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In modern prosthodontic dentistry, metal-free ceramics are widely used materials, and knowledge of their unique cementation procedures is paramount for a modern dentist. In order to achieve optimal adhesion between teeth and ceramics, knowing the composition and properties of adhesives is not enough. It is important to know how dental tissue and the different ceramics interact with them, and how these substrates can be treated beforehand in order to achieve optimal results.

As technology has progressed, different types of ceramics have been introduced, such as feldspathic porcelain, leucite-reinforced ceramics, lithium disilicate and zirconia. These materials have similar esthetic properties, but different mechanical and chemical properties. The difference in properties between ceramics is directly related to their structural differences: The presence or absence of leucite crystals, the radically different shape of lithium disilicate crystals and zirconium oxide particles, and other features of ceramics directly influence the type of surface treatment needed to obtain an optimal chemical adhesion. Each material needs to be treated in a certain way before cementation, and knowing this could yield overall better clinical results.

Nowadays, sandblasting glass-ceramic surfaces (feldspathic, leucite and lithium disilicate) is not advised, because this kind of treatment could flatten them and create microfractures in the glossy matrix, leading to future failure of the restoration. A tribochemical treatment on zirconia using aluminum oxide particles, however, is advised; it increases surface roughness and augments chemical adhesion owing to the particles embedded in the zirconia's surface.

The gold standard for treating glass-ceramic surfaces is etching; however, for different ceramics, different etching times must be applied:
- For feldspathic ceramics, etching with 5% hydrofluoric acid for 120 s is advised.
- For leucite-reinforced ceramics, etching with 5% hydrofluoric acid for 60 s is advised.
- For lithium disilicate, etching with 5% hydrofluoric acid for 20 s is advised.
For zirconia, etching is not advised, as it has been demonstrated that its surface is rendered chemically inert by this treatment.

In conclusion, clinicians should feel compelled to research and study this subject in order to combine their knowledge of adhesive materials with the knowledge of chemical characteristics and best surface treatments for both the dental substrate and the restoration substrate.

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Guided bone regeneration around 1-stage nonsubmerged dental implants with periimplant bone defects: A retrospective case series study

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Abstract

Objective

The aim was to evaluate the 3-year outcome of nonsubmerged dental implants with buccal periimplant defects treated with a guided bone regeneration technique in a 1-stage approach.

Method and materials

A retrospective chart review of consecutive patients treated with dental implants and bone regeneration at the time of implant placement, left nonsubmerged, and with a minimum follow-up of 3 years after implant loading was performed. Patients were treated between January 2005 and December 2009 at the Oral Surgery Unit of the University of Valencia, Valencia, Spain. The following variables were assessed: complications with the healing procedure, implant success (based on Buser et al.22), and periimplant marginal bone loss. Statistical analysis was performed applying Chi2 test, Spearman’s test and the Mann-Whitney test, using alpha set at 0.05.

Results

A total of 50 patients (26 women, 24 men) with a mean age of 54.8 ± 13.6 years (range: 25–79) and 75 implants were included. Seventy-one dehiscences (average height: 1.97 ± 1.06 mm) and 4 fenestrations (average height: 2.75 ± 0.95 mm) were treated. Five membrane exposures were recorded (10%). After 3 years post-loading, the implant success rate was 94% and mean marginal bone loss was 0.50 ± 0.27 mm.

Conclusion

Despite the limitations of this study, a nonsubmerged approach in connection with guided bone regeneration to treat periimplant bone defects is a feasible option with few healing complications and a good prognosis.

Keywords

Guided bone regeneration; periimplant defects; dental implants; marginal bone loss; success rate; nonsubmerged.

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Introduction

The application of guided bone regeneration (GBR) provides clinicians with the ability to place implants in areas of insufficient amounts of bone. The 1-stage approach, using grafting material with or without membranes at the time of implant placement, has the advantage of shortening the total treatment time. GBR utilizing a 1-stage procedure around submerged implants has been widely documented in humans and animals. Several experimental studies in animals on nonsubmerged immediate implants placed in extraction sockets with GBR indicated that bone regeneration around these implants was possible, and clinical studies on humans confirmed these results with good long-term outcomes.

Defects from fresh extraction sockets are characterized by the maintenance of intact surrounding bone walls, which offer favorable conditions for regenerative processes. However, when dental implants are placed in narrow ridges, the lack of 1 or more walls leads to open defects, which are less favorable for the regenerative process, since the blood clot is less protected, grafted bone particles are more subject to displacement, and a membrane placed to cover the defect may collapse. Despite the 1-stage approach having the advantage of shortening the total treatment time, different systematic reviews on clinical outcomes of GBR procedures to correct periimplant dehiscences and fenestrations show that in most of the included studies dental implants were left submerged. There are few studies on GBR around nonsubmerged implants for treating periimplant bone defects in narrow alveolar ridges. The purpose of the present study was to evaluate the 3-year outcome of 1-stage nonsubmerged dental implants with buccal periimplant defects treated with a GBR technique and resorbable membranes.

Materials and methods

Patient selection

A retrospective clinical study was conducted of patients with a minimum of 1 dental implant demonstrating a dehiscence or fenestration bony defect with an exposed implant surface during implant placement and thus undergoing simultaneous particulate bone grafting with resorbable membranes and left nonsubmerged. Patients were treated between January 2005 and December 2009 at the Oral Surgery Unit of the University of Valencia, Valencia, Spain, and were monitored annually for a minimum of 3 years post-loading. The study was performed following the guidelines of the Declaration of Helsinki for human research. Surgical procedures were performed by the same surgeon with extensive experience in regenerative procedures. Patients were given full information about the surgical procedures and duly signed informed consent forms. Preoperative analysis included registering complete medical histories and performing clinical and radiographic examinations.

Subject and site inclusion criteria:
- Dental implant with a dehiscence or fenestration bony defect during implant placement treated with particulate bone graft and resorbable membranes.
- Nonsubmerged dental implants.
- Tooth/teeth at implant site extracted > 6 months previously.
- Rehabilitation with a fixed or removable implant-supported prosthesis.
- Age > 18 years.
- No relevant medical conditions.
- Nonsmoking or smoking ≤ 20 cigarettes/day (all pipe or cigar smokers were excluded).
- Follow-up for at least three years after prosthetic loading.

Subject and site exclusion criteria:
- Patients with systemic or local conditions contraindicating implant therapy (previous chemotherapy, previous irradiation of the head and neck region, active progressive periodontitis and/or immunosuppression).
- Pregnant or lactating patients.
- Sites with acute infection.
- Poor oral hygiene.
- Implants with sinus augmentation.
- Immediate implants or placed in bone with a recent extraction (< 6 months).
- Reimplantation.
- Implants placed in bone previously regenerated with bone grafting.
- Patients failing to attend follow-up visits.

The present study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology statement.
GBR with a nonsubmerged approach

Fig. 1
Patient with dehiscences treated with GBR with a nonsubmerged approach.

(A) Preoperative panoramic radiograph.
(B) Preoperative occlusal view.
(C) Bone atrophy of the alveolar ridge visualized after flap elevation.
(D) Implant insertion in positions #35, 36 and 37.
(E) Synthetic bone over dehiscences.
(F) Resorbable membrane over bone graft.

Preoperative evaluation

Thorough medical histories, clinical examinations and panoramic radiographs were performed in all cases. Cone-beam computed tomographic scans were obtained to assess the availability of bone whenever the surgeon considered this necessary. Periodontal treatment was provided whenever necessary to control inflammation prior to implant placement surgery. Within 10 days of the implant placement surgery, a full-mouth professional prophylaxis appointment was scheduled.

Surgical procedures

All procedures were performed under local anesthesia using 4% articaine with 1:100,000 epinephrine (Inibsa, Lliçà de Vall, Spain) and intravenous conscious sedation with a 1% propofol solution, administered by an anesthesiologist. An initial incision was made slightly palatal/lingual of the alveolar crest. One or 2 releasing incisions were made and a mucoperiosteal flap was raised. The exposed alveolar bone was curetted to remove all soft tissue. In order to enhance primary stability, drills and osteotomes were combined to prepare implant beds. TSA implants with the Avantblast surface (Phibo Dental Solutions, Sentmenat, Spain) were inserted using standard procedures following the manufacturer’s guidelines. These implants had a polished surface portion of 1.5 mm. All implants were placed with adequate primary stability (≥ 35 N cm). All implants were treated by guided bone regeneration with autologous bone grafts harvested from the conformation of implant beds during drilling and adjusted to the bone contour, or a mix with synthetic bone of 0.25–1 mm of particle (Kera–Os, Keramat, Coruña, Spain) when the autologous bone obtained was insufficient to cover the periimplant defects. Grafted bone was protected with a textured collagen membrane (Lyopstic, B-Braun, Aesculap, Tuttlingen, Germany). Periosteal incisions were made to allow flap mobilization and tension-free primary wound closure. Afterward, the mucoperiosteal flap was resutured, leaving the implant head exposed to the oral cavity (Fig. 1). No provisional restorations were loaded on the implants. Patients were prescribed 1 g of amoxicillin (GlaxoSmithKline, Madrid, Spain) twice daily for 6 days, starting 1 h prior to surgery, 600 mg of ibuprofen (Bexistar, Laboratorio Bacino, Barcelona, Spain) 3 times per day for 5 days and a mouthrinse containing 0.12% chlorhexidine (GUM, John O. Butler/Sunstar, Chicago, Ill., U.S.) twice daily, commencing 3 days prior to surgery and for 2 weeks thereafter. Patients were instructed in adequate hygiene.
maintenance. Patients were not allowed to use removable prostheses for 3 weeks after bone grafting surgeries. A soft diet was recommended for 1 week, and patients were instructed to avoid brushing or any other trauma to the surgical sites. Sutures were removed 2 weeks after surgery.

Data collection and follow-up

All data collection was carried out by a single trained clinician different from the surgeon or the prosthodontist following a pre-established protocol. All patients were included in a maintenance program involving annual examinations and professional prophylaxis. Occlusal adjustment was performed when necessary.

Patient age (at implant placement), sex, hygiene and smoking habits (none/< 10 cigarettes per day/10–20 cigarettes per day) were registered. For each implant, the position, and the type and dimensions of defects (dehiscence/fenestration) were registered. Defects were measured using a millimetric periodontal probe (UNC, Hu-Friedy, Chicago, Ill., U.S.) placed parallel or perpendicular to the long axis of the implant. Measurements were recorded to the nearest 1 mm mark. The type of graft was recorded (autologous bone or mixed). The definitive prosthesis design (single or partial) and type of prosthesis (cemented or screwed) were recorded. The following outcome measures were recorded:

- **Receptor site healing**: Membrane exposure.
- **Implant success**: The definition of implant success was based on the clinical and radiographic criteria put forward by Buser et al.\(^2\). The implant success rate was provided per patient.
- **Radiographic periimplant marginal bone loss**: Intraoral radiographs were taken at the moment of prosthetic loading (baseline), 1 year post-loading and 3 years post-loading (control radiographs), using the X-Mind intraoral system (Satelec-Pierre Rolland Group, Merignac, France) and an RVG intraoral digital receptor (Dürr Dental, Bietigheim-Bissingen, Germany) with the aid of a Rinn XCP film holder (Dentsply Rinn, Elgin, Ill., U.S.) to achieve parallelism. The images were calibrated with CliniView (Version 5.1, Instrumentarium Imaging, Tuusula, Finland). Each image was calibrated using the known length of the implants. The vertical distance from the outer edge of the implant shoulder (reference point) to the most coronal point of bone-to-implant contact was evaluated at the mesial and distal aspects of each implant to the nearest 0.1 mm. Periimplant marginal bone resorption at 3 years post-loading was calculated from the change in bone level between the 1-year post-loading and the 3-year control radiographs; for each pair of

![Fig. 1](image-url)
GBR with a nonsubmerged approach

measurements (mesial and distal), the largest value was used. Intraexaminer calibration was analyzed before evaluating the entire implant sample by reassessing bone loss at a total of 30 randomly selected sites (using the random function of Microsoft Excel 2010) on duplicate measurements performed on different days. An intraclass correlation coefficient of 0.898 was obtained, showing a high concordance between the 2 sets of data. According to Dahlberg’s $d$ value, a 0.049 mm error was estimated for the measurement method.

Statistical analysis

Statistical analysis was performed using nonparametric tests for implant success, as this was a noncontinuous variable, and marginal bone loss, as this had an asymmetric distribution. The chi-square test was used to study the relationship between the survival and success rates with respect to sex, smoking and hygiene habits, position and location of the implants, type defect, type of graft, prosthesis design and membrane exposure. Spearman’s $r$ test was used to relate the mean of bone loss and age and mean periimplant defect dimensions; and the Mann-Whitney test to relate this variable with type of graft and exposure membrane. Statistical analysis was performed using SPSS software (Version 17.0, SPSS, Chicago, Ill., U.S.).

Results

A total of 66 patients with GBR around nonsubmerged dental implants performed owing to the presence of dehiscences and fenestrations were included. Sixteen patients were excluded as a result of failing to attend control visits. The final study sample was 50 patients (26 women, 24 men) with a mean age of 54.8 ± 13.6 years (range: 25–79). Hygiene maintenance was good in 39 patients and regular in 11. Thirty-eight patients were nonsmokers, 9 smoked <10 cigarettes per day and 3 between 10 and 20 cigarettes.

A total of 75 dental implants were placed: 28 maxillary (9 anterior, 19 posterior) and 47 mandibular (10 anterior, 37 posterior). Seventy-seven defects around 75 implants were produced (73 dehiscences, 4 fenestrations). The mean dimensions of the resulting dehiscence defects were 1.97 ± 1.06 mm (range: 1.5–8.0) in height and 3.29 mm (range: 3.0–5.5) in width. The mean dimensions of the resulting fenestration defects were 2.75 ± 0.95 mm (range: 2.0–4.0) in height and 2.1 mm (range: 1.5–3.0) in width. Regarding the type of graft, 12 implants received autologous bone and 63 a mix with synthetic bone. With regard to prosthetic rehabilitation, 21 implants had single crowns and 54 fixed bridges, and 28 prostheses were cemented and 47 screwed.

Receptor site healing

Wound dehiscence with membrane exposure during the early postoperative period occurred in 5 grafted sites in 5 patients. These exposures did not exceed 3 mm in diameter. In these cases, 0.2% chlorhexidine gel was prescribed for application 3 times daily to the exposed membrane for 6 weeks after surgery. All sites re-epithelialized uneventfully.

Implant success rate, and periimplant marginal bone loss

Three implants in 3 patients were lost, all of them before loading, between 1 and 3 months. All 3 implants had periimplant bone dehiscences of 2 mm in width and length. Two patients were men with an average age of 40–63 years and 1 a woman of 46 years. All these patients maintained regular oral hygiene. One was a non-smoker and 2 were smokers. All failed implants had been placed in posterior sites (2 mandibular and 1 maxillary) and did not exceed 10.0 mm in length and 4.2 mm in width.

Implant success rate per patient was 94% after 1 year post-loading. Mean periimplant marginal bone loss at 1 year post-loading was 0.42 ± 0.31 mm (range: 0.1–1.9). At 3 years post-loading, no further implants had been lost and were considered successful according to Buser et al’s criteria.22 Mean periimplant marginal bone loss at 3 years post-loading was 0.50 ± 0.27 mm (range: 0.2–1.8).

No significant differences were found between success rate and bone loss regarding patient factors (age, sex and smoking habit) or implant variables (location, type defect, defect dimensions, type of graft, prosthesis design or membrane exposure). However, all implant failures occurred in patients with regular oral hygiene (100%); these results showed a moderate tendency to significance, but were nevertheless nonsignificant ($P$ value: 0.073).
Discussion

This study was designed to evaluate, after a minimum of 3 years of prosthetic loading, the survival and success rates of nonsubmerged implants with perimplant bone defects treated with particulate bone grafts and resorbable membranes in a 1-stage approach. The results of this study show that a nonsubmerged approach is a feasible option when perimplant bone defects are produced during implant surgery owing to anatomical reasons.

The outcomes of the present study are comparable with those of studies on submerged implants.1, 4, 23, 24 In a recent systematic review, Chiapasco and Zaniboni reported that the overall survival rate of implants with perimplant defects treated with GBR, irrespective of the timing of the implants, the type of membrane and grafting materials, was 95.7% (range: 84.7–100) within the observation period, varying from 1 to 9 years.25 In only 1 out of 7 studies included in the review had nonsubmerged implants been placed.14 De Boever and De Boever studied long-term outcomes of nonsubmerged implants placed with a xenograft and a non-resorbable membrane to cover large dehiscences in a 1-stage approach and reported a 93.75% survival rate and stable marginal bone loss after a 5-year follow-up.14 Nonresorbable membranes are still regarded as the gold standard in GBR; however, frequently reported soft-tissue problems, such as exposure of the membrane and subsequent infection, as well as the need to remove the membrane, have led to the development and use of resorbable membranes.26, 27 The use of bioresorbable membranes almost always requires autologous bone or deproteinized bovine bone mineral as a scaffold for the membrane.9 In the present study, all defects were treated with autologous bone graft alone, or in combination with synthetic bone, and a resorbable membrane.

Regarding receptor site healing, Blanco et al. studied 26 implants with perimplant defects treated with nonresorbable membranes combined with autogenous bone grafts or decalcified freeze-dried bone allograft and reported 11.5% membrane exposure that required premature removal.23 In the present study, membrane exposure occurred in 10% of grafting sites. These results agree with those of Juodzbalys et al., who reported a 5% resorbable membrane exposure rate.17 The periapical radiographs of the sites showed no continuous periimplant radiolucency at the 3-year follow-up examination. The mean marginal bone loss after 3 years was 0.50 ± 0.27 mm. The results of this study are in agreement with those reported by De Boever and De Boever on GBR around nonsubmerged implants; these authors reported no marginal periimplant bone resorption except for 1 implant after 12–114 months of follow-up.18 Nevins et al., in a retrospective multicenter study, reported a mean radiographic bone loss, over a 74-month period post-loading, of 0.64 mm (range: 0.3–0.8).16 These results agree with those reported on a submerged implant approach; Ramel et al. reported a mean bone loss of 0.43 ± 0.56 mm 1 year post-loading and a further bone loss of 0.17 mm in the following 2 years.27 Juodzbalys et al. reported that 90% of all sites presented with stable crestal bone levels.17 Christensen et al. found that 14% of the sites treated with GBR showed 1.5 mm of bone loss 3 years post-loading.15

The results of the study seem to show that bone regenerated with GBR around nonsubmerged dental implants remains stable over time with a good prognosis for the implants; however, some limitations should be noted. The first limitation is that the study did not include a control group and re-entries were not performed, so it provides no evidence of the effectiveness regarding bone regeneration, and the effectiveness of this technique was thus based on the postoperative complications and dental implant survival and success rates. The second limitation of the study is the absence of a radiographic outcome that could measure the amount of regenerated bone, because using a one-stage approach does not make it possible to measure it directly.28 Finally, the third limitation is the retrospective nature of this research.

Conclusion

Despite the limitations of this study, nonsubmerged implant placement in connection with GBR to treat perimplant bone defects is a feasible option with few healing complications and good long-term prognosis. Further long-term studies with appropriate controls and larger sample sizes and longer follow-ups should be conducted in order to confirm or reject these findings.
GBR with a nonsubmerged approach

References


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Extraoral chairside digitalization: Clinical reports on a new digital protocol for surgical and prosthetic treatment of completely edentulous patients

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Abstract

Aim
Nowadays, virtual planning and the assisted placement of implants in 3-D positions relative to the bone, soft tissue and final planned prosthesis are becoming the gold standard. In order to obtain such visualization, it is necessary to correctly match the anatomical and prosthetic data. The aim of this paper is to present a new extraoral chairside prosthesis scanning protocol for fully edentulous patients.

Materials and methods
This study was designed as a pilot case series study aimed at evaluating the feasibility of a new extraoral chairside prosthesis scanning protocol for guided implant surgery in completely edentulous arches. This new protocol includes 2 extraoral chairside scans using a powdered intraoral scanner. The first part is based on the extraoral chairside digitalization of the current prosthesis with added radiopaque markers made in flowable composite and subsequent imaging superimposition with DICOM data. The second part is based on the extraoral chairside digitalization of conventional scan abutments fixed on a specially designed customized tray, based on the original virtual planning.

Results
Three patients (1 man and 2 women) with a mean age of 58.9 years were treated. A total of 13 implants were placed using a guided approach. All of the patients underwent 2 extraoral chairside digitalizations with no deviation from the original protocol. No implant failed and the prosthetic survival rate was 100%.

Conclusion
Within the limits of this study, it is suggested that extraoral chairside digitalization may provide better accuracy than conventional methods, permitting fast, easy and accurate treatment at a decreased cost. Randomized controlled trials are needed to evaluate predictability and repeatability of this workflow.

Keywords
Guided surgery; dental implants; intraoral scanner.
Extraoral chairside digitalization

Introduction

Advancements in computerized tomography scanning (cone beam computed tomography [CBCT] technologies), coupled with computer-assisted treatment, have allowed for the virtual planning and assisted placement of implants in 3-D positions relative to the bone, soft tissue and final planned prosthesis.\(^1\)\(^-\)\(^5\) In order to obtain such visualization, it is necessary to correctly match the anatomical and prosthetic data. The prosthetic information can be acquired in different ways, and it depends on whether the patient is edentulous or still has remaining teeth. With edentulous patients, it is possible to create a scan prosthesis by converting a functionally and esthetically correct prosthesis into a scan prosthesis by placing radiopaque markers such as gutta-percha hemispheres (double-scan protocol).\(^6\) The double-scan protocol is based on 2 separate sets of DICOM files. It can be used for both partially and completely edentulous patients. The first CBCT scan is of the patient wearing the radiographic guide with the radiopaque markers. The second scan is of the patient’s radiographic guide alone. Converting raw data to 3-D information is done by various software available or by sending the data to the master site of the particular software manufacturers. Noticeable drawbacks of the original double-scan technique are the need for 2 CBCT scans and the associated costs, as well as the technique-sensitive nature of the process. Furthermore, extraoral chairside digitalization allows for easy handling of the controlling factors for the accuracy of impression techniques, compared with intraoral scanning.

In order to overcome these disadvantages, a new digital protocol has been introduced to the profession for the treatment of fully edentulous patients. This newly developed protocol involves 2 parts. The first part (planning) is based on extraoral chairside digitalization of the current prosthesis with added radiopaque markers made in flowable composite and subsequent imaging superimposition with the DICOM data.\(^7\) The advantage of this new technique is that the surgical template obtained is derived from the intraoral scan that is more precise than the one obtained from CBCT. The second part (finalization) is based on the extraoral chairside digitalization of conventional scan abutments fixed on a specially designed customized tray, based on the original virtual planning. The purpose of this article is to present this new extraoral chairside prosthesis scanning protocol for fully edentulous patients.

Materials and methods

This study was designed as a pilot case series study aimed at evaluating the feasibility of a new protocol for guided implant surgery of completely edentulous arches that includes 2 extraoral chairside scans using a powdered intraoral scanner (True Definition Scanner, 3M Italia, Pioltello, Italy). Three patients (1 man and 2 women) with a mean age of 58.9 years were treated. Basically, patients with an adequate pre-existing or a newly developed removable complete dental prosthesis in at least one jaw and requiring an implant-supported rehabilitation were considered eligible for this pilot study and consecutively treated in a private center in Rome, Italy. The study was conducted in accordance with the principles outlined in the Declaration of Helsinki of 1964 for biomedical research involving human subjects, as amended in 2008. The patients were duly informed about the nature of the study. Written informed consent to surgical treatment was obtained from each patient.

Extraoral chairside digitalization of the current prosthesis

The patient’s medical history was collected, preoperative photographs and radiographs were obtained, and periodontal screening was performed for initial evaluation. During the clinical examination, the existing removable complete dental prosthesis was evaluated for function and esthetics. Then, the fit was carefully assessed, rebasing the existing prosthesis directly chairside if needed (Fig. 1). The prosthetically driven planning workflow started by adding 6–8 drops of flowable composite to the existing prosthesis (Fig. 2). Then, the patient underwent a CBCT scan (CRANEX 3Dx, SOREDEX, Tuusula, Finland) wearing the modified dental prosthesis. A wax bite was used to separate the dental arches (Fig. 3). The second scan was for the extraoral chairside digitalization of the prosthesis with added radiopaque markers (True Definition Scanner). In accordance with the manufacturer’s instructions, the entire area to be scanned was powdered just before scanning (Fig. 4). The STL and DICOM data were imported into a
Fig. 1
Pre-existing complete removable denture during intraoral rebasing.

Fig. 2
Pre-existing complete removable denture with 6–8 drops of radiopaque flowable composite.

Fig. 3
Pre-existing complete removable denture in the patient’s mouth during CBCT scanning.

Fig. 4
Powdered pre-existing complete removable denture before extraoral digitalization.

Fig. 5
Matching of the digitalized pre-existing prosthesis with the CBCT scan.

3-D software planning program (3Diagnosys, Version 5.0, 3DIEMME, Cantù, Italy). The repro-cessed surface extrapolated from the DICOM data and the surface of the existing prosthesis generated by the scanning process were merged with the best-fit repositioning tools of the software using the composite radiopaque markers (Fig. 5). Implants (Osstem TSIII, Osstem, Seoul, South Korea) were planned according to the prosthetic setup. After careful functional and esthetic evaluation and final verification, the prosthetically driven plans were approved, and stereolithographic surgical templates were fabricated with a newer rapid prototyping technology (LightSolutions, New Ancorvis, Bargellino, Italy).

One hour before implant placement, patients underwent professional oral hygiene and received prophylactic antibiotic therapy (2 g of amoxicillin or 600 mg of clindamycin if allergic to penicillin). A total of 13 implants were placed using a guided approach according to previously published protocols.

Extraoral chairside digitalization of the final implant positions

After osseointegration, extraoral chairside digitalization of the final implant positions was performed using dedicated scan abutments (Type AQ, New Ancorvis; Fig. 6) fixed intraorally on a specially designed customized tray based on the approved prosthetic setup (Figs. 7 & 8). In accordance with the manufacturer’s instructions, before scanning (True Definition Scanner), the entire area to be scanned was powdered lightly (Fig. 9). The customized tray was designed maintaining the tooth design, but allowing the screwing on of the scan abutments. The obtained STL files were matched with the previous planning containing all the information about esthetics and function, including occlusal vertical dimension and bite registration in centric relation (Fig. 10).

Definitive restorations were delivered according to the individual treatment plans. Up to 1 year after definitive prosthesis delivery, no implant had failed and the prosthetic survival rate was 100%.

Discussion

Nowadays, guided surgery is aimed at preparing the implant case and placing implants in the correct prosthetically guided positions. Implant-supported overdentures are an accepted and predictable treatment modality for patients with edentulous jaws. Clinical studies have documented high survival rates for observation periods of up to 10 years, a high level of patient satisfaction and an improved quality of life compared with conventional dentures.
However, it should not be forgotten that the improvement of intraoral scanning techniques and technologies can allow us to make the most of the digital workflow for the finalization of the case and consequently to reduce the number of appointments and costs for the patient. Another advantage is the significant reduction in laboratory time and complexity when compared with more conventional approaches that involve fabrication of the bar patterns with acrylic resin, investment, and casting of dental alloys.11 Additionally, because the casting step is eliminated, problems associated with the cost of the alloy, control of the investment expansion, and shrinkage of the alloy are also eliminated.12–14

After a careful literature review and correctly analyzing the latest technological developments of intraoral scanners, it was decided to modify the double-scan technique proposed by Van Steenberghe et al. that provided for 2 CBCT scans.6 In the proposed technique, the second scan results in the extraoral digitalization of the radiographic guide with added 3-D radiopaque markers. The advantage of this new technique is that the surgical template obtained is derived from the intraoral scan that is more precise than the one obtained from CBCT.
Presently, after implant osseointegration, the best way to finalize the case is to take a definitive impression of the implants and to use the temporary prosthesis, if present and functionally and esthetically suitable, to articulate the opposite arch cast to incorporate into the articulator functional information on the provisional (function, vertical dimension, centric relation, esthetics).

With the new proposed impression tray, which is derived from the prosthetic setup used for the guided surgery, then already approved by the clinician and the patient, we transfer to the dental technician, with a single appointment, the final implant positions, the centric relation, the vertical dimension, and the esthetic and functional parameters. The limits of this technique are the management of soft tissue, which may require a second scan of the tissue with the scan abutments, always in the same session. The advantage is also that the scan of this new modified tray can be done outside the patient’s mouth, reducing the discomfort for the patient and increasing the accuracy.

**Conclusion**

Extraoral chairside digitalization may provide better accuracy than conventional methods, permitting fast, easy and accurate treatments at a decreased cost. Randomized controlled trials are needed to evaluate predictability and repeatability of this workflow.

**Competing interests**

The authors declare that they have no competing interests.

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**References**


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Digital face-bow transfer technique using the dentofacial analyzer for dental esthetics and 2-D, 3-D smile design: A clinical report

Abstract

This article describes an effective and affordable technique for transferring a face-bow relation record to a virtual articulator for the proper orientation of the maxillary digital model using the Kois Dento-Facial Analyzer System. In complex esthetic and full-mouth rehabilitation cases, the orientation of the models to the articulator is crucial for the evaluation of excursive movements. The article elaborates on the necessary steps to use the face-bow transfer technique to design esthetic veneers based on a 2-D, 3-D smile design approach using a clinical case as an example of the protocol.

Keywords

Digital face-bow; digital wax-up; CAD/CAM; smile design; dentofacial analyzer.
Digital workflows are becoming more popular and are in demand among clinicians and laboratory technicians owing to the increased incorporation of CAD/CAM tools into the daily practice. Digitization of records and data through cone beam computed tomography (CBCT) scans, intraoral scans and model manipulation contributes to better communication processes for diagnostics, treatment planning, designing and manufacturing in dentistry.

In past decades, clinicians and laboratory technicians have used analog articulators to simulate hinge and eccentric movements of the mandible, allowing for the fabrication of wax-ups and final restorations; the evaluation of occlusal function is fundamental to any dental treatment.\(^1,2\) Face-bows were developed as a complement to different articulator systems to orient the maxillary arch to the center of rotation of the condyles in 3 planes of space and transfer the position to the articulator; similar movements can be reproduced for occlusal evaluation and diagnosis once the models have been properly mounted.\(^3,4\)

In recent years, the incorporation of CAD/CAM technology has provided for more efficient protocols by automating processes and reducing manual labor. Intraoral scanners can digitize dental arches and register maxillomandibular relationships.\(^5,6\) Currently, many CAD/CAM systems include a virtual articulator simulatory module as a tool to simulate mandibular movements, which can be adjusted by using numerical values to represent condylar inclination, Bennett angle, vertical dimension, etc. The equivalent of analog mounted maxillary and mandibular casts still applies in the digital workflow for a proper evaluation; however, a major challenge has been to transfer the maxillary arch position without an analog tool such as a face-bow. A digital model behaves similarly to a floating object in space: The 3-D models are not accurately oriented in the x, y and z coordinates when they are digitally scanned, which makes identifying the facial midline and occlusal plane impossible without proper points of reference (Fig. 1). In complex esthetic and full-mouth rehabilitation cases, it is crucial to identify the midline and plane of occlusion to recognize any potential canting and occlusal problems.\(^7\)

Panadent introduced a simplified system for transferring mounted study casts to the analog articulator, called the Kois Dento-Facial Analyzer System, or Dento-Facial Analyzer (DFA). The Dento-Facial Analyzer system is a device created by Dr. Kois and sold by Panadent (Panadent, California); the occlusal stand fits directly onto the magnetic mount of the Panadent articulator series; several companies have developed compatible occlusal stands to fit their articulators and similar systems. The device basically consists of a Fox plane with an adjustable middle rod (Fig. 2). An index tray is attached to the device to record the position of the maxillary arch using bite registration material and to transfer the patient’s occlusal plane and midline in the 3 planes of space to the analog articulator with a magnetic plate that attaches to an occlusal stand (Figs. 3 & 4). This allows mounting of the casts at a fixed distance of 100 mm, which is based on Kois’s research on average axis–incisal distance, which is substantiated by Bonwill’s equilateral triangle theory and Monson’s spherical theory.\(^8-10\)

Different techniques have been proposed to transfer this information into the CAD software, but most are more time-consuming and complex, using full-volume CBCT data or 3-D facial scanners and different software to generate data able to align the maxillary scan to the skull.\(^11,12\) Most affordable 3-D facial scanners (under $5,000) do not generate high-quality meshes that can be used to directly align dental casts. The scans are able to capture color and can confuse clinicians about the true quality of the underlying mesh; without the color, the quality of the underlying mesh is typically distorted and does not represent the shape of the actual object (Fig. 5). Moreover, 3-D facial scanners need to have reference markers to align the digital dental models to the facial scan, which makes the process more complicated than using an analog face-bow.

The technique described in this article overcomes these problems because it can align digital casts to the virtual articulator by using a bite scan in conjunction with the DFA. The face-bow transfer technique is described as follows:

1. Properly take a dentofacial record using the Kois DFA, aligning the middle rod to the midline of the patient and capturing the occlusal plane orientation with the Fox plane. Several materials, such as polyvinylsiloxane bite registration material, wax or impression compound, can be used on the plastic index tray.

2. Scan the maxillary and mandibular arches with an intraoral scanner along with the bite record. The intraoral scan used in this case...
Digital face-bow transfer technique

3. Scan 1 bite record to align maxillary and mandibular arches and scan an additional bite record using the previous record captured with the plastic index tray on the maxillary cast. Since the plastic index tray was used as a record to capture the midline and plane of occlusion with the DFA, the external middle rod and the Fox plane are not needed for the bite record scan. The anterior middle notch in the index tray corresponds to the facial midline and the base of the tray corresponds to the occlusal plane (Fig. 8).

4. Align all models and bite records in the software.

5. Export all STL models and import to the design software or use it within the CAD software if the digital system has a CAD module integrated to start designing the anterior restorations or digital wax-up.

6. If the CAD software has an articulator module available, the bite record can also be used; in this case, the exocad articulator module was used (exocad, Darmstadt, Germany). Click the boxes that display the horizontal and vertical planes of the articulator. Align the corresponding planes: midline notch of the index tray to the vertical plane of the articulator; and base of the index tray to the horizontal occlusal plane of the articulator (Figs. 9 & 10).

In addition to the basic alignment, the clinician has 2 different ways to correlate the anterior posterior distance of the digital model with the virtual articulator. The first option is available if the clinician already has a full-face skull CBCT (wide field of view, approximately 20 × 18 cm, standard resolution). The distance from the center of rotation of the condyles to the central incisors can be measured and reproduced in the articulator module (Fig. 11); the exocad DICOM viewer module can be used to measure the CBCT data and correlate the dental model scan of the maxillary arch. The second option is using the average axis-incisal distance reported by Kois’s research of 100–110 mm, which corresponds to the average anthropometric distance from the center of rotation of the condyles to the incisal edge of the maxillary central incisors; that is the distance traditionally used with the Panadent articulator models PCF and PSH and the occlusal stand used to mount the plastic index tray. A 3-D measurement ruler tool can be used in most CAD dental software to establish the distance and thus position the models.
Fig. 5
3-D facial scan showing the same mesh with and without color. The quality of the mesh without color can be appreciated and is not a good representation of the patient anatomy for registration purposes.

Fig. 6
Maxillary and mandibular models aligned in occlusion.

Fig. 7
Maxillary and mandibular models aligned displaying the bite record.

Fig. 8
Scanned model and index tray bite record showing the corresponding facial midline determined by the middle notch of the index tray and the occlusal plane determined by the base of the index tray.

Fig. 9
Frontal view of the model orientation based on the horizontal plane of the virtual articulator.
This technique is beneficial in anterior esthetic cases and helpful in 3-D smile designs. The advantage of using a 2-D, 3-D integrated CAD design is that any request from the patient can be done instantly in the 3-D design, eliminating the need for a conventional wax-up, which takes hours, and minimizing the clinical time needed to obtain a cast, because the cast can be manufactured by means of a 3-D printer or milling machine, making the protocol extremely efficient. Furthermore, using 2-D images captured by photographic cameras or high-definition video cameras and superimposing them to 3-D data is the quickest and simplest approach. A 3-D facial scanner often cannot capture a smile in fractions of a second like a photograph can; instead, the patient has to hold the smile for several seconds, making it more difficult for clinicians to capture a true smile.
Another advantage to using a virtual wax-up is the possibility of using cross-sectional views to visualize and measure the addition of restorative material prior to starting an invasive procedure. This is an extremely useful educational tool for minimally invasive techniques that can improve the appearance of the smile and at the same time offer a better prognosis by preserving tooth structure.13, 14

The purpose of this article is to describe the 2-D, 3-D smile design integration and its benefits in the provisionalization stage after using the digital face-bow transfer technique.

Clinical report

A 62-year-old woman presented to the Comprehensive Care Clinic at the Dental College of Georgia at Augusta University, Augusta, Georgia, U.S., with the chief complaint of worn and stained anterior teeth (Figs. 12 & 13). The patient was a smoker and reportedly smoked a pack per week. During the first appointment, clinical and radiographic examinations were done for proper diagnosis and formulation of a treatment plan. The clinical examination revealed attrition on the anterior teeth and maxillary premolars, stable periodontal health with probing depths of < 3 mm, and no endodontic lesions or pathology. A thorough occlusal analysis was done, with no significant findings. Maximum intercuspation position was coincidental with centric relation, and no alteration of the vertical dimension was diagnosed. After evaluation of the patient records, a set of intraoral and extraoral preoperative photographs was taken, along with a DFA record, which includes a record of the midline and occlusal plane based on facial esthetics (Fig. 14). Incisal edge position
Digital face-bow transfer technique was determined first by adding composite to the left maxillary central incisor as a guide to establish the new length based on the evaluation of lips at rest and during smiling. The composite restoration is not bonded to tooth structure and is only used to determine the esthetic incisal edge position during rest position, phonetics and smiling. Once the position is stabilized the length is recorded for the future digital wax-up and the composite is removed. A prophylaxis was done during the appointment to treat some of the extrinsic staining present on the teeth.

With the diagnostic information acquired during the first appointment, the steps of aligning the models using the face-bow transfer technique with the DFA system were followed. A 2-D image of the patient was imported and aligned using match points to develop a 3-D functional virtual wax-up by adding restorative material to the maxillary anterior teeth and first premolars. A natural tooth library with square-shaped teeth similar to the patient’s natural anatomy was selected to create the virtual diagnostic wax-up to reproduce shape and texture. The dental software used in this case (exocad) also has a tooth color selection option to show a simulation of tooth shade, which facilitates the patient’s visual perception of the proposed treatment and improves treatment acceptance (Fig. 14). The design was evaluated functionally using the articulator module for excursive movements (Fig. 15).

The virtual 3-D smile design was shown to the patient at the second visit. She was able to visualize the possible results of the esthetic treatment and participate by giving feedback before any invasive procedures were initiated. No modifications were requested. The virtual wax-up was 3-D printed (MoonRay S, SprintRay, Los Angeles, Calif., U.S.) and a putty jig was created on the model to generate a mock-up for the patient using bis-acryl (Integrity, Dentsply Sirona, York, Pa., U.S.; Fig. 16) owing to its minimal shrinkage and excellent esthetic results. The mock-up has 2 functions. The first is to serve as an esthetic and functional prototype that enables the patient to visualize and experience the end result with a restorative material. Any modifications can be done at this stage because it is temporary and noninvasive. The second function is to work as a reduction guide once the patient has approved it; the reduction is created through the mock-up material and not through tooth structure (Fig. 17).

Minimally invasive preparation (0.5–0.8 mm facial reduction and 1.5 mm incisal/occlusal reduction) was done for the labial esthetic veneers, allowing for enamel preservation (Figs. 18 & 19). A final impression was taken and the 3-D virtual design was used as the preoperative digital model, since no modifications were done intraorally after verification. Leucite glass-ceramic blocks (IPS Empress CAD, Ivoclar Vivadent, Schaan, Liechtenstein) were milled for the final veneer restorations in-house using a milling machine (PlanMill 4.0, Planmeca; Figs. 20 & 21). Final characterization was done after glazing.

At the delivery appointment, an esthetic try-in was done prior to bonding the restorations. The patient approved the aesthetics, marginal fit was verified, and the teeth and restorations were etched and bonded (Variolink Esthetic, Ivoclar Vivadent). The patient was extremely satisfied.
with the treatment outcome (Figs. 22–25). An occlusal guard was provided as part of the treatment plan. At the 1-year follow-up, the patient reported no complications.

**Discussion**

This article presents a simplified digital technique for transferring the face-bow information to the articulator. Transferring the position of the digital models in relation to the face is important to reproduce functional movements and have predictable esthetic results. Previous techniques using CBCT units require that the patient be submitted to unnecessary radiation to orient the models. In addition, other techniques using 3-D facial scanners require expensive hardware; most clinicians cannot justify this expense only for orientation purposes, and both of these methods require more time and are more complex in nature.

The face-bow transfer technique could also be used with edentulous patients by using occlusal rims as the reference points for the central incisors. The occlusal rim and the bite record with the plate would have to be scanned in order to register the meshes and align the edentulous models. However, this could be more technique-sensitive owing to the lack of stability of the bases.

While other bite forks can be used for the technique presented here, the authors highly recommend the DFA because of its ease of use. This technique is compatible with any virtual articulator, unlike analog articulators that require brand-compatible stands. This creates a universal digital transfer technique that can be efficiently shared digitally with any other clinician or laboratory technician. While additional studies are needed to validate accuracy and reproducibility, this technique has the potential to greatly improve the workflow of digital dentistry. The process could be made even more efficient with the implementation of a direct align algorithm in dental software upgrades and with the incorporation of jaw tracking devices and tracking scans. This technique is extremely useful in 3-D smile design cases or esthetic cases that require the visualization of facial landmarks such as the midline and plane of occlusion.

**Conclusion**

The digital face-bow transfer technique using the DFA system is a predictable, quick and easy method of scanning and aligning digital models to a virtual articulator without the need for expensive equipment.

**Competing interests**

The authors declare that they have no competing interests.

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Digital face-bow transfer technique

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Low implant insertion torque allows minimal bone loss: A multicenter 2-year prospective study

Abstract

Objective

The aim of this multicenter prospective study was to evaluate the survival rate of implants after insertion using low torque (< 35 N cm), by recording measurements from resonance frequency analysis (RFA), probing pocket depths and changes in interproximal crestal bone level.

Materials and methods

This multicenter prospective clinical study was performed in partially edentulous subjects. The patients treated in the study received 1–4 SPI implants (Alpha-Bio Tec, Petah Tikva, Israel), which were loaded 4 months after implantation. Measurements of torque and RFA were recorded immediately after implant insertion. New RFA measurements were taken at the time of implant exposure surgery, prior to connection of the healing abutments. Baseline measurements of bone level were taken both directly and radiographically immediately after insertion and were compared with measurements taken during the 2-year follow-up period.

Results

Of 88 treated subjects, 83 completed the 2-year follow-up. Of 137 implants, 5 were lost. The survival rate after 2 years of follow-up was 96.5% and the mean marginal bone loss was 0.531 mm. The mean measurement for RFA at the time of implantation was 74.92 and this increased to 76.26 prior to insertion of the prostheses.

Conclusion

Within the limits of the study, implants inserted with low torque (< 35 N cm), displayed high survival rates with high RFA scores and minimal bone loss at the 2-year mark after implantation.

Keywords

Implants; bone loss; RFA; resonance frequency analysis.
Low torque leads to minimal bone loss

Introduction

Nowadays, dental implants are widely used as a treatment for fully and partially edentulous patients, and the survival rate has been reported to be high. However, certain risk factors may predispose to an increased risk of implant failure and a lower success rate. Risk factors for implant failure can be divided mainly into 2 groups. The first group of risk factors includes surgical technique, retention technique, the primary stability of the implant, and variables affecting the implant prosthesis, such as the length, diameter and location of the implant. The second group involves patient-related factors, such as smoking, diabetes, alcohol abuse, oral hygiene habits and a history of periodontitis. Controversy remains, however, concerning the linkage between certain risk factors and dental implant failure.

Dental implant success may be characterized by initial and long-term stability of the implant and healthy periimplant hard and soft tissue. It is widely accepted that marginal bone loss of approximately 1.0 mm during the first year after prosthetic loading and subsequent annual bone loss not exceeding 0.2 mm are consistent with successful treatment.

A wide variety of techniques have been used for measuring implant stability at various clinically relevant reference points in time. The techniques currently most often used to measure stability are insertion torque, Periotest and resonance frequency analysis (RFA). While clinically useful, insertion torque is limited to implant insertion and thus cannot be used to determine secondary stability. Conversely, RFA is a noninvasive and widely used method to quantify implant stability at any stage during implant treatment and the follow-up period.

The RFA technique for measuring implant stability was developed by Meredith and co-workers almost 30 years ago and is commercially available as the Osstell device. A sensor (SmartPeg) is mounted on top of the implant and the sensor is then brought to vibration by gently moving it with magnetic pulses. The sensor will vibrate for a short while and then stop. If the implant stability (stiffness of the bone–implant interface) increases, then the vibration frequency of the sensor will increase. Resistance to vibration of the transducer by the surrounding bone is registered by a small computer device and measured in hertz. Hertz are converted to ISQ (Implant Stability Quotient) values ranging from 1 to 100; the higher the ISQ, the greater the implant stability. This method is known as RFA.

Dentists feel better whenever an implant is inserted using high torque (< 35 N cm). There are some publications claiming that this is an ultimate demand for immediate loading. However, using low insertion torques yields favorable survival rates with optimal marginal bone levels compared with the accepted norm.

In 2004, the SPI implant system (Alpha-Bio Tec, Petah Tikva, Israel) was introduced to the dental market. The implant has an internal hexagon connection and is available in several lengths and diameters. The implant surface is sandblasted and acid-etched (NanoTec). Its tapered core and sharp threads result in firm bone grip, which enables stable insertion and high primary stability.

The aim of this multicenter prospective study was to evaluate the survival rate of implants after insertion using low torque, by means of recording measurements from RFA, probing pocket depths and monitoring changes in the interproximal crestal bone level.

Materials and methods

Study design

This prospective study was designed as a controlled multicenter clinical trial, and it involved the participation of the following 4 medical centers in China: West China Hospital of Stomatology, Chengdu; Stomatology Hospital of Shandong University, Jinan; Yantai Stomatological Hospital, Yantai; and Affiliated Stomatology Hospital of Tongji University, Shanghai.

The study was conducted in accordance with the 1964 Declaration of Helsinki (and all subsequent amendments) and Good Clinical Practice (ISO 14155:2003). It was approved by the ethics committee of Sichuan University and was submitted to the other centers for approval prior to commencement of the study. The study was registered at www.clinicaltrials.gov (registration No. NCT02367261).

Subjects and implants

Subjects were selected according to the following predetermined inclusion and exclusion criteria:
Inclusion criteria
1. Men and women over the age of 18 years who were in need of 1–4 implants.
2. Patients able to understand the requirements of the study and willing and able to comply with its instructions and schedules.
3. Patients who provided written informed consent to participate in the study prior to any study procedure.
4. Patients in good general health in the opinion of the principal investigator, as determined by the medical history and oral examination.

Exclusion criteria
1. Immediately loaded implants.
2. Patients requiring bone augmentation.
3. Patients receiving treatment with bisphosphonates.
4. Patients receiving treatment with anticonvulsant drugs or anticoagulant drugs (international normalized ratio under 1.8).
5. Patients with untreated periodontal disease and poor oral hygiene.
6. Patients with a history of alcohol, narcotic or other drug abuse.
7. Patients undergoing steroid therapy.
8. Patients receiving radiotherapy, chemotherapy or any other immunosuppressive treatment, or who had received radiotherapy to the head and neck region at any time in the past.
9. Patients with metabolic bone disorders.
10. Patients with uncontrolled bleeding disorders, such as hemophilia, thrombocytopenia and granulocytopenia.
11. Patients with degenerative diseases.
12. Patients with osteoradionecrosis.
13. Patients with renal failure.
15. HIV-positive patients.
16. Patients with malignant diseases.
17. Patients with diseases that compromise the immune system.
18. Patients with uncontrolled diabetes mellitus (hemoglobin A1c level above 6.5%).
19. Patients with psychotic diseases.
20. Patients with hypersensitivity to any of the components of the implant in general or to titanium in particular.
21. Pregnant or lactating women.
22. Lack of patient cooperation.
23. Patients with uncontrolled endocrine diseases.
24. Patients with any systemic condition that precluded surgical procedures.
25. Patients with parafunctional habits, such as bruxism.
26. Patients with temporomandibular joint disease.
27. Patients with various pathologies of the oral mucosa, such as benign mucous membrane pemphigoid, desquamative gingivitis, erosive lichen planus, oral malignancy and bullous erosive diseases of the oral mucosa.
28. Patients who required flapless procedures.
29. Patients who smoke over 10 cigarettes a day.

The most important inclusion criteria were subjects over 18 years old who had good general and dental health. The most important exclusion criteria were as follows: immediate implantation, smokers of over 10 cigarettes a day, alcohol abuse, various medical conditions as specified by the clinician, and pregnant or lactating women.

Surgical protocol
All subjects received 1–4 SPI implants. Using a delayed implant approach, all implants were inserted 4 months after tooth extraction. The implants were 3.3–5.0 mm in diameter and 8.0–13.0 mm in length. Implant surgeries were performed under local anesthesia and followed standard surgical techniques. After flap elevation, the implant bed was prepared using medical-grade stainless-steel drills (Alpha-Bio Tec) with progressively increasing diameter, in accordance with the drilling protocol (Table 1). The implant insertion torque was measured with a physiodispenser machine (NSK, Stevenage, U.K.; Nouvag, Goldach, Switzerland), which was placed at the level of the crestal bone. RFA was measured immediately after implant placement using an Osstell device (Osstell, Gothenburg, Sweden). A periapical radiograph was taken as a baseline, using a paralleling technique.

Implants were exposed 4 months after implantation, and RFA measurements were taken immediately prior to connection of the healing abutments. The final prostheses were fabricated 6 months post-implantation. The occlusion of the restorations was adjusted, and oral hygiene was reinforced with the patients. Patients were recalled at intervals of 12 and 24 months after implant insertion surgery in order to evaluate the periimplant bone level and the status of the prosthetic work.
Low torque leads to minimal bone loss

Table 1
The drilling protocol used in the study.

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<tr>
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<td>5.80 cortical</td>
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</tbody>
</table>

Cortical = Drill through cortical plate

Survival of implants was defined as those implants that were still in place 24 months after placement and that met the criteria set by Buser et al.: the absence of persistent subjective complaints (e.g., pain, foreign-body sensation and dysesthesia), the absence of periimplant infection with suppuration, the absence of mobility, the absence of a persistent periimplant radiolucency, and the possibility of restoration.15

Bone level changes
Periapical radiographs with standardized settings were taken as a baseline at the time of implant surgery and were retaken at the time of abutment connection and at 12 and 24 months postsurgery (Figs. 1–3). Digital images were analyzed using ImageJ open software (Version 1.33, National Institutes of Health, Bethesda, Md, U.S.) by an independent reader who was blind to the study material. The implant length was used as a reference measurement, and bone level was therefore defined as the distance from the reference point to the first radiographic bone-to-implant contact; changes in mesial and distal bone levels in this region were considered to be remodeling. Mesial and distal measurements were recorded and the mean of these 2 values was used.

Statistical analysis
Bone level was calculated as the average of the mesial and distal levels at 3 time intervals (baseline and 12 and 24 months later). Repeated measures general linear models with Bonferroni
Low torque leads to minimal bone loss

Eighty-eight patients out of 90 were included in the study. Of the 88 treated subjects, 83 participated up to the 24-month follow-up mark (2 patients had dropped out and 3 had implant failure diagnosed). The study group consisted of 47.73% men and 52.27% women and the mean age of the participants was 47.45 ± 11.15 years. The majority did not smoke at all, and 22% of the subjects smoked less than 10 cigarettes a day.

The average measurement for insertion torque was 33.250 ± 9.913 N cm (Table 2). Of 137 implants, 132 survived. The calculated survival rate of the implants after 2 years was 96.5%. Five implants were lost during the first year of the study, while no implant was lost during the second year.

RFA measurements were taken after implant placement and retaken immediately prior to connection of the prostheses (Fig. 4). The mean immediate measurement for RFA was 74.92 ± 8.93, while analysis at the time of implant exposure 4 months later yielded a 76.26 ± 7.42 mean score.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N (missing)</th>
<th>Mean ± SD (N cm)</th>
<th>Min, Max</th>
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<tbody>
<tr>
<td>Insertion torque</td>
<td>137 (0)</td>
<td>33.250 ± 9.913</td>
<td>5, 50</td>
</tr>
</tbody>
</table>

**Table 2**

Results

Eighty-eight patients out of 90 were included in the study. Of the 88 treated subjects, 83 participated up to the 24-month follow-up mark (2 patients had dropped out and 3 had implant failure diagnosed). The study group consisted of 47.73% men and 52.27% women and the mean age of the participants was 47.45 ± 11.15 years. The majority did not smoke at all, and 22% of the subjects smoked less than 10 cigarettes a day.

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<td>137 (0)</td>
<td>33.250 ± 9.913</td>
<td>5, 50</td>
</tr>
</tbody>
</table>

**Table 2**

The mean change in marginal bone level at the 1-year follow-up was 0.44 ± 0.52 mm and the mean change at the 2-year follow-up was 0.54 ± 0.50 mm (Fig. 5). The average bone loss between the 1- and 2-year follow-up marks was calculated and found to be 0.105 mm.

Soft-tissue changes were monitored by probing pocket depths at 4 locations: mesial, distal, buccal and lingual (Fig. 6). The probing depths before connection of the final restoration averaged 1.04 ± 1.08 mm mesially, 0.91 ± 0.93 mm buccally, 1.04 ± 1.42 mm distally and 0.86 ± 0.88 mm lingually. At 12 months postsurgery, the average probing depths were 2.40 ± 0.80 mm, 2.08 ± 0.82 mm, 2.30 ± 0.85 mm and 2.10 ± 0.80 mm, respectively. At 24 months postsurgery, the average probing depths were 2.60 ± 1.05 mm, 2.10 ± 0.98 mm, 2.55 ± 1.11 mm and 2.33 ± 1.20 mm, respectively.

Discussion

This was a controlled multicenter prospective study that evaluated performance of the SPI implant system with 24 months of follow-up. The study demonstrated a stable survival rate of 96.5% after 1 and 2 years of follow-up. This finding correlates with previously performed studies by Artzi et al. and Ormianer et al. that showed similar implant survival rates of 96.95% and 96.6%, respectively, over longer follow-up periods.

According to Chrcanovic et al., failures of dental implants can be subdivided into early and...
Late failures, depending on whether they occur either before/after abutment connection surgery (early) or after occlusal loading of a prosthetic restoration (late).\textsuperscript{18} Failures in each of these 2 distinct periods may be associated with different factors. Early failure of an implant results from an inability to establish intimate bone-to-implant contact. Based on our data, the excellent stability and integration of SPI implants was evident within 4 months after implantation (before connection surgery), even though the average insertion torque did not exceed 35 N cm.

The average insertion torque used in this multicenter study yielded quite a low degree of bone loss 2 years after implant insertion surgery. The drilling protocol used in the study resulted in a low insertion torque, accompanied by quite a high RFA reading. The torque in this study is much lower than the values reported in the literature.\textsuperscript{19, 20} Lower insertion torques yield favorable survival rates with optimal marginal bone levels compared with the accepted norm.\textsuperscript{14, 21} In contrast, studies in which high insertion torque was implemented demonstrated significant bone loss compared with low insertion torque.\textsuperscript{19, 20}

In order to identify the risk factors associated with implant failure, a multivariate Cox model was formulated, and a rigorous model was selected that was constructed with statistically significant variables ($P < 0.05$) identified by bivariate Cox regression analysis. As a result, 2 variables were statistically associated with implant failure: tobacco use ($P = 0.021$) and alcohol use ($P = 0.047$). In the multivariate model, however, only tobacco use remained statistically associated with implant failure. These results are in accordance with those of several previous studies.\textsuperscript{18, 22, 23}

The mean amount of bone loss detected in the study was 0.426 mm at 1 year postimplantation and 0.531 mm at the 2-year mark. These results are in agreement with those of Artzi et al.\textsuperscript{16} and Ormianer et al.\textsuperscript{17}, which reported bone loss of 0.78 mm at the 3-year follow-up and 2.00 mm at the 9-year follow-up.

In addition, this minimal rate of bone loss was accompanied by improved RFA measurements, which may be associated with increased implant stability. The results suggest that the SPI implants allowed progressive biological integration with their bony housing.

Probing depths before connection of the final restoration connection were $1.04 \pm 1.08$ mm mesially, $0.91 \pm 0.93$ mm buccally, $1.04 \pm 1.42$ mm distally and $0.86 \pm 0.88$ mm lingually. At 1 year postimplantation, the probing depth measurements had increased to $2.40 \pm 0.80$ mm, $2.08 \pm 0.82$ mm, $2.30 \pm 0.85$ mm and $2.10 \pm 0.80$ mm, respectively, and at 2 years
postimplantation, they had increased to 2.60 ± 1.05 mm, 2.10 ± 0.98 mm, 2.55 ± 1.11 mm and 2.33 ± 1.20 mm, respectively.

The analysis thus revealed that probing depths increased moderately compared with the baseline over the period of the study, and one may conclude that a more fastidious oral hygiene regimen was required by all subjects, especially with regard to the implant sites, even though bone loss measurements were not found to be higher at these sites. None of the implants were diagnosed with periimplant mucositis or periimplantitis, according to the diagnostic criteria, such as bleeding on probing.

### Conclusion

Within the limits of the study, implants inserted with low torque displayed high RFA scores, minimal bone loss and a high survival rate at 24 months after implantation.

### Competing interests

The authors declare that there are no competing interests. Prof. Ofer Moses serves as an external medical adviser for Alpha-Bio Tec. The study was funded by Alpha-Bio Tec.

### References


The 66th Annual Meeting of Japanese Association for Dental Research

Back to the tangible - the symbiosis of basic research and clinical dentistry -

11/17 (Sat.) - 18 (Sun.), 2018

Hokkaido University Clark Hall, Sapporo-city, Hokkaido, Japan

Hidehiko Sano
Professor & Chairman
Graduate School of Dental Medicine, Division of Oral Health Science, Department of Restorative Dentistry, Hokkaido University

http://jadr66.umin.jp/eng/index.html
Implant-supported mandibular complete fixed prosthesis with conometric retention after 3 years of functional loading

Abstract

Objective

The aim of the study was to assess the clinical performance of implant-supported mandibular complete fixed prostheses with conometric retention after 3 years of functional loading.

Materials and methods

In this retrospective study, patients treated with implant-supported mandibular complete fixed prostheses with conometric retention were considered. Standardized radiographic examinations were performed to assess the marginal bone. Radiographs were acquired at the time of prosthesis insertion and at the 3-year follow-up, and marginal bone loss was calculated. The occurrence of implant failures, and biological and technical complications was registered.

Results

Thirty-nine patients were selected. At the 3-year follow-up, 134 out of the 160 placed implants did not show any marginal bone loss and 4 of them had been lost. The percentage of restorations free of technical complications was 71.8% during the entire follow-up period. Complications that occurred in restorations were as follows: veneer fracture (n = 4), framework fracture (n = 3), loss of retention (n = 2) and need for relining (n = 2). Mucositis was recorded in 1 patient and it was successfully treated.

Conclusion

The clinical performance of implant-supported mandibular complete fixed prostheses with conometric retention after 3 years of functional loading showed a low rate of marginal bone loss and technical complications. Owing to the easy retrievability, all complications were successfully treated.

Keywords

Fixed prostheses; dental implants; conometric retention; edentulous mandible.
Introduction

The rehabilitation of edentate patients with the use of implant-supported fixed dental prostheses (IFDPs) has shown high long-term survival rates, comparable to those of tooth-borne restorations.1 The clinical success, however, depends on the extent of biological and technical complications occurring throughout the period of function.2 According to a systematic review, the patient-centered estimated 5-year complication rate for IFDPs was 33.6%.3 Such issues can be better addressed when restorations can be easily removed. Thus, a remarkable research effort has been dedicated to protocols with enhanced retrievability.4

One of the major topics of discussion among researchers and clinicians is the type of fixation between the implant and the prosthesis. Such connection is commonly provided by means of screws or cement. None of the fixation methods has been found to be clearly advantageous over the other.5 Moreover, they typically show some drawbacks. Screw-retained prostheses tend to experience more technical complications, such as screw loosening and fractures, while cemented restorations exhibit more biological complications, such as implant loss and marginal bone loss.2

Recently, the conometric connection was proposed as a fixation system for IFDPs. Such a system is composed of a tapered coping fixed to the prosthesis and inserted into a tapered abutment. When a suitable insertion force is applied, this system is capable of providing a fixed connection.6 Such retention is based on the friction between the components, without the use of cement. The clinical use of the conometric retention has been described for implant-supported complete7 and partial8 fixed prostheses.

One of the reported advantages of a conometric connection system is the retrievability of the restoration.7 Conometric-retained prostheses can be easily removed by the operator in order to check the periimplant soft-tissue status and for periodic hygiene procedures. Despite the promising results in terms of clinical success, long-term studies on mandibular full-arch conometric-retained restorations with a larger study population are lacking in the current literature. Thus, the aim of the present retrospective study was to assess the clinical performance of implant-supported mandibular complete fixed prostheses with conometric retention after 3 years of functional loading. Outcomes were evaluated in terms of implant and prosthetic survival, marginal bone loss and incidence of technical complications.

Materials and methods

In this retrospective study, patients consecutively treated with implant-supported mandibular complete fixed prostheses with conometric retention were selected. The IFDPs were supported by 4 mandibular implants placed in each patient. All cases were treated in a single center and had 3 years of follow-up from the time of prosthesis delivery. This study was conducted according to the principles of the Declaration of Helsinki on human medical experimentation. All patients signed informed consent prior to the implant treatment.

The adopted surgical and prosthetic protocol has been described in a previous study.7 After prosthetic delivery (baseline, T0), patients were recalled at 6 months, 1 year, 2 years and 3 years (T3) for follow-up visits. At each visit, the prosthesis was removed and oral hygiene, implant maintenance and patient-centered motivational instruction were delivered. Data were extracted from patient files at T3. Variables were subdivided between patient-based and implant-based. The following patient demographic characteristics were reported: sex, age at the time of surgery, smoking habit, bruxism, drug intake, systemic disease and time of prosthetic loading. Implant information, such as diameter and length, were recorded. Moreover, intraforaminal (positions .1, .2, .3, .4) or extraforaminal (positions .5, .6, .7) implant position was recorded (Fig. 1). Implant failure and technical complications, such as loss of retention, veneer fracture, need for relining and framework fracture, that occurred during the period of function were recorded. Standardized radiographic examinations with the use of a Rinn Universal Collimator (Dentsply Sirona, York, Pa., U.S.) were performed to assess the marginal bone. Radiographs were acquired at T0 and at T3. For marginal bone assessments, ImageJ software (Version 1.48, National Institutes of Health, Bethesda, Md., U.S.) was used. The measurements were performed with a precision of 0.01 mm at a 7× digital magnification level. For each analyzed radiograph, measurement calibration was carried out using the diameter and length of the implant. Then, the distance from the implant shoulder to the first appreciable contact point between the bone and implant was measured. In cases where the marginal bone level was coronal or at the level of the implant
shoulder, the reported value was 0 mm. The measurement was performed both medial and distal to the implant. The mean mesial and distal values were calculated at T0 and T3. The radiographic analysis was performed in a blind manner by 1 experienced examiner not involved in the study. Marginal bone loss (MBL) was calculated as the difference between the 2 time points.

According to the MBL results, patient-based variables were subdivided in 2 categories: patients with no MBL and patients who presented with MBL (Table 1). In the same manner, implant-based variables were subdivided into the following categories: implants with no MBL, implants with an MBL of < 1 mm, implants with an MBL of between 1 and 2 mm, implants with an MBL of > 2 mm, and implant failure (Table 2). Moreover, the incidence of technical complications was calculated.

Results

Thirty-nine patients (19 men and 20 women) were enrolled in the study. Demographic characteristics are shown in Table 1. A total of 160 implants were placed, 98 intraforaminally and 62 extraforaminally (Fig. 1). There was no sign of MBL around 83.75% of the implants, while 2.5% were lost during the 3-year follow-up. Implant-based variables according to MBL can be found in Table 2. Mucositis in 1 patient was encountered during periodic follow-up (Fig. 2). Regarding the restorations, 71.8% were free of technical complications during the entire follow-up period. Complications that occurred in restorations were veneer fracture, framework fracture, loss of retention and need for relining (Table 3; Fig. 3).

Discussion

In the present retrospective study, 39 patients with complete mandibular edentulism were rehabilitated with implant-supported conometric-retained prostheses. Our aim was to report the clinical performance in terms of incidence of technical and biological complications in a 3-year follow-up period. For this purpose, we included data on both immediate and delayed loading. The rehabilitation of edentate mandibles with implant-supported fixed restoration has been reported in long-term studies since the 1990s.9 Despite the high success rates after 15 years, several surgical and prosthetic procedures have been introduced over the years in terms of number of supporting implants, intra-arch locations, time of loading, and type of connection between the implant and the prosthesis.10

A meta-analysis on mandibular IFDPs11 investigated the implant survival rate of restorations supported by a range of 4–9 implants. In that study, 17 trials, including 501 patients and 2,827 implants, were considered. According to the results, intraforaminal implant placement was the most common technique (88.5% of all implants). In the present study, all restorations were supported by 4 implants, which were placed either intraforaminally or extraforaminally. Implants in the distal position were placed posterior to the mental foramen whenever the bone amount was sufficient in order to reduce the distal cantilever.
Table 1

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<tr>
<th>Patients without MBL</th>
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<td>Number</td>
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<tr>
<td>Average age</td>
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<td>Immediate</td>
<td>17 (77.3%)</td>
<td>5 (22.7%)</td>
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<tr>
<td>Delayed</td>
<td>9 (53%)</td>
<td>8 (47%)</td>
</tr>
</tbody>
</table>

MBL = marginal bone loss.

Table 2

<table>
<thead>
<tr>
<th>Position</th>
<th>Implants without MBL (mm)</th>
<th>Implants with MBL (mm)</th>
<th>Implant failures</th>
<th>Total</th>
</tr>
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<tr>
<td></td>
<td>0 &lt; MBL &lt; 1</td>
<td>1 &lt; MBL &lt; 2</td>
<td>MBL &gt; 2</td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>134 (83.75%)</td>
<td>13 (8.12%)</td>
<td>7 (4.37%)</td>
<td>2 (1.25%)</td>
</tr>
<tr>
<td>Intraforaminal</td>
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<td>8</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Extraforaminal</td>
<td>52</td>
<td>5</td>
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<td>1</td>
</tr>
<tr>
<td>Loading</td>
<td>80</td>
<td>6</td>
<td>7</td>
<td>2</td>
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Table 3

<table>
<thead>
<tr>
<th>Technical complications</th>
<th>28 (71.8%)</th>
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</thead>
<tbody>
<tr>
<td>Veneer fracture</td>
<td>4 (10.24%)</td>
</tr>
<tr>
<td>Framework fracture</td>
<td>3 (7.68%)</td>
</tr>
<tr>
<td>Loss of retention</td>
<td>2 (5.12%)</td>
</tr>
<tr>
<td>Need for relining</td>
<td>2 (5.12%)</td>
</tr>
</tbody>
</table>

The majority of implants were placed in the intraforaminal area; however, 62 implants were placed distal to the foramen. A total of 33 restorations were supported by at least 2 extraforaminal implants. This means that in the majority of cases (65%) the placement of implants of at least 8 mm in length was possible in the distal sites. This is in accordance with a recent study that evaluated the dimensions of the alveolar ridge in the edentulous posterior mandible based on CBCT data. A mean bone height of 11.20 mm and 10.28 mm in the sites of the second premolar and mesial root of the first molar, respectively, was measured.

During the present 3-year follow-up study, 4 out of 160 implants failed. Therefore, the overall implant survival rate was 97.5%. In all cases, implants were lost during the first year after placement. This result is in accordance with recent studies with similar groups of patients and follow-up. In addition, a systematic review showed similar results. In the study, the cumulative implant survival rate estimates were
calculated based on the number of supporting implants for mandibular full-arch restorations. At the 5-year endpoint for restorations supported on 4 implants, the implant survival rate was 97.65% (95% CI: 94.48–100). Regarding biological complications, a good performance in terms of incidence of MBL was observed in the present study, since 134 out of the 156 surviving implants (85.9%) did not show any MBL after the 3-year follow-up. However, as previous studies observed, the stability of marginal bone is related to patient-related factors.15

From our results, a relevant difference in the incidence of MBL was observed based on smoking habit, since it occurred in 58.30% of the smoking patients, while it occurred only in 28.57% of the nonsmoking patients. It is well known that placing implants in smoking patients has always been a challenging situation, as many clinical studies have shown a lower implant success rate in this regard. In a systematic review on the effect of smoking habit,16 15 observational studies with a follow-up period ranging from 8 to 240 months were included. A total of 5,840 implants placed in smoking patients were compared with 14,683 placed in nonsmoking patients. The authors concluded that the risk of MBL is higher in smokers, especially in the maxillary bone.16

In the present study, at periodic follow-up visits, the prostheses were removed in order to check the periimplant soft-tissue status. Mucositis affecting two implants was successfully treated with interceptive supportive therapy. The protocol adopted consisted of professional oral hygiene followed by the use of a 0.2% chlorhexidine mouthrinse 3 times per day for 2 weeks. Therefore, the easy retrievability of the restoration facilitated primary and secondary prevention of periimplant diseases.

It is well known that occurrence of complications for full-arch restoration is relevant.2, 17 In a systematic review by Papaspyridakos et al., the cumulative rate of prostheses free of complications was 29.3% at the 5-year follow-up.11 Interestingly, the estimated cumulative rates of screw fracture and screw loosening complications were 10.4% and 9.3%, respectively. In contrast, in the present study, the percentage of restorations free of technical complications was 71.8% at 3 years. A reason for this result could be the prosthetic design adopted: The avoidance of screws might have had a major role in decreasing the incidence of technical complications.

The most severe technical complication encountered in this study was framework fracture. Cracks were located in the distal cantilever in all 3 cases. This result is not surprising, since it is generally accepted that the incidence rate of prosthetic complications is increased dramatically when distal extensions are applied.18 In cases of framework fracture, the prosthesis was removed and then repaired. In order to reduce this occurrence, a distal cantilever is to be avoided whenever anatomical structures allow it. Thus, the positioning of distal implants posterior to the mental foramen is advocated. Interestingly, all patients in which framework fractures occurred were bruxers. These results are in accordance with previous studies found in the literature in which many prosthodontic failures were associated with bruxism.19, 20 Other minor technical complications were veneer fracture (n = 4), loss of retention (n = 2) and need for relining (n = 2). In all cases, the problem was addressed after easy removal. Direct veneer repair, coping replacement and indirect relining were provided respectively.

One major limitation of the study was that immediate and delayed loading restorations were included in the same study. However, since the aim of this study was to record the performance of a specific prosthetic protocol, it is believed that different clinical procedures could give a wider picture. Moreover, the substantially similar behavior of immediate and delayed loading implants justifies a direct comparison.
With the present retrospective study, a good clinical performance after 3 years of follow-up in terms of survival rate, marginal bone resorption, and incidence of biological and technical complications was observed. One of the major advantages was the effortless retrievability of the restoration, which facilitated primary and secondary prevention. As a matter of fact, with the periodic prosthesis removal for routine hygiene procedures, perimplant disease at early stages could be intercepted and technical complications could be easily solved.

**Conclusion**

Within the limitations of the study, the clinical performance of implant-supported mandibular complete fixed prostheses with conometric retention after 3 years of functional loading showed a low rate of MBL and technical complications. Owing to the easy retrievability of the system, all complications were successfully addressed. A careful patient selection must be undertaken, since bruxism and distal cantilever may represent risk factors for major technical complications such as framework fracture. The efficacy of this treatment option in terms of cost and maintenance has to be confirmed by multicenter, longer-term studies.

**Competing interests**

The authors declare that they have no competing interests.

**References**


Abstract

**Objective**

The aim of this study was to identify and classify temporomandibular joint dysfunction (TMJD) in psychiatric patients using typical antipsychotics compared with healthy individuals, both physically and mentally.

**Materials and methods**

The present study had a descriptive cross-sectional design, developed over a 6-month period, at the Teaching Assistant Nucleus of Dentistry and Mental Health affiliated with the Juliano Moreira Psychiatric Hospital, Salvador, Brazil, and the Federal University of Bahia School of Dentistry, Salvador, Brazil. To that end, 120 patients aged 18 years or older, 40 psychiatric patients (20 women and 20 men), all using typical or first-generation antipsychotics of the pharmacological groups of butyrophenones and phenothiazines, and 80 mentally healthy patients (40 women and 40 men), underwent assessment of TMJD severity through an Anamnestic Index.

**Results**

There were statistically significant differences in the prevalence of TMJD in the group of patients with mental illness. Among the 40 individuals with mental and behavioral disorders, moderate TMJD was the most prevalent (16/40.0%), but in the control group, there was a higher prevalence of mild TMJD (34/42.5%). Two cases of severe TMJD were diagnosed in psychiatric patients.

**Conclusion**

In this study, it was possible to identify the prevalence and incidence of TMJD among those with mental and behavioral disorders using typical antipsychotic drugs, justifying the importance of their monitoring for TMJD. However, owing to its subjective nature, these patients should be referred for a specialized examination to confirm the diagnosis of TMJD.

**Keywords**

Temporomandibular joint dysfunction; mental disorder; psychiatric care.
Introduction

Every human being may present with some kind of psychopathological disorder throughout his or her life, and may or may not seek help, and in some cases, the disorder may not be resolved. Each individual constructs within himself or herself a mental organization capable of making frequent adaptations to the outside world, and performing these tasks requires a continuous functioning of regulatory and adaptive mechanisms. The proper development of these mechanisms leads the individual to develop a personality within normal patterns. However, if there is an imbalance of these mechanisms, mental and behavioral disorders may occur.¹

The oral health of patients with psychiatric disorders is generally more impaired than that of the general population, mainly owing to the precariousness of oral hygiene associated with nonreality and the side effects of the psychotropic drugs used in treatment that affect psychomotor performance, salivary flow and oral soft tissue. Antipsychotic therapy may increase the risk and duration of oral disease, since these drugs are used for a long period, thus justifying the establishment of preventive/educational oral health programs.² ³

Schizophrenic disorders affect about 1% of the general population and are a major problem for health services, since high rates of recurrence and comorbidity may require high long-term costs for the individual, family and society.³ ⁴ The treatment of schizophrenia often involves antipsychotics (APs) of 2 pharmacological groups: typical and atypical. Typical or conventional first-generation APs represented by dopamine (D₂) antagonists—phenothiazine derivatives (such as chlorpromazine) were used initially, and later, in the 1950s, butyrophene derivatives (such as haloperidol) were introduced—mainly eliminate the psychotic symptoms of schizophrenia. Second-generation, atypical or new-generation APs, such as risperidone,⁵–⁷ may cause bilateral displacement of the TMJ.⁹

The scientific literature has reported that those with mental disorders do not have access to adequate dental care owing to dental professionals’ lack of knowledge of how to assist patients with mental disorders, as well as fear, stigma or negative attitudes on behalf of dentists.⁶ Generally, such patients have poor oral hygiene, a high number of decayed or missing teeth, bad breath, inflammation of the gingival tissue, and, in more severe cases, edentulism and a tendency toward temporomandibular joint dysfunction (TMJD).⁸ Orofacial movement disorders associated with daily use of psychoactive drugs, particularly typical APs, may have repercussions for the temporomandibular joint (TMJ) and lead to TMJD.⁷

Although TMJD does not have a definite etiology, its appearance is credited to functional, structural and psychological factors. Conditions such as malocclusion, parafunction and modifi-
cation of the emotional state (stress) may be present in patients with this dysfunction. The signs and symptoms of TMJD are characterized by TMJ pain and painful masticatory muscles; headache; otological manifestations, such as tinnitus, auricular fullness, vertigo and auditory symptoms; limitation and/or lack of coordination of mandibular movements; limitation of mouth opening; temporary joint blockage; and joint cracking.⁸ Therefore, the morphological and functional disorders of the oral cavity influence the skeletal-motor action of the masticatory muscles, leading to a breakdown of the orofacial anatomical and neurological homeostasis, and affecting not only the stomatognathic system but also the general health of the patient.⁷

Oromandibular dystonia can be diagnosed by the contractions of the jaw, compromised phonation and swallowing. In severe cases, it may cause bilateral displacement of the TMJ.⁹

The etiology of TMJD is considered complex and multifactorial, with the presence of predisposing, initial and perpetuating factors. Such conditions follow an evolutionary course of days, months or years, occasionally transient and self-limiting, and aggravated by parafunctional habits.¹⁰

Given the strong suspicion of the correlation between TMJD and psychiatric patients and the limited scientific literature on the topic, the objective of this research was to identify and classify TMJD in psychiatric patients using typical APs, using the Anamnestic Index advocated by Fonseca in 1994.¹¹
Materials and methods

This study was conducted in accordance with the norms of Resolution No. 466/12 of the National Health Council of the Ministry of Health, published on December 12, 2012, and by the Code of Professional Dental Ethics, according to Resolution No. 179/1993 of the Federal Council of Dentistry. The project was submitted to the Research Ethics Committee of the School of Dentistry of the Federal University of Bahia, Salvador, Brazil, and approved by CONEP under registration CAAE 08119812.0.0000.5024, dated April 14, 2015, Consustantiated Opinion No. 1023044.

The participants in the test group—40 psychiatric patients, 20 women and 20 men, users of typical APs of the pharmacological grouping of butyrophenones and phenothiazines—were examined at the Teaching Assistant Nucleus of Dentistry and Mental Health affiliated with the Juliano Moreira Psychiatric Hospital, Salvador, Brazil, and the Federal University of Bahia School of Dentistry, Salvador, Brazil. The evaluation of the oral health of the participants in the control group—80 volunteers, 40 women and 40 men clinically healthy from a psychiatric point of view—was carried out at the periodontic clinic of the Federal University of Bahia.

A population of patients with mental and behavioral disorders institutionalized at the Juliano Moreira Psychiatric Hospital, users of typical APs drugs, composed of 10 participants, were evaluated. However, because it was an investigation with psychiatric patients, who, in some situations, do not cooperate to allow the performance of this type of examination, the sample size was chosen by convenience sample, based on the number of individuals who fulfilled the necessary requirements to participate, respecting the exclusion and inclusion criteria established.

The inclusion criteria common to the 2 groups analyzed were: age greater than or equal to 18 years, acceptance to participate and signing of the free and informed consent. For the test group, the following inclusion criteria were also considered: being assisted at the Juliano Moreira Psychiatric Hospital, regardless of the assistance model; being a typical AP user; for ethical-legal reasons, the person responsible and/or the companion signed the informed consent in the case of patients assisted in an outpatient clinic, and for internees, the acceptance was by the chief nurse.

The present study had a descriptive cross-sectional design and data collection started in May 2015 and ended in October 2015.

The Anamnestic Index advocated by Fonseca (IAF)¹¹ was used in this study as a screening instrument aimed primarily at classifying the severity of TMJD symptoms, with an accessible language to be self-completed; however, owing to the fact that the sample was made up of mentally ill patients assisted in a public psychiatric hospital, the interviews for data collection were performed in the presence of the caregiver or the nurse, in the case of hospitalized patients. The IAF consists of 10 questions that verify the presence of TMJ pain in the neck, headache, masticatory and movement difficulties, crackles, parafunctional habits, perception of malocclusion and feelings of emotional stress.² It allows 3 types of responses—yes, sometimes or no—with scoring equivalent to 10, 5 and 0, respectively. By aggregating the points, the index classifies participants into these categories of symptom severity: (I) no TMJD: 0–15 points (II) mild TMJD: 20–40 points (III) moderate TMJD: 45–65 points (IV) severe TMJD: 70–100 points

Despite its subjective nature, it can be considered as indicative of the need for more accurate tests to confirm the severity of TMJD impairment in patients who present with signs or symptoms compatible with TMJD.¹⁵

The IAF was chosen because it is a suitable tool for the study of population profiles for TMJD symptoms and for screening potential patients, aiming at the later application of more accurate diagnostic indexes and tests for TMJD—the Diagnostic Criteria for Research on Temporomandibular Disorders.

Statistical analysis

The chi-square (Pearson), Fisher exact and Mann–Whitney test were used for the statistical analysis of the categorical variables. The parametric variables were submitted to the Pearson correlation test and the nonparametric variables to the Spearman correlation test.

All 120 records from the 40 patients with mental and behavioral disorders (test group) and 80 data records from the mentally healthy participants (control group) were included. The data related to the dental clinic record were tabulated in the EpiData program (Version 3.1, EpiData Association, Odense, Denmark) and transferred to the Excel 2010 program for further exploratory analysis, performed through the SPSS for Windows statistical program (Version 13.0, SPSS, Chicago, Ill., U.S.).
For the descriptive step, we calculated the absolute and relative frequencies, and the measures of central tendency and dispersion presented by means of tables. For the exploratory analysis, the Pearson chi-square association test was used to verify the differences between the 2 groups. For the analyses, a confidence level of 95% and a value of \( P < 0.05 \) were considered. Odds ratios and confidence intervals were calculated as significant values of \( P < 0.05 \).

For statistical inferences, when the variables presented dependence, that is, when comparing different moments of the same group (test group), the Mann–Whitney test was used for the independent variables, such as in the cases of normality patterns obtained from the asymptomatic participants of the control group, or in the comparisons between the test group and the control group. The decision to use nonparametric tests was due to the small sample size.

Results

According to the entries in the medical records of the 40 patients in the test group—13 of them hospitalized and 27 treated on an outpatient basis, some of whom had more than 1 diagnosis—obtained from the statistical medical archiving service of the hospital, 63.3% had schizophrenia and schizotypal and delusional disorders; 24.5% mood disorders (affective); 8.1% mental retardation and 4.1% schizophrenic-type organic delusional disorder, including World Health Organization (1996) coding for each of these disorders.

The characterization of the sample analyzed in this study considered the following sociodemographic variables: sex, age group, ethnic group, educational level and individual monthly income (Table 1). The sex of the participants was equally distributed: 50% men and 50% women. As for the ethnic group, 50% were white/brown and 50% were black. The majority of the participants (77.5%) were over 35 years old, with a monthly income equal to or less than the minimum wage effective in 2013, in the state of Bahia (80%). The educational level of the participants showed a higher percentage of individuals who had not completed 9 years of study: 75%. From these findings, it can be inferred that, probably, for those with mental disorders and behavioral users of psychoactive drugs, access to school would have been restricted to basic education because of the limitations that the mental pathologies impose, as well as the extrapyramidal effects of APs typical for psychiatric treatment, which may compromise motor coordination.

The assessment of the degree of severity of TMJD was performed with the application of the IAF Test 15, and the data obtained in this research demonstrated statistically significant differences when comparing the presence of TMJD among patients with mental illness to among mentally healthy volunteers: 82.5% of the former had a higher prevalence of TMJD, irrespective of the degree of severity of the dysfunction, and the dysfunction was diagnosed in 55.0% of the volunteers in the control group.

Regarding the degree of TMJD severity as suggested by FONSECA, statistically significant differences were identified between the test and

<table>
<thead>
<tr>
<th>Group Variable</th>
<th>Test group</th>
<th>Control group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>20</td>
<td>40</td>
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</tr>
<tr>
<td>Female</td>
<td>20</td>
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<tr>
<td>Age</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>18–34</td>
<td>9</td>
<td>22.5</td>
<td>31</td>
</tr>
<tr>
<td>≥ 35</td>
<td>31</td>
<td>77.5</td>
<td>89</td>
</tr>
<tr>
<td>Ethnic group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White/brown</td>
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<td>50.0</td>
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</tr>
<tr>
<td>Black</td>
<td>20</td>
<td>50.0</td>
<td>32</td>
</tr>
<tr>
<td>Not declared</td>
<td>1</td>
<td>1.2</td>
<td>1</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 9 years</td>
<td>10</td>
<td>25.0</td>
<td>67</td>
</tr>
<tr>
<td>&lt; 9 years</td>
<td>30</td>
<td>75.0</td>
<td>13</td>
</tr>
<tr>
<td>Individual monthly income</td>
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</tr>
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<td>≤ minimum wage</td>
<td>32</td>
<td>80.0</td>
<td>44</td>
</tr>
<tr>
<td>&gt; minimum wage</td>
<td>8</td>
<td>20.0</td>
<td>33</td>
</tr>
<tr>
<td>No income</td>
<td>3</td>
<td>3.8</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 1 Absolute and relative values of the sample according to sociodemographic variables.
control groups ($P = 0.001$). A mild degree of TMJD was recorded in 37.5% of the participants in the test group and 42.5% in the control group; moderate TMJD was diagnosed in 40.0% of the individuals in the test group and 12.5% in the control group; and the only clinical cases of severe TMJD were identified in 2 patients with mental and behavioral disorders (5.0%); 17.5% of the participants in the test group and 45.0% of the control group did not present with TMJD (Table 2).

In the analysis of the association between the possible risk factors for the occurrence of TMJD in the 120 participants and the socio-demographic variables, only a statistically significant correlation was registered considering the different degrees of TMJD severity and ethnic group ($P = 0.025$), both in the test and in the control groups. Moderate TMJD was diagnosed in 40% of the participants in the test group, 45% white/brown and 35% black. In addition, in the control group, 55.3% of the white/brown participants did not present with TMJD, but in the test group, only 15.0%. It should be noted that the 2 clinical cases of severe TMJD were diagnosed in 10% of the black participants in the test group (Tables 3 & 4).

### Discussion

Epidemiological surveys have shown that 40–75% of the population have at least one sign of TMJD, and 33% at least one symptom, such as face or TMJ pain. In the present study, mild TMJD had a higher occurrence among participants in the control group (42.5%/34) than in the test group (37.5%/15). These results corroborate those of Al-Mobeeriek, who also study the TMJ condition in psychiatric patients and concluded that bruxism and tooth clenching were the most common parafunctions in both groups (34.5% in the control group and 27.0% in the test group).12

It is also worth mentioning the review article by Araújo et al., which calls attention to the decisive role of the adverse effects of psychotropic drugs on the onset of TMJD, associated with constant headache, reported by people with schizophrenia, and the difficulty in diagnosing and treating TMJD in schizophrenic patients who use psychoactive drugs that may cause extrapyramidal effects, and recommends a careful evaluation when such patients complain of orofacial pain.13 Given the impossibility of suspending the use of medications that keep the symptoms of schizophrenia under control, the monitoring of these patients, including occasional evaluations of the orofacial region during dental appointments, is fundamental.

TMJD has already been analyzed in schizophrenic patients, such as in the case–control study carried out by Velasco-Ortega et al., in which 32% of schizophrenics presented with symptoms of TMJD; 24% reported articular clicks on opening and closing of the mouth; and 8%, abnormal displacement of the mandible when opening the mouth.14 Among the control group, only 8% reported cracking of the TMJ. The authors concluded that schizophrenic patients are an at-risk population for TMJD because they present a higher prevalence and severity of TMJD than do normal individuals. In addition, Gurbuz et al. pointed to a high prevalence of TMJD in schizophrenics, with an additional record of severe tooth wear and bruxism.15 These results are in line with those obtained in the present study, which included 31 schizophrenics among the 40 participants in the test group.

TMJD Group

<table>
<thead>
<tr>
<th>Test</th>
<th>Mild</th>
<th></th>
<th>Moderate</th>
<th></th>
<th>Severe</th>
<th></th>
<th>Absent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
<td>Number</td>
<td>%</td>
<td>Number</td>
<td>%</td>
<td>Number</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>37.5</td>
<td>16</td>
<td>40.0</td>
<td>2</td>
<td>5.0</td>
<td>7</td>
<td>17.5</td>
</tr>
<tr>
<td>Control</td>
<td>34</td>
<td>42.5</td>
<td>10</td>
<td>12.5</td>
<td>0</td>
<td>0</td>
<td>36</td>
<td>45.0</td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>40.8</td>
<td>26</td>
<td>21.7</td>
<td>2</td>
<td>1.7</td>
<td>43</td>
<td>35.8</td>
</tr>
</tbody>
</table>

* $P = 0.001$. 

Table 2

Absolute and relative values of the sample according to severity of temporomandibular dysfunction. 

In investigating the most prevalent oral lesions in psychiatric patients, Moralez-Chaves et al. observed that 36.92% presented with noises of the TMJ and 10.76% had muscular pain.5 The authors emphasized the need to implement specific preventive and educational oral health programs for these patients.

Clinical cases of severe TMJD were observed in 2 psychiatric patients, who were older than 35 years and of the black ethnic group and had an educational level of less than 9 years. One was a man with a monthly income greater than the minimum wage and the other a woman with a monthly income of less than the minimum wage in force at the time. The impact of mental disorder and daily use of APs on the onset of TMJD is evident because only 17.5% of the psychiatric patients did not present with TMJD.
impairment, whereas TMJD was found in 82.5% of the participants of the test group in its different degrees of severity, indicating the need for longitudinal follow-up of these individuals, with a view to improving their quality of life.

The IAF can be used for the screening of patients for TMJD, since it has acceptable measurement properties, especially concerning internal consistency and reproducibility. However, it is a screening questionnaire, not a diagnostic. It should be remembered that this index characterizes only the presence of symptoms and not clinical signs of TMJD.

Fonseca was concerned with the development of an anamnestic index for evaluation of TMJD adapted to the Brazilian population that was easy to understand and apply. The simplicity of this index favors its use in epidemiological studies. However, it has not yet been completely validated and does not offer a TMJD diagnostic classification; the data obtained with this index are therefore restricted to the classification of severity of TMJD. Another limitation is its scoring system, since if 3 affirmative answers are given to the questions about headache, cervical pain and perceived emotional tension, the respondent will be classified as having mild TMJD. However, these same symptoms may occur in isolation, with no association with TMJD.

In this study, in the group with mental and behavioral disorders (including schizophrenics), 17.5% had no TMJD, 5.0% were diagnosed with severe TMJD, 40.0% moderate TMJD and 37.5% mild TMJD regardless of the diagnosed mental illness. Possibly the subjectivity of the index used to assess the severity of TMJD may have induced these results; however, few studies have evaluated the presence of TMJD in patients with mental and behavioral disorders who are users of typical APs.

Side effects from the use of typical APs are associated with effects on central nervous system transmission sites and receptors and appear in relation to dose and potency levels of the drugs. Patient characteristics, including sex, age and comorbidity, may make patients more or less susceptible to certain side effects of APs. Side effects influence the patient’s quality of life and affect compliance regarding medications.

Table 3: Absolute and relative values of the test group according to the association between the sociodemographic variables and the severity levels of temporomandibular dysfunction.
cognitive factors suggest an influence on the individual's response to pain, behavioral factors determine the patient's attitude, and emotional tension promotes the onset or aggravation of clenching and bruxism. In this sense, studies indicate that anxiety and depression lead to exacerbation of symptoms and modify perception to pain.\textsuperscript{10}

Delays in the diagnosis of TMJD and incorrect treatment contribute to the onset and perpetuation of pain. However, successful treatment depends on the identification and control of etiological factors and usually requires the efforts of a multidisciplinary team, associating dental approaches with those of other areas, such as those that use different physical, pharmacological or behavioral therapies.\textsuperscript{10}

There are few reports of published cases of TMJ dislocation due to the use of antipsychotic medication, which is usually associated with the use of haloperidol and less associated with drugs such as risperidone and amisulpride; however, Karthik and Prabhu reported a case of oromandibular dystonia with displacement of the TMJ in a psychotic patient treated with oral risperidone and amisulpride.\textsuperscript{9}

The prevalence of TMJD in schizophrenics was also the focus of a case–control study conducted by Gurbuz et al. in Istanbul, Turkey, in which 339 schizophrenics and 107 healthy adults were selected.\textsuperscript{15} The signs and symptoms of TMJD were analyzed using the Diagnostic Criteria for Research on Temporomandibular Disorders and the results pointed to a high prevalence of TMJD in schizophrenic patients (284/339; 83.7%), characterized mainly by pain on palpation and articular cracklings.

Al-Mobeeriek assessed 100 psychiatric patients regularly attending a clinic in Saudi Arabia and compared the results obtained with those of 84 psychologically normal volunteers.\textsuperscript{12} Muscular pain, TMJ crackling, limitation of opening of the mouth, bruxism and harmful habits, such as nail biting and chewing of the lips and cheeks, were the criteria analyzed in both groups that composed the sample. According to the results, the oral health status of psychiatric patients was worse than that of healthy individuals, and those with special needs are more likely to have oral disorders. This study observed the prevalence of pain sensitivity in the masticatory muscles detected in 37.0% and 22.6% of the case and control groups, respectively, with temporal muscular pain present in 50.0% of the psychiatric patients and in 44.1% of the healthy volunteers. Cracking was present in 25.0% of the patients in the case group and in 27.4% of the control group, and only 1 psychiatric patient presented with limitation of mouth opening. Bruxism and tooth clenching were the most

### Table 4

Absolute and relative values of the control group according to the association between the sociodemographic variables and the severity levels of temporomandibular dysfunction.

<table>
<thead>
<tr>
<th>TMJD Variable</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
<th>Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>12</td>
<td>30.0</td>
<td>5</td>
<td>12.5</td>
</tr>
<tr>
<td>Female</td>
<td>22</td>
<td>55.0</td>
<td>5</td>
<td>12.5</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>42.5</td>
<td>10</td>
<td>12.5</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–34</td>
<td>9</td>
<td>40.9</td>
<td>4</td>
<td>18.2</td>
</tr>
<tr>
<td>≥ 35</td>
<td>25</td>
<td>43.2</td>
<td>6</td>
<td>10.3</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>42.5</td>
<td>10</td>
<td>12.5</td>
</tr>
<tr>
<td><strong>Ethnic group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White/brown</td>
<td>18</td>
<td>38.3</td>
<td>3</td>
<td>6.4</td>
</tr>
<tr>
<td>Black</td>
<td>16</td>
<td>50.0</td>
<td>7</td>
<td>21.9</td>
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<td>Not declared</td>
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<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>42.5</td>
<td>10</td>
<td>12.5</td>
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<tr>
<td><strong>Education</strong></td>
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<tr>
<td>≥ 9 years</td>
<td>29</td>
<td>43.3</td>
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<td>&lt; 9 years</td>
<td>5</td>
<td>38.5</td>
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<tr>
<td>Total</td>
<td>34</td>
<td>42.5</td>
<td>10</td>
<td>12.5</td>
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<tr>
<td><strong>Individual monthly income</strong></td>
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<td>≤ minimum wage</td>
<td>20</td>
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</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>42.5</td>
<td>10</td>
<td>12.5</td>
</tr>
</tbody>
</table>

*Pearson chi-square (P < 0.0010).
common parafunctions in both groups (34.5% in the control group and 27.0% in the case group).

In Latin America, a cross-sectional study was carried out to determine the most prevalent oral lesions in 65 hospitalized psychiatric patients at an institution in Caracas, Venezuela. The presence of TMJD was described, and 36.92% of the participants reported joint sounds and 10.76% reported muscular pain, particularly when the temporal muscle was palpated. Among the most prevalent parafunctional habits, the authors cited bruxism, nail biting and cheek chewing, leading to the conclusion that, in these patients, mouth changes are more often diagnosed than in mentally healthy individuals, and they pointed to the need for the implementation of oral health programs, with the commitment of the entire multidisciplinary team involved in mental health care.²

In this study, it was possible to observe the role of the adverse effects of typical APs in the onset of TMJD among patients with mental and behavioral disorders, thus justifying the monitoring of these patients through dental consultations. The identification of possible signs and symptoms of TMJD represents an important resource for the early diagnosis of this dysfunction. In this context, the use of indexes has been widely reported in the literature, especially when validated and easy to apply and interpret, and with a view to standardization for data comparison. The IAF can be used in the screening of patients for TMJD, since it has easy application and interpretation; however, owing to its subjective nature, it requires more accurate examination.

Conclusion

References


Industry news

Planmeca introduces new crown jewel of intra-oral scanning

HELSINKI, Finland: According to Planmeca, one of the largest dental equipment manufacturers, with products distributed in over 120 countries worldwide, its new Emerald intra-oral scanner has set the bar for capturing digital impressions and “represents the highest level of scanning available in the world today”. Planmeca Emerald has been designed with effective usability in mind and provides accuracy and speed in all situations, the Finnish company said.

Planmeca Emerald’s seamless, autoclavable and exchangeable tips make infection control measures simple and efficient. The scanner’s two buttons allow it to be operated without touching a mouse or keyboard, and it can even be controlled from a foot pedal when connected to a dental unit. The scanner’s plug-and-play capability allows it to be effortlessly shared between different rooms and laptops. Owing to its small size and light weight, the scanner provides superior control and is comfortable for patients, the company said.

According to Planmeca, the scanner has the flexibility to support various workflows. It can be used for a wide range of treatment options and offers benefits across several disciplines, such as implantology, orthodontics, prosthodontics and maxillofacial surgery. With open export and import options, regular updates and constant new features becoming available, the company continues to evolve and improve the scanner further. By using a multicolour laser-based system, Planmeca Emerald produces images with a vibrant colour palette for realistic digital impressions that allow dentists to distinguish between hard and soft tissue.

The Planmeca Emerald scanner is part of the Planmeca FIT chairside CAD/CAM system that integrates the entire chairside restorative workflow.
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