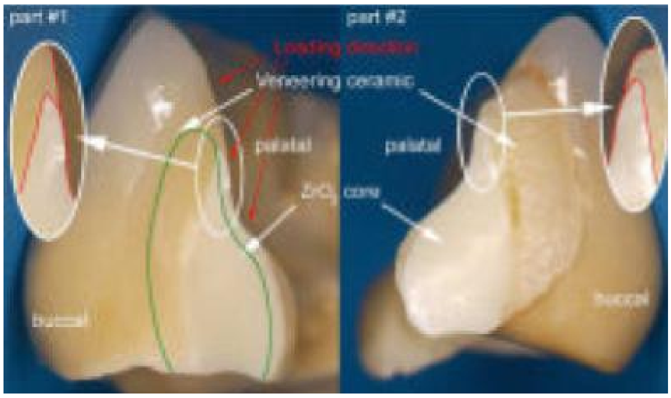

Figure 2. Recovered part #1 and part #2, exhibiting the fracture planes. The green line indicates an appropriate and clinically correct shape and positioning of the framework connector.

contribute to connector failures (Aboushelib et al., 2009). In the anterior sector, connector dimensions may be difficult to achieve and dental technicians tend to create sharp embrasure forms to improve the esthetics (Oh and Annusavice, 2002).

Fractography is a well established tool in engineering to examine fractured, brittle surfaces (Frechette, 1990; Mecholsky, 1995; Quinn, 2007). The use of fractographic pattern and surface feature recognition has been applied in dentistry to clinical ceramic restoration failure analyses (Thompson et al., 1994; Quinn et al., 2005; Scherrer et al., 2006; Scherrer et al., 2007; Scherrer et al., 2008; Taskonak et al., 2008). Features like compression curl, hackle, wake hackle, twist hackle, and arrest lines were the most commonly found markings in failed all-ceramic restorations. (Quinn et al., 2005; Scherrer et al., 2006; Scherrer et al., 2007; Scherrer et al., 2008). Those markings are all contribute to identify the direction of crack propagation (dcp) and failure origin to finally state the specific reasons for failure.

The purpose of this work was to fractographically analyze the broken parts of an in vivo fractured six unit anterior zirconia FPD, revealing the responsible causes for premature failure.

2. Materials and Methods

A 24 hours in vivo fractured anterior (canine to canine) six-unit maxillary FPD was provided by a dental clinician, as shown in Fig 1. The FPD was manufactured by that dental technician in a private laboratory who had been trained in CAD/CAM techniques and handling the Cercon® system (Cercon® base, Degudent, Hanau, Germany)* for the zirconia framework. The Cercon® framework consisted of a Y-TZP sintered at 1350°C, (coefficient of thermal expansion (CTE): $\alpha f = 10.5 \times 10-6$ 1/K) and veneered with a feldspar-based porcelain ($\alpha v = 9.9 \times 10-6$ 1/K) (Elephant® Sakura, Elephant Dental, Hoorn, Netherlands). For FPDs, connector dimensions of 9 mm2 are recommended by the Cercon manufacturer. According to the dental technician, after CAD-CAM machining, the framework was manually adjusted by reshaping the palatal surface. A final regeneration firing was conducted at 1000°C for 15 min, even though not necessarily recommended by the manufacturer. According to the clinician, additional occlusal grinding adjustments were performed as a fine-tuning step after veneering prior to luting the bridge with a temporary cement (Temp Bond®, Kerr Hawe, Bioggio, Switzerland) on the three abutment teeth, two canines and the central right incisor (#13, #11, #23 FDI numbering system), for an initially planed one week try-out period. A through-the-core fracture occurred while chewing after 24 hours in vivo at the connector level between the abutment teeth #11 (central incisor) and the lateral incisor pontic #12. The patient reported no excessive or abnormal loading events during the day. The fractographic examination of the two retrieved fragments was performed using a systematic approach (Scherrer et al., 2008) with light stereomicroscopy (LM) as well as scanning electron microscopy (SEM). Prior to the microscopic investigation, the broken pieces were cleaned in an ultrasonic alcohol bath for 10 min. The macroscopic appearance was examined

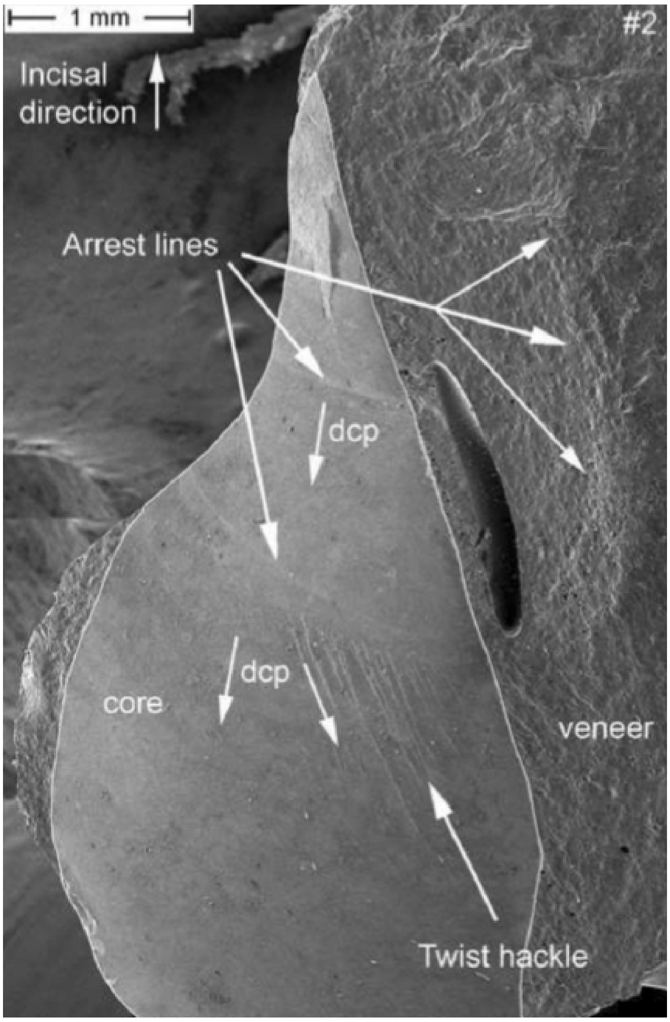

Figure 3. SEM image of the zirconia core section of part #2. A connector area of 8.4 mm2 was measured. Fractographic features like arrest lines and twist hackle are indicated. The direction of crack propagation (dcp) is indicated. A major processing pore is seen in the veneering ceramic.

using the LM (SV11, Zeiss, Oberkochen, Germany) under different illumination. The SEM (Leitz ISI SR 50, Akashi, Japan) was used for characterization of morphology, microstructure and fractographic details on the fractured surfaces.

3. Results

Figure 1 shows the global palatal overview of the Cercon® six-unit anterior zirconia bridge repositioned on the working stone model. The fracture is located at the connector level (white circle) between the central right incisor (tooth #11) and the pontic tooth #12. The two fractured parts analyzed have been labeled part #1 for the fractured surface view towards tooth #11 and part #2 for the fractured surface view towards tooth #12. From the palatal direction, regions of exposed zirconia core structure can be seen as indicated by the arrows. The actual

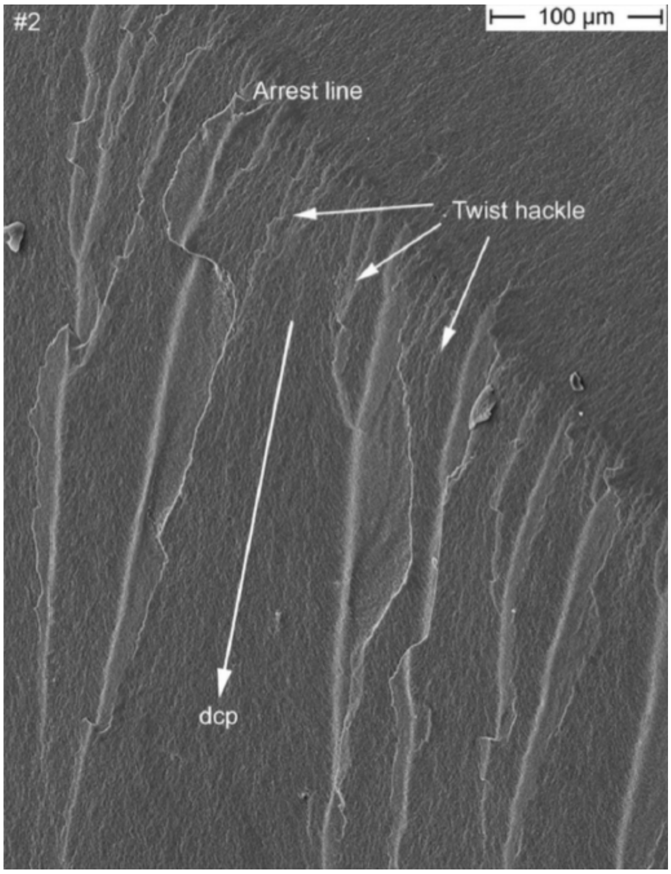

Figure 4. SEM image of a detailed view of the twist hackle region, indicated in Fig 3. The direction of crack propagation (dcp) is indicated by the arrow (moving downwards towards the gingival side)

fracture planes of the fractured parts #1 and #2 are shown in Fig 2. The zirconia core has a non-suitable drop-shape connector design (outlined in red), whereas the veneering porcelain shows a high volume on the buccal side but is almost absent from the occlusalpalatal surface. The green line indicates what would have been a more clinically appropriate shape and positioning of the framework connector. Fig. 3 provides a SEM closeup view of part # 2. On this image, the actual connector area was measured to be only 8.4 mm^2 using image analysis software (KL ACI Focus, Klughammer, Markt Indersdorf, Germany) which does not match the minimal requirement by the manufacturer of 9 mm^2.

At low magnifications, two clear arrest lines and twist hackle are visible on the zirconia core as indicated by the arrows in Figure 3. These two easily seen features provide already a clear indication as to the dcp which is running from top (incisal) to bottom (gingival). Indeed, the arrest lines are perpendicular to the crack propagation and the origin of the crack is located on the concave side of the first arrest line, which means further up, near the incisal

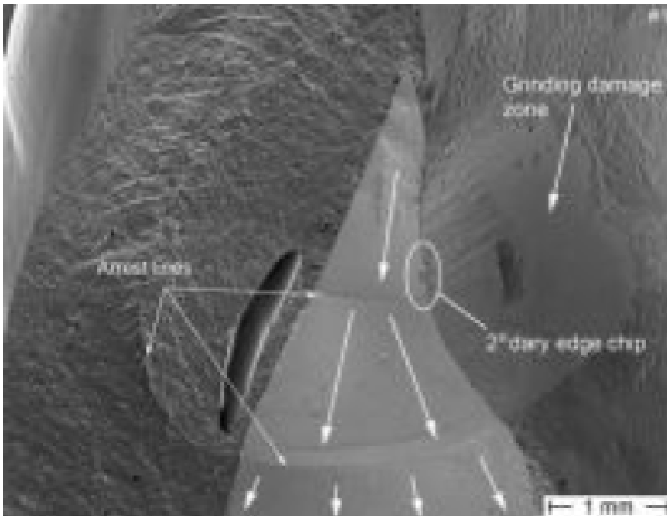

Figure 5. SEM image of the fracture part #1 exhibiting the same arrest lines in the zirconia core as with part #2. A major processing pore is seen in the veneering ceramic. The direction of crack propagation (dcp) is indicated by the white arrows. The concavity of the arrest lines as well as the presence of twist hackle in the zirconia framework point back to an origin located at the tip of the framework (see Fig. 6). A secondary edge chip (see Fig. 7) on the zirconia palatal surface next to a manually reground zirconia frame region is indicated by the white circle.

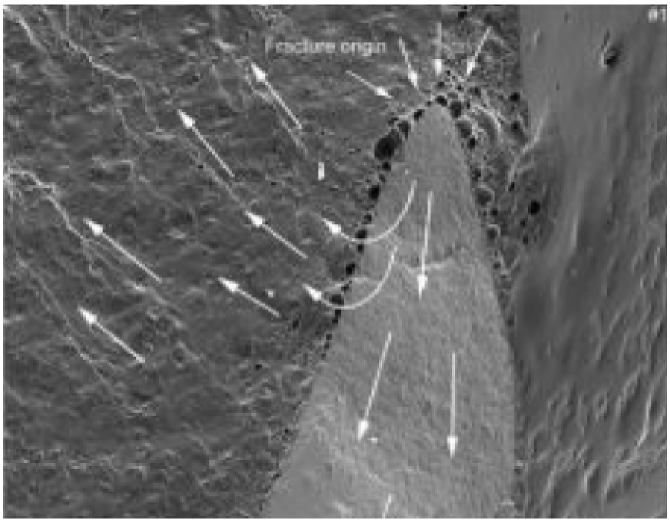

Figure 6. Higher magnification of Fig 5, shows the fracture origin at the tip of the zirconia core frame in form of a pore cluster within the veneering ceramic at the interface core-veneer (small arrows). The primary crack front moves from the tip downwards along the core (very fine hackle and arrest lines are visible on the core surface), whereas a secondary crack front moves with a twist direction towards the buccal side within the veneering ceramic as seen by the presence of hackle and wake hackle. The large arrows indicate the dcp.

tip of the core. Next to these two arrest lines, and within the veneering ceramic is a major pore. An arrest line is in continuation with this pore but can be better seen in the matching half (part #1) in Fig. 5. This veneer arrest line represents a slowing down of the crack front soon after encountering the pore. The second feature visible in Fig. 3 and serving as an indicator of dcp are twist hackle. These are seen at higher magnification in Fig. 4 emanating from a core arrest line. They are hackle with a rotation due to a new stress direction giving them the appearance of lances as the small hackle lines merge into coarser needle like hackle lines. The dcp (arrow) is moving from incisal (top) to gingival (bottom). The second recovered broken part (Fig. 5) shows a better overall image. Three arrest lines are clearly visible on the zirconia core surface, and so is a big pore and an arrest line in the veneering ceramic. In addition, a small edge chip and a grinding damage zone on the palatal exposed zirconia frame are marked and are discussed in more detail further in the text under Fig. 7. A closeup image of the incisal tip of the zirconia frame (Fig. 6), shows the fracture origin at the tip of the zirconia core frame in form of a pore cluster within the veneering ceramic at the interface core-veneer (small arrows). Wetting of such a thin (< 200 µm) zirconia frame tip is a difficult task for the lab technician and may result in trapped air bubbles. Such a flawed core-veneer interface was seen with the pore cluster in Fig. 6. Classic fractographic features such as a fracture mirror surrounding the failure-initiating defect were not present in Fig. 6. This is not uncommon in clinical fractographic failure analyses (Thompson et al., 1994; Quinn et al., 2005; Scherrer et al., 2006; Scherrer et al., 2007) and it indicates there were either very low stresses that caused fracture, or stress gradients existed that decreased the stresses away from the origin site. The primary crack front moves downwards but is slightly perturbed at the initial stage by some surface irregularities on the fractured core surface giving rise to a secondary crack front which moves with a twist towards the buccal side within the veneering ceramic. Large arrows indicate the general dcp.

Fig. 7 shows a higher magnification of Fig. 5 of the edge chip which started on the palatal exposed zirconia frame next to some grinding damage and next to some glaze remnants. The initial flaw size of the chip is of 35 µm and delineated by an arrest line. This edge chip crack is however stopped soon after as seen by the absence of hackle penetrating into the core beyond the chip, indicating that this is a secondary event. Indeed, many micro-fine texture hackle in the core material are propagating downwards to the gingival margin and are perpendicular to the edge chip. Those fine hackle together with the major arrest lines (Fig. 3 and 5) are clear indicators of the prime crack front (big white arrows) moving downwards towards the gum. There also is no indi-

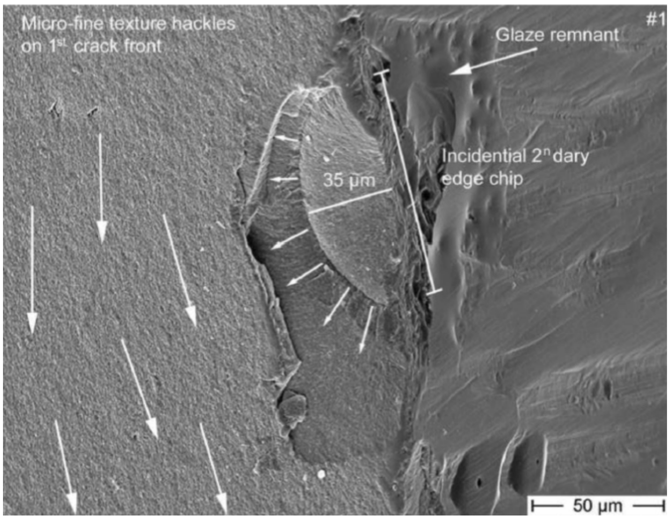

Figure 7. SEM magnification of the secondary edge chip from Fig 5 starting on the exposed zirconia frame on the palatal surface next to some glaze remnant. The initial flaw size of the chip is of 35 μm and delimited by an arrest line. This edge chip crack is however stopped soon after as seen by the absence of hackle penetrating into the core beyond the chip size, indicating that this is a secondary event. Many micro-fine texture hackle visible in the core material are propagating downwards to the gingival margin, perpendicular to the edge chip (big white arrows).

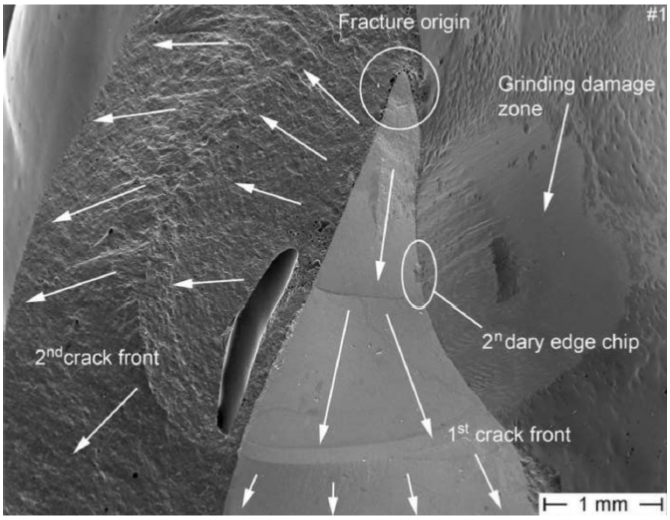

Figure 9. Final mapping of the fracture event. Failure occurred from a stress concentrating zone at the tip of the zirconia framework (origin). Based on fractographic evidences (arrest lines, hackle, wake hackle, twist hackle) the crack moved in a downward direction as indicated by the arrows. A secondary edge chip on the palatal exposed zirconia framework was incidental and not related to the final failure.

cation whatsoever of this edge chip on the matching fracture half on part 2 shown in Figure 3, which confirms the edge chip is a secondary fracture that only occurred in part 1.

Fig. 8 provides a close-up view of the big pore in the veneering ceramic. This enormous pore is approximately 1.3 mm in length. Wake hackle emanate from tiny pores in the veneering ceramic which allow us to follow the direction of the crack front. It moved through and around the big pore in a counter

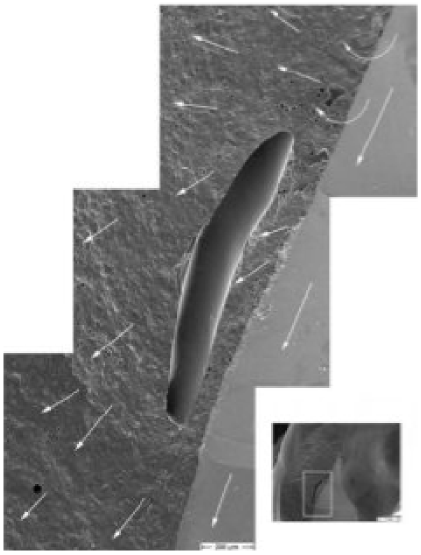

Figure 8. This SEM photomontage shows the region of the big pore as seen in part #1. Hackle and wake hackle within the veneering ceramic indicate the direction of the crack front, contouring the big pore in a counterclock rotation. The dcp is marked with the white arrows.wake hackle. The large arrows indicate the dcp.

clock rotation and finished parallel to the zirconia core crack front moving downwards in a gingival direction. All the above evidence show that this large pore was not the origin of fracture.

4. Discussion

A six-unit bridge failure after 24 hours of intra-oral use is always a bit suspicious and thorough investigations have to be performed to understand the problem. In this case, the patient factor can be neglected to be responsible for failure, since the bridge fracture happened after the first day of provisional cementation and there were no special events reported of critical intraoral chewing during this period. Also slow crack growth or aging as fatigue mechanisms are not likely to contribute to the present clinical case in such a short in vivo period (Lohbauer et al., 2002; Studart et al., 2007). After fractographic analysis of the broken parts, several errors have been identified contributing to the early failure.

The first important observation was that fracture was in a plane perpendicular to the dental arch. From the law of normal crack propagation (Frechette, 1990; Quinn, 2007), it may be deduced that the axis of maximum principal tensile stress was parallel to the framework long axis.

The fracture surface examinations show the general direction of crack propagation as evidenced by arrest lines, hackle, twist hackle, and wake hackle, and could be mapped on the fractured parts. Fracture clearly started from the incisal tip of the palatal zirconia framework and propagated towards the cervical region in this maxillary FPD. This is somewhat surprising, since most bridge and framework fractures start from the gingival side, often at a connector, and propagate towards the palatal regions due to bending stresses generated by occlusal loading on the pontic (Oh et al., 2002; Luthy et al., 2005; Kelly et al., 1995). One likely scenario is that this 6 unit FPD was unevenly supported by the three abutments. Upward occlusal loadings on units 13 or 12 as well as upwards occlusal loadings on the other side (units 21 to 23) caused bending about unit #11 which acted as a fulcrum (or pivot point) such that tensile bending stresses developed at the incisal side of the FPD on the connector side of unit #11.

Another very likely source of the tensile stresses may be from the unbalanced thermal contraction strains, which may also have contributed to fracture. The CTE of the veneer is typically less than that of the core ceramic, so that after cool down, the veneer is in a state of residual compression and the framework material is in residual tension (Kingery et al., 1960; Taskonak et al., 2008b). In the present case, the framework is so thin at the origin location that the contraction is dominated by the thick veneer (Fig 2). The thin framework is held in tension by the veneer which contracts less. A simple estimate of the framework stresses, σf, may be made by assuming the veneer contacts fully, and thus the stress in the framework is:

$$\sigma_f = (\alpha_f - \alpha_v) \times E_f \times \left(T_g - 25°C\right) = 66 \quad \text{MPa}$$

where the framework expansion coefficient, αf, is 10.5 × 10−6 1/K, the veneer αv, is 9.9 × 10−6 1/K, Ef is the elastic modulus of the framework (205 GPa), and Tg is the glass transition temperature of the veneer (Tg = 565°C for a similar zirconia veneer (Taskonak et al., 2008b). This tensile stress σf, which acts in the direction of the dental arch and is perpendicular to the plane of fracture, is not large, but it will be severely concentrated around the flaws that exist at the tip of the core material. The stress concentration factor for a through hole in a plate is a factor of 3, and it is not hard to imagine even higher stress concentrations around the pore network at the fracture origin site (see Fig 6), so the residual thermal stresses could be several hundred MPa.

The crack origin itself was identified as being located at the tip of the core frame surrounded by pores resulting from poor wetting of the veneering ceramic. This drop shape design is unsuitable for a bridge frame as high stresses will concentrate at the tip if the FPB bends as described above. This is also an area subjected to occlusal contact pressure. A wider plateau design of this frame tip and in general a larger connector surface area (Filser et al., 2001) would have prevented this type of failure from the occlusal-palatal contact surface.

The volume distribution of the core/veneer is erroneous as the framework is located far too much the palatal side resulting in a high veneer volume on the buccal side and little to no veneering on the palatal side due to a lack of vertical space. Figure 2 (green line) shows a clinically recommendable framework design. Several authors have emphasized on the importance of an anatomically supportive design of the frame and appropriate core-veneer distribution (Tinschert et al., 2008; Molin and Karlsson, 2008). Usually, the unveneered framework is tried-in and checked by the dentist before moving on with the veneering. The dentist at that stage controls the occlusion and fit and will recognize any oversized framework dimensions or problematic core design. He will then proceed with the acceptance or rejection of the framework providing a feed-back to the laboratory. This try-in session was unfortunately not done in the present case and would have prevented the lab technician from further performing core adjustments through grinding as well as veneering an unsuitable core design to start with.

The zirconia framework was reshaped in the laboratory by grinding off the palatal surface due to an excessive thickness interfering with the occlusion, as seen from the grinding marks on palatal side of the broken bridge. This rough reshaping risks the introduction of critical surface damage which will lower the zirconia strength (Kosmac et al., 1999; Wang et al., 2008; Curtis et al., 2006). Such reshaping could have been prevented by a more careful and adequate computer design, aided if necessary by a wax-up of the frame.

Finally, the investigated zirconia bridge was provisionally cemented using a temporary zinc oxide-eugenol based luting material (Temp Bond®). For zirconia restorations, most manufacturers recommend conventional, retentive glass-ionomer or zinc phosphate cementation (Taskonak et al., 2008). However, superior adhesion has been reported when using tribochemical silica coating on the intaglio side of the zirconia frameworks and in combination with resin-based luting agents containing reactive monomers (pendant phosphate esters) (Leevailoj et al., 1998; Ernst et al., 2005; Blatz et al., 2003; Atsu et al., 2006). Finite element analysis support this hypothesis due an effective stress transfer between a stiff frameworks and the supporting tooth structure, when using resin luting agents (Proos et al., 2003). Such a resin-based luting procedure would have helped delay the failure event.

Acknowledgments

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FRACTOGRAPHIC ANALYSIS OF A DENTAL ZIRCONIA FRAMEWORK

6. At what temperature was the regeneration firing done:
    a) 1350 °C
    b) 1100 °C
    c) 1000 °C
    d) 950 °C

7. The study was conducted on what type of Zirconia system:
    a) Zircon Zahn
    b) Cercon
    c) Bruxzir
    d) Lava

8. Which fractographic features were most commonly found in failed all-ceramic restorations:
    a) Wake hackle
    b) Cross-section
    c) Compression curl
    d) a & c

9. Because of the difference in CTE between the framework and the veneered porcelain, the framework is in a state of:
    a) Residual compression
    b) Residual tension

10. Which two systems were used to do the fractographic examination:
    a) DCP & CTE
    b) SEM & DCP
    c) SEM & LM
    d) LM & DCP

Comparison of immediate complete denture, tooth and implant-supported overdenture on vertical dimension and muscle activity

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PURPOSE: To compare the changes in the occlusal vertical dimension, activity of masseter muscles and biting force after insertion of immediate denture constructed with conventional, tooth-supported and Implant-supported immediate mandibular complete denture.
MATERIALS AND METHODS: Patients were selected and treatment was carried out with all the three different concepts i.e, immediate denture constructed with conventional (Group A), tooth-supported (Group B) and Implant-supported (Group C) immediate mandibular complete dentures. Parameters of evaluation and comparison were occlusal vertical dimension measured by radiograph (at three different time intervals), Masseter muscle electromyographic (EMG) measurement by EMG analysis (at three different positions of jaws) and bite force measured by force transducer (at two different time intervals). The obtained data were statistically analyzed by using ANOVA-F test at 5% level of significance. If the F test was significant, Least Significant Difference test was performed to test further significant differences between variables.
RESULTS: Comparison between mean differences in occlusal vertical dimension for tested groups showed that it was only statistically significant at 1 year after immediate dentures insertion. Comparison between mean differences in wavelet packet coefficients of the electromyographic signals of masseter muscles for tested groups was not significant at rest position, but significant at initial contact position and maximum voluntary clench position. Comparison between mean differences in maximum biting force for tested groups was not statistically significant at 5% level of significance.
CONCLUSION: Immediate complete overdentures whether tooth or implant supported prosthesis is recommended than totally mucosal supported prosthesis. [J Adv Prosthodont 2012;4:61-71] 61

KEY WORDS: Immediate denture; Implant-supported denture; Electromyography; Bite force

INTRODUCTION

Edentulous patients with complete dentures are generally satisfied but up to 30% of the patients have complaints.[1] They suffer from a variety of problems with their dentures, especially with regard to the lower denture, such as insufficient stability, retention and pain during mastication.With time, the resulting pain and difficulty may increase during oral functions to an extent that proper nutritional intake and the patients' ability to communicate with ease and confidence are jeopardized. Psychosocial problems are the result of diminished attractive facial appearance, difficulties with speech and avoidance of social contacts.[2]

Immediate dentures are dental prostheses constructed for insertion immediately following the extraction of the natural teeth and the attendant surgical procedures. Reviewing through the literatures[3-6] has indicated that immediate denture service has several advantages as the natural facial expression and appearance is maintained because the facial muscles are maintained in their correct position and the patient never appears edentulous. Facial height is retained as the facial muscles will function at their natural length, neutral zone is maintained because the artificial teeth are arranged in a similar manner to their natural predecessors. Mastication is easy or even better than after a period of edentulousness without dentures and minimal speech impairment as there is minimal loss of masticatory efficiency because pa-

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tient is not without teeth anytime. Other advantages of immediate dentures are that the occlusal vertical dimension can be accurately determined and that the remaining natural teeth aid in recording centric relation. The immediate insertion of dentures may also control hemorrhage, aid tissue healing, and contribute to the patient's comfort following surgery. However, rapid resorption of the alveolar ridge which often occurs following tooth extraction is considered as a disadvantage in immediate denture service.

For many years, traditional complete denture designs have been modified to gain additional support and stability from a few retained and suitably prepared natural teeth. Mericske-Stern et al.[7] attested to the effectiveness of such tooth-supported complete dentures or overdentures as alternative to complete dentures. Roots maintained under the denture base preserves the alveolar ridge, provide sensory feedback and improve the stability of the dentures.

Recently, Morais et al.[8] reported that overdenture treatment with the use of implants has become popular for edentulous elderly patients who are maladaptive to complete dentures. Although the biologic basis of implants installed in the bone is different from roots surrounded by a periodontal membrane, but the prosthetic concept is similar. Tactile sensation for implant is reduced because of the absence of periodontal receptors. However, oral function with overdentures supported by roots or implants is comparable and does not seem to depend on the presence of a periodontal membrane. They are a preferable alternative to treatment with conventional complete denture, the main advantages are decreased resorption of the residual ridges; psychological benefits for the patients and maintenance of masticatory efficiency.[9]

Reviewing of the literature had demonstrated a higher tendency for success when overdentures are supported by implants than by roots. This is particularly true for mandibular overdentures whereas for maxillary implants, more frequent failures are observed with low bone quality and short implants.[7] Dental implants present several advantages over questionable teeth. From a restorative perspective, dental implants are made of materials with known physical properties that can provide standardized structural durability as abutments, also dental implants are not subjected to caries and may be used successfully even in caries-prone individuals.[10]

According to the previously cited merits with immediate denture, the question remained unanswered to what extent, provision of tooth and implant-supported mandibular overdentures would beneficially aid to edentulous patient in maintaining his or her masticatory force and occlusal vertical dimension rather than rendering him or her completely edentulous. This question warranted us to plan this study to evaluate to what extent immediate tooth and implant-supported overdentures would aid beneficially to preserve occlusal vertical dimension, biting force and maintain masticatory muscle activity. Parameters of evaluation and comparison were occlusal vertical dimension changes measured by radiograph, masseter muscle electromyographic changes measured by EMG analysis and maximum bite force changes measured by force transducer.

MATERIALS AND METHODS

Fifteen patients were selected from the out patient clinic, Faculty of Dentistry, Mansoura University. Their age were ranging from 45 to 55 years, with the mean age of 53 years. Patients were selected according to the following criteria; no signs and symptoms of TMJ dysfunction, no systemic disease which may affect the muscles, ligaments or bone, no history of prosthesis wearing and Angle's class I maxillo-mandibular relation. They had at least second premolars on each side acting as a bilateral occlusal vertical stoppers, sufficient to maintain vertical dimension of occlusion. Remaining teeth were present with unfavorable conditions needed to be subsequently extracted. All patients had approved to participate in this study and strongly motivated to retain their remaining canines.

The fabrication of immediate mandibular dentures was started by construction of a transitional distal extension acrylic partial dentures for lower jaws and complete dentures for upper jaws. Surgical preparation of the remaining natural teeth was done and all were extracted leaving the mandibular anteriors and a bilateral centric occlusal stopper on both jaws (second premolars). After a healing period, the impression procedures for construction of a maxillary complete denture opposing to a transitional mandibular bilateral distal extension acrylic removable partial denture were done in a conventional way.

Jaw relation records were judged by the contact of the remaining natural teeth which indicated occlusal vertical dimension and casts were mounted on the semi-adjustable articulator according to it. Shape, shade and form of the extracted and the remaining natural teeth were used as a guide to select the acrylic denture teeth. For freeing of occlusion, posterior teeth with thirty degrees of cuspal incline were used for maxillary denture and cuspless teeth were used for mandibular denture. Anterior teeth arrangement with zero overbite and two millimeter overjet was done. Selection and setting of posterior teeth were done according to procedure described by Passamonti et al.[11] with main objective to reduce occlusal interference. Trial dentures were tested in the patient's mouth. The remaining natural premolars were trimmed off from the casts and replaced with the acrylic to complete the arrangement of the posterior teeth. A simple circlet stainless steel wrought wire clasp was adapted on each retained mandibular canines for gingivally approaching undercuts. Acrylic partial denture was planned on the remaining anterior teeth. Steps for denture completion were done including flasking, acrylic resin packing and curing, deflasking, finishing and polishing.

Prior to delievery of denture, laboratory remount was done to eliminate minor occlusal error resulting from acrylic resin processing. The remaining premolars were extracted with a minimal trauma. Bony spicules and sharp edges were carefully removed. Insertion of the dentures was done while the patients were under local anesthesia. The dentures were tested to ensure that, there were no sharp ridges or acrylic pearls on the impression surface of the denture. After appropriate infection control, the lower removable partial denture was placed in the mouth and assessed so that no overextensions were present along the periphery of the denture. Gentle pressure was applied on the occlusal surfaces of the lower premolar teeth to ensure that no stability problems were evident at this stage. Similarly, the upper denture was inserted and tested.

Occlusal relationships were confirmed and initial spot grinding was done to remove any occlusal prematurities. Patients were instructed about denture hygiene, mucosal tissue rest and denture manipulation. They were motivated for maintenance of good oral hygiene. Period of 45 days was permitted for patient adaptation to their prosthesis and any prosthesis correction and adjustment needed were done.

Grouping of the selected patients according to the study design was done and the patients were randomly classified into three equal groups as follows:

Group A: 5 patients who will be receiving conventional acrylic immediate complete mandibular denture (mucosal-supported).
Group B: 5 patients who will be receiving acrylic immediate complete mandibular denture supported by reduced root canal treated canines (tooth-supported).
Group C: 5 patients who will be receiving acrylic immediate complete mandibular denture supported by osseointegrated fixtures in the canines region (implant-supported).

In Group A, addition of the anterior teeth to the mandibular partial dentures was done in the conventional way, stored in a germicidal solution and inserted just after extraction of the lower anteriors. The patient was instructed to take care and not to remove the denture during the first 48 hours. Following that evaluation of the denture and the supporting tissues was done. Any ulceration from denture pressure or overextension of the base was relieved. The patients were instructed to clean the denture several times a day and utilize warm saline rinses and keep the denture in at night for five days.

In Group B, the procedures were followed according to Schwartz and Morrow.[12] The mandibular canines were prepared on the cast to approximate the preparation that will be done intra orally and the remaining teeth were trimmed away in the usual manner. Abutment area in the finished denture fitting surface was relieved using a suitable acrylic finishing stone. Before surgical procedure, the retained mandibular canines were root canal treated, shortened to a level 2 - 3 mm in a dome shape and sealed occlusally with amalgam filling. Adaptation of the mandibular overdenture to the patient abutment was done after complete healing of the surgical site and suture removal.

Caries protective varnish (Fluor Protector, Ivoclar Vivadent, Lichtenstein, Germany) was applied for two minutes weekly, for two weeks. For complete protection from caries, construction of a casted dome shaped dowel coping were done and inserted above the prepared mandibular canines abutment after two weeks. Readaptation of the mandibular overdenture was done.

In Group C, extraction of mandibular canines and immediate placement of an implant in the extraction site was discussed with each patient as an alternative for total extraction of their teeth and insertion of conventional denture. The implant surgical procedure in this study was followed according to Palmer et al.[13] The surgical protocol for immediate dental implant placement into fresh extraction socket with two part dental implant system was followed according to el Charkawi's[14] procedure as follows; atraumatic extraction of the canines was achieved with extraction forceps and every effort was made to preserve labial cortical plate, avoiding gingival laceration and canine fracture.

Uncoated titanium screw shaped implant (Impladrill Titanium Dental Implant System, Basel, Swiss) 3.8×13 mm were used for placement in extracted canine sites. After completion of the surgical procedures, the removable partial denture was seated in its place and tested for adequate relief above the implant sites. Once the surgical sutures were removed, intra oral adaptation and close fitness of the mandibular partial denture above the implant sites was achieved using a cold cure soft liner. Following this patients were seen frequently in the first 3 months, the proper oral hygiene was followed-up for all the patients.

The implant suprastructure used was modified to resemble dome shape, which provided abutment denture point of contact that permited mandibular overdenture free movement. After insertion of the abutments, extraction of the remaining incisors and insertion of the mandibular complete overdenture was done and post insertion care was taken. After the surgical sutures were removed, adaptation of the mandibular overdenture to the patient abutment with tooth shade autopolymerizing acrylic resin was done.

For determination of changes in occlusal vertical dimension for patients in all groups; lateral cephalometric radiographs were taken to detect occlusal vertical dimensional changes. Radiographic exposures were made at four occasions:

1. Before dental extraction with only bilateral upper and lower second premolars maintaining centric occlusion, vertical and horizontal relation.
2. Two weeks after transitional removable partial denture insertion (Time 1).
3. Two weeks after complete immediate mandibular denture insertion (Time 2).
4. One year after immediate denture insertion (Time 3).

Tracings of lateral cephalometric radiographs were done and the reference points, lines and measurements used for determination of occlusal vertical dimension were made according to the procedure described by Lambadakis and Karkazis.[15] Reference lines marked were palatal plane, anterior cranial base, mandibular plane and d (line). d line was considered as a measure of vertical dimension of occlusion (Fig. 1). Comparison between mean variance of occlusal vertical dimension between observation times was statistically analyzed at 5% level of significance.

Masseter muscle electromyographic activity measurements were recorded and processed digitally in the Medical Electronics Laboratory, Faculty of Engineering, Mansoura University using the BIOPAK system (MP100 WS BIOPAC Systems, BIOPAC Systems Inc., Santa Barbara, USA) connected to an electromyographic nodule. BIOPAK electromyographic device with a band pass of 25 to 1500 Hz = 3 dB and noise level < 0.05 Mv were used to record the EMG from the bilateral masseter muscles for 30 seconds. The surface electromyographic activities were made while the patient was sitting upright on a chair, head unsupported relaxed and looking straight. Bipolar surface electrodes were used for masseter muscle activity recording after scrubbing the superficial skin with alcoholic ether. The electrodes were circular with a diameter of 10 mm and a fixed inter electrode distance of about 10 mm was maintained to avoid pick-up of non specific facial muscle activity. To position the electrodes in the proper location according to Saifuddin et al.,[16] one line was drawn from the inferior border of the tragus of the ear to the angle of the mouth. The masseter muscle width was measured by palpation and half of the width of the muscle was marked with an ink spot on that line. Electrodes were placed on both sides of the line around the ink spot and parallel to the main direction of the masseter muscle fibers. A common ground electrode was attached to the forehead of the patient. The electromyographic activity of the masseter muscle was recorded bilaterally during rest position (RP), initial contact position (IC) and maximum voluntary clench (MVC) after one year from immediate denture insertion.

EMG data were recorded with a sampling frequency 2 KHz for a time interval of 10 seconds. The recorded data were stored for further analysis. The EMG recorded data were transmitted to a personal computer and processed using MATLAB 7.0.1 (Release 14SP1, The MathWorks, Inc., Natick, USA) computer program. Wavelet packet coefficients values were computed for the masseter muscles (Right & Left) during RP, IC and MVC for each patient of the three groups and statistically analyzed by using ANOVA-F test at 5% level of significant. If the F test was significant, Least Significant Difference (LSD) test was performed to test further significant differences between the variables.

Bite force strength of each patient was measured using bite force transducer. Force transducers employed beam deflection and this deflection was sensed by a strain gauge which converts forces into measurable electrical signals. Bite force transducer consisted of force transducer and bite fork. Force transducer was composed of elastic load-bearing element for load application, strain gauge, for induced strain recording in terms of millivoltage and elastic load-bearing element. The elastic load-bearing element was constructed according to concept developed originally by Slagter et al.[17] and van Kampen et al.,[18] but with some modifications to suite this study as follows: casted dumbbell shaped bearing element with chrome cobalt was constructed as compared to hollow one to prevent the permanent deformation. Hard stainless steel coil was incorporated to the inner site of elastic element and a side cut with 2 mm space was made along one ring of the dumbbell to make it more flexible without permanent deformation during loading (Fig. 2).

Strain gauge was used for recording strain induced on the elastic bearing element in term of millivoltage. The Kyowa (Strain gauge, Kyowa Electronic Instruments Com. Ltd. Tokyo, Japan) type strain gauge was used with the following criteria; Gauge 2.13 ± 105%, Resistance 119.6 ± 0.3, Length 10 mm, Thermal output µC- /°C ± 1.8 and Gauge cement Ep-IC- . Strain gauge attachment to the elastic bearing element was done. The force transducer unit was attached to a side of specially constructed bite fork. The other side of the fork was attached to a polyethylene elastic tube, for the stabilization of the dentures during maximum biting force measurement. The mouth pieces (force transducer and stabilizing unit) were covered with an elastic rubber

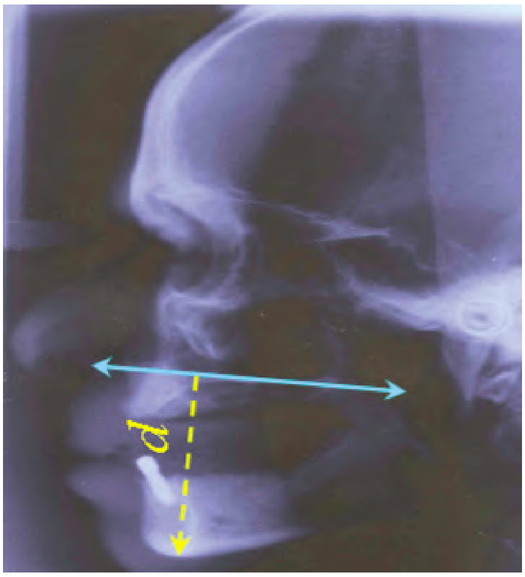

Fig. 3. Comparison between the mean differences in occlusal vertical dimension changes measured in mm for groups after insertion of transitional mandibular RPD (Time 1), after insertion of immediate mandibular dentures (Time 2) and after one year of immediate mandibular dentures insertion (Time 3).

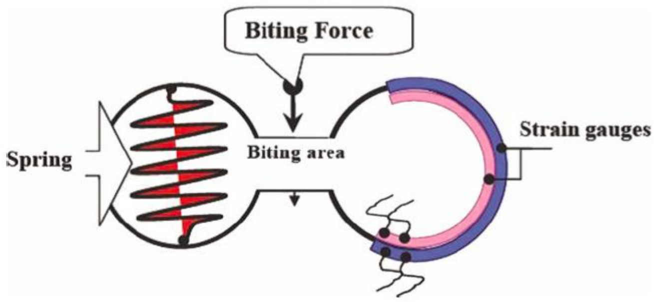

Fig. 2. Cross section diagram of the elastic load bearing element and mounted strain gauges.

fingers which were changed for every patient, every time the measurement was done.

Measurement of voltage changes in the circuit with mV was done using Radioshack Digital Multimeter with a computer program 22-812 Meter View version 1.0 compatible with Windows XP. The differences between unloaded force transducer record and maximum loaded force transducer record were calculated as mV value of the maximum biting force. A simple method of calibration of bite force transducer was used according to Prombonas et al.[19] to assort it by different applied load. Calibration was done in the Agriculture Engineering Laboratory, Faculty of Agriculture, Mansoura University using a testing machine (FGN - 50 Digital - LCD force testing machine, Lloyd InstrumentsTM, AMETEK, Inc., West Sussex, UK) to apply loads of 1, 2, 4, 6, 8, 10, 12, and 14 kilograms.

The transducer output was varied linearly with the force, therefore calibration was done experimentally using weights of known mass. For calibration purpose, complete maxillary and mandibular finished dentures were mounted on a simple hinge articulator to simulate the oral condition during biting. All loads were applied through a bar mounted in contact with the central point present in the upper part of the articulator during loading. The mV measurements were converted to kilogram (kg) according to the following equation: Bite Force (kg) = mV×1.074 where 1.074 = constant factor from calibration curve.

The bite force transducer was positioned between the occlusal surfaces in the first molar region. The reproducible bite position for all measurements were obtained by insertion of the pin like projection which was present in the elastic element in a hole formed at the central fossa of the occlusal surface of the first molar of the denture. Patient was encouraged to bite as hard as possible on the bite-force transducer for a few seconds. The measurements were performed three times and the highest bite force of the three efforts was selected as a valid record. The procedure was repeated with the transducer placed on the contralateral side for recording of bite force. Right (R) and left (L) maximum biting force values were summed and the main value was calculated. The measurements were done for all groups one month after prosthesis preparation and twelve months after insertion of immediate dentures for all groups.

Data were collected from all the different groups and were subjected to statistical analysis via ANOVA-F test at 5% level of significance. If the F test was significant, LSD test was performed to test further significant differences between variables.

RESULTS

Comparison between mean differences in occlusal vertical dimension for tested groups at Time 1 and Time 2 was not statistically significant while at Time 3 it was statistically significant at 5% level of significance (Table 1 and Fig. 3)

The mean occlusal vertical dimension changes in Group B were -0.34 ± 0.0894 in time 1, -0.74 ±

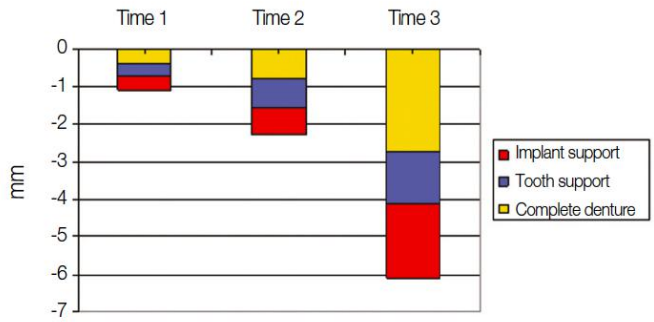

Fig. 3. Comparison between the mean differences in occlusal vertical dimension changes measured in mm for groups after insertion of transitional mandibular RPD (Time 1), after insertion of immediate mandibular dentures (Time 2) and after one year of immediate mandibular dentures insertion (Time 3).

Table 1. Comparison between the mean differences in occlusal vertical dimension changes measured in millimeter for patients with immediate mandibular complete dentures, mucosal (Group A), tooth (Group B) and implant (Group C) supported overdentures

Time / Means / Groups	After insertion of transitional mandibular RPD	After insertion of immediate mandibular denture	After one year of immediate mandibular denture insertion
	X'± SD	X'± SD	X'± SD
Group A	-0.38 ± 0.0837	-0.78 ± 0.1924	-2.75 ± 0.4970
Group B	-0.34 ± 0.0894	-0.74 ± 0.2074	-1.38 ± 0.1304
Group C	-0.36 ± 0.1140	-0.76 ± 0.2075	-2.00 ± 0.2646
F test		Statistically significant	
LSD		0.2978	

0.2074 in time 2 and -1.38 ± 1304 in time 3, in Group C were -0.36 ± 0.1140 in time 1, -0.76 ± .2075 in time 2 and -2.00 ± 0.2646 in time 3. Comparison between mean differences in occlusal vertical dimension for tested times were statistically significant at 5% level of significance.

Comparison between mean differences for tested sides was not statistically significant difference at 5% level of significance (Table 2, Figs 4 and 5).

Comparison between mean differences in wavelet packet coefficients of the electromyographic signals of masseter muscles for tested groups was not statistically significant at 5% level of significance during rest position while it was statistically significant at 5% level of significance during initial teeth contact position and maximum voluntary clench position.

The mean maximum biting force before insertion of immediate mandibular dentures was 10.21 ± 1.05 in Group A, 9.97 ± 0.89 in Group B and 10.02 ± 0.72 in Group C. Comparison between mean differences in maximum biting force for tested groups was not statistically significant at 5% level of significance (Table 3 and Fig. 6).

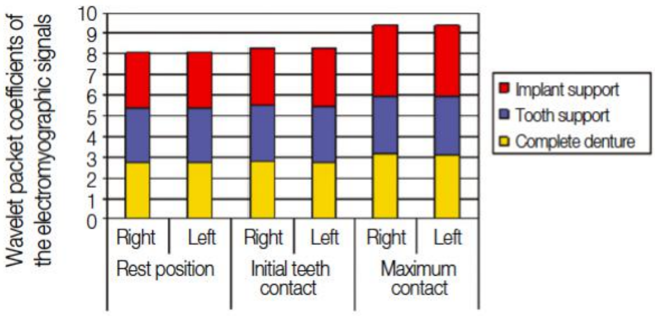

Fig. 4. Comparison between the mean difference of wavelet packet coefficients of the electromyographic signals of masseter muscles for patients with immediate mandibular complete dentures, mucosal (Group A), tooth (Group B) and implant (Group C) supported overdentures during rest (R), initial teeth contact (IC) and maximum voluntary clench (MVC).

The mean maximum biting force after 12 months from insertion of immediate mandibular dentures was 9.56 ± 0.99 in Group A, 13.48 ± 1.85 in Group B and 17.87 ± 1.67 in Group C. Comparison between mean differences in maximum biting force for tested groups was statistically significant at 5% level of significance.

The mean maximum biting force in Group A before insertion of immediate mandibular dentures was 10.21 ± 1.05 and 9.56 ± 0.99 after 12 months from insertion of immediate mandibular dentures. Com-

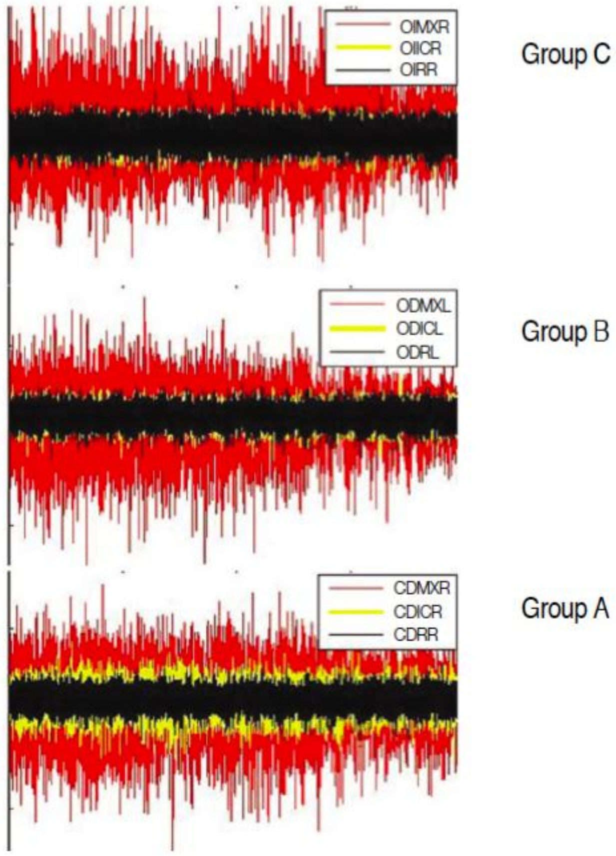

Fig. 5. Superimposed EMG signals during rest position (R), initial contact (IC) positions and maximum voluntary clench (MVC) of immediate mandibular complete denture in Group A, Group B and Group C.

Table 2. Comparison between the mean difference of wavelet packet coefficients of the electromyographic signals of masseter muscles for patients with immediate mandibular complete dentures, mucosal (Group A), tooth (Group B) and implant (Group C) supported overdentures during rest position, initial teeth contact position and maximum voluntary clench

Groups	Rest Position		Initial contact position		Maximum voluntary clench	
	Right X' ± SD	Left X' ± SD	Right X' ± SD	Left X' ± SD	Right X' ± SD	Left X' ± SD
Group A	2.7132 ± 0.0215	2.7108 ± 0.0167	2.7682 ± 0.0663	2.7466 ± 0.0591	3.1442 ± 0.1370	3.0762 ± 0.1388
Group B	2.7062 ± 0.0497	2.6766 ± 0.0114	2.7354 ± 0.0397	2.7036 ± 0.0287	2.8442 ± 0.2224	2.8876 ± 0.0577
Group C	2.6576 ± 0.0266	2.6692 ± 0.0543	2.7816 ± 0.0470	2.7968 ± 0.0354	3.3836 ± 0.3166	3.3946 ± 0.3086
F test	Statistically significant					
LSD	0.1647					

Table 3. Comparison between the mean differences in maximum biting force measured in kg. for patients with immediate mandibular complete dentures in Group A, Group B and Group C

Groups	Before insertion of immediate mandibular denture X' ± SD	After insertion of immediate mandibular denture X' ± SD
Group A	10.21 ± 1.05	9.56 ± 0.99
Group B	9.97 ± 0.89	13.48 ± 1.85
Group C	10.02 ± 0.72	17.87 ± 1.67
F test	Statistically significant	
LSD	1.6557	

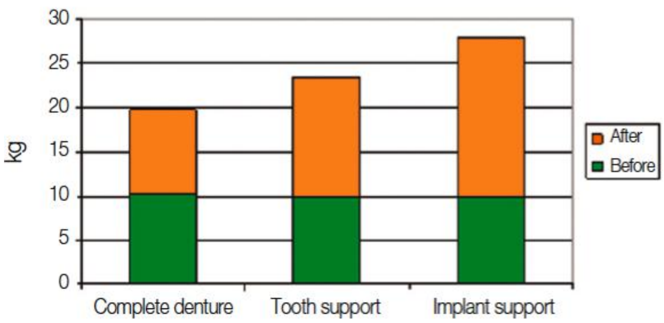

Fig. 6. Comparison between the mean differences in maximum biting force measured in kg. for patients with immediate mandibular complete dentures groups, before insertion and after insertion of immediate mandibular dentures.

parison between mean differences in maximum biting force for tested times was not statistically significant at 5% level of significance.

The mean maximum biting force in Group B before insertion of immediate mandibular overdentures was 9.97 ± 0.89 and 13.48 ± 1.85 after 12 months from insertion of immediate mandibular overdentures. Comparison between mean differences in maximum biting force for tested times was statistically significant at 5% level of significance.

The mean maximum biting force in Group C before insertion of immediate mandibular overdentures was 10.02 ± 0.72 and 17.87 ± 1.67 after 12 months from insertion of immediate mandibular overdentures. Comparison between mean differences in maximum biting force for tested times was statistically significant at 5% level of significance.

DISCUSSION

The loss of the remaining natural teeth is a major and irreversible procedure for the patient. The level of anxiety, with which people face the prospect of losing all their teeth and having to rely on complete denture is unlimited as recorded by Todd and Lader.20 Moreover Basker et al.[5] added that irrevocable loss of all teeth can be a serious blow to a patient's morale as it signals, perhaps, that a major milestone in life has been reached and that all that senile decay.

For this study, fifteen patients were selected and the patients were borderline cases for whom a particular form of treatment with immediate overdentures or immediate complete dentures was not clearly indicated.[21]

Mandibular canines were retained in tooth-supported overdenture group and used as overdenture abutments, because the mandibular canines are usually amenable to endodontic treatment, have strong roots and are strategically located at the corner of the arch as discussed by Renner[22] and Langer et al.[23] Retaining of mandibular canines also has the main concern for alveolar bone preservation particularly in mandibular anterior segment. Canine abutments were reduced about three mm above the free gingival margin and they were reduced to dome shape to provide point of contact between denture base and abutment for freeing of mandibular denture movement that reduces the damaging effect of horizontal forces.[12]

Adaptation of the mandibular overdenture to the patients abutments using tooth shade autopolymerized acrylic resin was done to compensate the differences in arbitrary reduction of the canines in the cast and intra orally. This compensation enhances the role of periodontal ligament in overdenture patient.[24] Adaptation of the mandibular overdenture to the patient abutments was done after complete healing. The adaptation of the overdenture to the abutments has a positive effect on the reduction of the alveolar bone in the period during which the bone reduction is the maximum and helps in preserving the residual ridge from pressure during the period of bone healing.[21] Casted dome shaped dowel coping were made and inserted above the prepared mandibular canines abutment for their protection from caries and for establishing and maintaining specific abutment contours.[5,12]

Two implants were used to support the immediate mandibular overdenture in the present study for implant supported overdenture group. The use of implant supported overdentures with two implants placed in the mandibular canine region was an efficacious modality for providing an improved chewing function for the completely edentulous patients as found by Jemt et al.,[25] Schmitt and Zarb,[26] Naert et al.,[27] Payne and Solomons[28] and Karkazis,[29] Visser et al.[10] also concluded that there is no difference in clinical and radiographical state of patients treated with an overdenture on two or four implants during a 5-year evaluation period. Hemmings et al.[30] added that the implantsupported overdentures presents fewer complications and maintenance requirements. Immediate implants were used in this study to prevent the loss of alveolar bone in height and width as believed by Huys.[31] Dental implants are placed directly into an extraction socket site, it decreases the treatment time compared with the traditional 2-stage protocol, and sometimes cost, as mentioned by Castellon and Yukna.[32]

The implant type used in this study was Impladrill with apical lock osseointegrated implants. The apical lock implant design provides initial stabilization and resists torsional movement of implant as recommended by manufacturer. Implant initial stabilization is an essential need for implant bone osseointegration. The immediate implant, in the present study, replaced the mandibular canines; because the mandibular canine area is the area of choice for most over-implant mandibular overdentures[33] and also the single-rooted teeth have been the most frequent sites for immediate implants.[34-36]

In this study, immediate dental implantation was employed in two stage surgical procedures, firstly submerging for four months, secondly re-exposure and abutment insertion. These procedures of implant submerging and re-exposure were crucial to avoid loading of the implant during the initial healing period.[37,38] The implant suprastructure used in this study was modified to be dome shape to provide abutment denture point of contact that permit mandibular overdenture free movement, direct the occlusal forces along the long axes of the implant and reduced the destructive horizontal forces. Adaptation of the mandibular overdenture to the implant abutments using tooth shade autopolymerized acrylic resin was done to compensate the differences in reduction of the canine areas arbitrary in the fitting surface of the denture base and actual size of abutment suprastructure of the implant intraoral during insertion of the mandibular overdenture.

Lateral cephalometric radiograph was used for evaluation of the occlusal vertical dimension changes. This analysis have provided information on skeletal, facial proportions and visualized the changes of occlusal vertical dimension for edentulous patients.[39] For determination of occlusal vertical dimension changes in centric occlusion position; reference points, lines and measurements on cephalometric radiographs were used according to procedure described by Lambadakis and Karkazis.[15]

Electromyography is excellent for information on diagnostic aid of muscle function and is also a reliable and a reproducible method in detecting changes in electrical muscle activity and changes in isometric muscle tension.[16,40-46] Evaluation of masseter muscle activity was performed during rest, initial tooth contact from the mandibular rest position and maximum voluntary clench in centric occlusion as described by Tallgren et al.[47]

In this study, electromyographic recording of the masseter muscle activity was decomposed into wavelet packet coefficient values. The decomposition of the signal into the basis of wavelet functions implies the computation of the inner products between the signal and the basis functions, leading to a set of coefficients called wavelet coefficients. The signal can consequently be reconstructed as a linear combination of the basis function weighted by the wavelet coefficients. The main characteristic of wavelet packet coefficient is the timefrequency localization. It means that most of the energy of the wavelet is restricted to a finite time interval. The advantage of time-frequency localization is that contrary to the short-time Fourier transforms, a wavelet analysis varies the time-frequency aspect ratio, producing good frequency localization at low frequencies (long time windows), and good time localization at high frequencies (short time windows). This produces segmentation or tiling of the time-frequency plane that is appropriate for most physical signals. According to the above cited merits, the wavelet coefficient decomposition of electromyographic signals makes it more accurate method than power spectral analysis.[48]

Force transducer used in this study for bite force recording employs beam deflection and this deflection was sensed by a strain gauge, which converts forces into measurable electrical signals. Among research workers[17-19,49-50] measuring bite force; a bite force transducer was the most commonly used. The elastic load-bearing element of bite force transducer was constructed according to the concept developed originally by Slagter et al.[17] and van Kampen et al.,[18] but with some modifications to suite this study. A hollow dumbbell shaped stainless steel bearing element was constructed with the same dimensions as developed by Slagter et al.,[17] but it was noted that during its calibration, permanent deformation was induced at time of load application at 8 kg. This permanent deformation was considered as a drawback of original designed stainless steel dumbbell shaped bearing element, particularly the suspected average loading for overdenture patients exceeding 8 kg. So, casted dumbbell shaped bearing element with chrome cobalt was constructed to overcome this problem. During calibration of the bite force transducer for this study, it was noted that the recorded strains in relation to applied loads was minimal and not corresponding to the greater changes in load application, for example, when load was 6 kg, the recorded strain was 3 mV, by increasing load up to 12 kg, the induced strain was 3.25 mV. To overcome this problem and make it more suitable for recording the extremity of patients own bite loading, hard stainless steel coil was incorporated to the inner site of elastic load bearing element. Also a side cut with 2 mm space was made along one ring of the elastic load bearing element to make it more flexible without permanent deformation during loading.

For calibration purpose, complete maxillary and mandibular finished dentures were mounted on a simple hinge articulator and mounting of the bite force transducer was aimed to simulate the oral condition during biting.

Method of calibration of bite force transducer was made according to Prombonas et al.[19] and to assort it by applying loads of 1, 2, 4, 6, 8, 10, 12, and 14 kilograms. For frequent bite force recording, the elastic load bearing element was designed with metal pin projection that had two mm height and one mm diameter. This pin projection housed in a pinhole formed in the central fossa of the first molar of the denture. The elastic load bearing element was positioned accurately for all frequent recall measurements. While the other method provided by van Kampen et al.[18] who used the bite-force transducer covered with rubber base dental impression material to fit the profile of the subjects' teeth. Using this method, a reproducible bite position was obtained for all the five measurements during the fourteen month period, but in this study no attempt was made to follow this procedure due to distortion of rubber base impression material.

The maximum biting force measurements were taken for all groups; one month after prosthesis insertion and twelve months after insertion of immediate dentures. It was aimed to study the changes in maximum biting force in different treatment groups. The measurements were performed three times and the highest bite force of the three efforts was selected as recommended by Slagter et al.[17] and van Kampen et al.[18]

Results of measured occlusal vertical dimension demonstrated regression for all the tested groups. The regression of the occlusal vertical dimension might be due to the continuous decrease in bone volume related to residual ridge resorption. Lambadakis and Karkazis[15] found that the reduction in the occlusal vertical dimension can be attributed to continuous vertical reduction of the alveolar process. Also, according to Tallgren et al.,[47] the alveolar ridge reduction and settling of the dentures on the basal seats brought about a mandibular inclination with forwardupward rotation of the mandible. This rotation leads to decrease in occlusal vertical dimension with mandibular prognathism.

The results of this study demonstrated that there was significant decrease of the occlusal vertical dimension in the complete denture group, compared with the overdenture groups (tooth and implant-supported), in the first year after extraction of the last remaining teeth and after insertion of the dentures.

This result is in agreement with Van Waas et al.[21] He also explained the forces on the bone near and at some distance from the remaining roots or implants are less, resulting in less bone reduction and less occlusal vertical dimension changes.

A greater decrease of occlusal vertical dimension for Group C than that for Group B can be because of the sensory feedback input of tooth which preserves alveolar bone, while the absence of such tooth sensory feedback in implant-supported overdenture group may contribute to more alveolar bone resorption. This explanation appeared logic as Sigvard et al. found that the situation with a mandibular overdenture supported by 2 bar-connected implants resembled the situation with natural anterior teeth and a removable partial denture. Maxillary changes were similar to the combination syndrome with anterior bone loss in the maxilla and posterior loss of occlusal contact. Result of this study did not show any significant electromyographic recording activity differences along the right and left masseter muscles. This result confirms the proper patient's selection as all have healthy stomatognathic system.

In addition, the results of this study had shown an interesting finding, that there was no statistically significant difference in masseter muscles electromyographic recording in the rest position between all the tested groups. This indicated that the rest position is a postural mechanism which coexist with the sensorimotor feed back mechanism during dentate life and manifest itself again when teeth are removed and clinical rest position disappear and suspecting that primitive unlearned postural reflexes of the mandible also exist. Another argument might be that the facial muscles are maintained in their correct position in immediate denture as found by Tallgren et al.[47]

The result of this study also showed a significantly decreased masseter muscles' electromyographic activity in tooth-supported overdenture group compared with that of conventional immediate complete denture and implant-supported overdenture groups during initial tooth contact position. This result might be due to the role of periodontal ligament as suggested by Nagasawa et al.,[24] who suggested that the periodontal ligament plays an important role in the efficiency of the muscular activity during chewing in patients wearing overdenture prosthesis.

Another finding was significant differences in the electromyographic masseter muscles' activity during maximum voluntary clench in all the tested groups. Patients with implant supported overdentures seemed to exhibit a greater masseter muscles' electromyographic activity during maximum voluntary clench than mucosal and tooth supported overdentures. This can be attributed to the voluntary reflex which made jaw closing to a much greater extent.

Results of increased masseter muscle activity for implant supported overdenture group than tooth and mucosal borne prosthesis is according to van Kampen et al.,18 who observed a significant increase in masticatory function after the new overdenture was attached to the oral implants and implant-supported prostheses tend to increase masticatory muscles activity. Results of recording maximum biting force for Group A, who received immediate complete mandibular denture (totally mucosal supported) demonstrated insignificance difference in their maximum biting after one year of immediate denture insertion. This result was properly related to recent extraction and patient's inability to bite hard with new dentures. Although all sore spots had been eliminated before recording bite force; patients were still unable to bite hard. The fact that patients wearing complete dentures for one year without complaints and still experiencing the same magnitude of biting force, could be due to the changes in occlusal relationships of the dentures because of alveolar ridge resorption and settling of the dentures on the basal seat. This explanation appears to be supported by results of decreased occlusal vertical dimension for mucosal supported mandibular complete dentures.

Results of significant increase in maximum biting force for both tooth and implant supported overdenture after one year than that before immediate denture insertion can be explained as there is improved support and stability, more self confidence, assurance and satisfaction with their prosthesis. With respect for implant-supported, the same explanation for tooth supported overdenture group can be used.

The result of this study also revealed a significant increase in maximum biting force after one year for implant and tooth-supported overdenture groups compared to conventional immediate denture group. This result may be due to the good support and stability of the tooth and implant-supported overdentures in comparison to the mucosal-supported dentures.

In comparison of maximum biting force for tooth and implant supported overdentures after one year of overdenture wearing, the implant-supported overdenture group experienced greater increase in the maximum biting force than tooth-supported group. This can be explained as the patient with implant-supported prosthesis exhibited voluntary reflex which make their jaw close to a much greater extent than the patient with tooth borne prosthesis. Patient with tooth-supported prosthesis still had tactile proprioceptive reflex arising from periodontal ligament that alarm them against overload.

CONCLUSION

With increased experience comes a greater understanding of potential complications and features when applying immediate prosthetic fabrication to better insure its success. Immediate fabrication of implant overdenture prosthesis can be successful with increased clinical efficiency under specific clinical situations. The biting force of masticatory muscle is functionally dependent on maintenance of muscle health and occlusal vertical dimension.

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COMPARISON OF IMMEDIATE COMPLETE DENTURE, TOOTH AND IMPLANT-SUPPORTED OVERDENTURE ON VERTICAL DIMENSION AND MUSCLE ACTIVITY

11. What are the main advantages of an overdenture supported by roots or implants to a conventional complete denture:
    a) Decreased resorption of the residual ridges
    b) Maintenance of masticatory efficiency
    c) Improve the stability of the dentures
    d) All of the above

12. What type of implant was used in this study:
    a) Southern Implants
    b) Bicon Implants
    c) Branemark Implants
    d) Impladrill Implants

13. What is the difference in the mean maximum biting force after 12 months between immediate mandibular complete dentures and implant supported overdentures:
    a) 10.21
    b) 9.56
    c) 8.31
    d) 13.48

14. Why is there a difference in maximum biting force between tooth and implant supported overdentures:
    a) Changes in the occlusal relationship
    b) Decreased masseter muscles
    c) Alveolar ridge resorption
    d) Tactile proprioceptive reflex arising from periodontal ligaments

15. Which group had the least amount of alveolar bone resorption:
    a) Immediate complete dentures
    b) Tooth supported overdenture
    c) Implant supported overdenture

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5 Top LinkedIn Training Tips

By Denise Stenzelmann

Looking to enrol onto a LinkedIn training course? If you're still unsure about the power of LinkedIn, here are five top tips you can start using today to start generating increased revenue for your company.

Invite Your Existing Contacts

The first place to start is to build your follower count by inviting existing email contacts. This is important as the more first degree connections you have, the more visible your profile is in search results and the more people you will reach. Invite everyone you know professionally and privately, as these connections are essential to generate referrals and attract an audience. LinkedIn training can also help you learn how you can grow your audience among people you do not yet know in real life.

Learn How To Use Search

The search function that comes free is very powerful, but there is an even more powerful advanced search available to premium members who are willing to pay a small monthly subscription. A LinkedIn training course can help you decide whether to go for a free or paid account, however we'll go over some of the basics here.

Simply put, the difference between free and paid is the amount of filters available to you. Free accounts do have a wide range of filtering options, however paid accounts get much more. You can filter by company size, revenue, job role and seniority. This makes LinkedIn a very powerful tool when it comes to prospecting for new clients.

Start Networking

Networking is one of the most important uses of this social platform. As most LinkedIn training mentors say, it's important to interact with your contacts on a weekly basis in order to build your relationships with others. This can lead to referrals, recommendations and ultimately, more sales. Try to stay up to date with the news in your industry and post this to others who you think this will be relevant to. That way, people see you as an expert and knowledgeable person, which is a perfect way of generating referrals.

Build Buzz About Yourself

The next most important thing is to build buzz about yourself. Be sure to post at least one update per day to your first degree connections. Joining several groups is also a great idea as you can engage with people outside of your first degree connections. Make sure you deliver value in both groups and to your followers as you need to be seen as an expert in your field. This way, people will refer their friends to you for help on your subject, leading to more clients.

Know Your Competition

Finally, one of the best features of LinkedIn is that you can follow your competition. Thanks to LinkedIn company pages, you can follow rival businesses and see what their next marketing and sales push is by tracking their activity. LinkedIn training experts suggest following other competitors from further afield too, not just local ones, as it's a good idea to see what some of the other industry leaders are doing to generate business.

Denise is a LinkedIn training professional living and working in London, UK

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The DENTASA executive has, after many requests from its members, decided that as from 2012 the questionnaires in the SADTJ, regarding the CEU'S will be available for DENTASA members only.

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