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Apical periimplantitis: Diagnosis and treatment

Apical periimplantitis—also known as periapical implant lesions—develops in the tissues around the apex of an implant after placement, while the bone architecture in the coronal portion is maintained. If left untreated, this pathology eventually causes osseointegration failure. The diagnosis of apical periimplantitis is based on the clinical and radiographic findings. Clinically, early apical periimplantitis is characterized by symptoms (pain and tightness) and signs (swelling, fistula and drainage) of variable intensity, depending on the stage of the lesion. Clinically, the patient complains of pain and inflammation appearing, although in the early phase, there may be pain but not inflammation. Radiographically, a radiolucency around the implant apex may be observed (although it is not necessary—the same happens in acute periapical periodontitis, which may have symptoms without radiographic alterations). The use of new imaging technologies such as small-volume cone beam computed tomography is helpful in establishing an early diagnosis, showing a clear clinical image of periapical implant bone loss.

In the literature, there are few papers on diagnosing this disease and these lack homogeneity of diagnosis criteria. Diagnosis of apical periimplantitis involves clinical and radiographic evaluation, and the treatment will vary according to the findings:

- a) If the implant has a radiolucent area (not present after surgery owing to overdrilling and manifesting over time) without pain, monitoring of the lesion is recommended, without medical treatment.
- b) If the radiolucency has increased in size or if the patient develops pain, medical and surgical treatment are indicated.

Early diagnosis and management of active apical periimplantitis lesions (nonsuppurative phase with symptoms, acute suppurative and subacute phases) includes the surgical approach and its follow-up to evaluate the success of the treatment and avoid implant failure.

The literature describes medical and surgical approaches to treating periapical implant lesions. Medical treatment using antibiotics (amoxicillin, amoxicillin/clavulanate, metronidazole and clindamycin) alone has proved ineffective in controlling symptomatic or active lesions, and surgical access must be performed. There is no established gold standard treatment, so the goal is to eliminate the area of infection. Surgical treatment entails anesthesia, incision, full-thickness flap elevation, ostectomy, apical curettage and abundant irrigation. After debridement, some authors have described irrigation of the bone defect with saline solution or with chlorhexidine. Other agents have been suggested for local decontamination of the implant surface, such as chlorhexidine, calcium hydroxide paste and tetracycline pastes. There is no clinical evidence on the efficacy of any of these agents. Some studies describe the use of biomaterials, with or without membranes, in order to achieve complete bone regeneration of the defect. Resection of the apex of the implant is recommended in those cases where access for removal of the granular tissue is not otherwise ensured, likewise when there is an anatomical relationship with the maxillary sinus or nasal cavity.

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Guided soft-tissue emergence profile techniques using CAD/CAM technologies: Multiple case reports

Abstract

Objective

The following article describes 2 original techniques that use CAD/CAM technology to generate a pre-surgical healing abutment or provisional restoration.

Materials and methods

Two clinical cases are described using different techniques to create a guided soft-tissue emergence profile using a pre-surgical custom healing abutment or provisional restoration and their benefits. The first case describes the use of digital libraries with pontic emergence profiles. The 3-D object (tooth) is manipulated to replicate or to establish a natural contour that will determine the shape of the soft tissue during the healing process. The second technique describes the use of segmentation and mirroring of a natural tooth to generate an exact replica and emergence profile of the patient's dentition.

Conclusion

These techniques constitute a very simple and efficient way of generating a pre-surgical customized healing abutment or provisional restoration that allows the clinician to guide the soft-tissue healing process and emergence profile immediately after the surgery. The techniques are developed not to be software-specific, but rather to be used with any free or paid open architecture software.

Keywords

CAD/CAM; guided surgery; 3-D printing; segmentation; digital wax-up.

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Introduction

Since 1989, Smith and Zarb incorporated appearance into the criteria for dental implant success.¹ Decades of evidence supports the importance of generating implant-supported esthetic restorations, with little attention to improving the soft-tissue emergence profiles or natural contours of the teeth.² Immediate provisional restorations are generally a good way to manage soft-tissue contours, aiding during the healing process with obvious esthetic benefits. Several authors have reported great results during decades of using traditional provisional techniques by minimally altering the biology of the soft tissue during the healing process.3 The main limitation of traditional techniques is the chair time needed during or after the surgical procedure to fabricate such provisional restorations; when determining the efficiency of a protocol, the time factor is critical and most clinicians choose standard cylindrical abutments to guide tissue contours before the final impression. Abrahamsson et al. reported that subsequent disconnections and reconnections of abutment components might compromise the mucosal barrier, and this could lead to retraction or apically positioned connective tissue due to increased bone remodeling.⁴ In addition, most cylindrical and unnatural emergence profiles could lead to food impaction and possible biological complications due to poor emergence profiles, food impaction and potential periimplantitis.

In the past, several authors described accelerated dental implant protocols such as immediate placement and immediate provisionalization.^{2,5} Recently, some companies have developed anatomical healing abutments that, in contrast to custom healing abutments, have an anatomical shape based on average standardized healing profiles. Systems such as Contour Healer (Common Sense Dental Products), which are anatomical PEEK abutments that can be shaped, and the VPI EPI mold system (VP Innovato Holdings), which helps fabricate composite anatomical abutments from a silicone mold, are among the most popular systems. The limitations of using such analogue systems are reliance on the limited implant brands they are compatible with, the healing process not being guided from the emergence profiles of the final restoration or wax-up, and being able to fabricate healing abutments only, but not provisional crowns (Figs. 1 & 2A & B).

The use of CAD/CAM technologies has offered different techniques to generate custom restorations. Most systems allow for the scanning of scan bodies after implant placement to generate an implant-supported provisional restoration, but this technique only allows the clinician to generate the provisional restoration after the surgery. The use of guided surgery in combination with pre-surgical customized healing abutments or provisional restorations with natural emergence profiles can provide the clinician with a very cost-effective and predictable way of replicating nature and minimizing soft-tissue trauma.

Two different techniques are described for the creation of a pre-surgical custom healing abutment or provisional restoration. The first case describes the use of digital libraries with pontic emergence profiles. The 3-D object (tooth) is manipulated to replicate or to establish a natural contour of a tooth. The second technique describes the use of segmentation and mirroring of a natural tooth to generate an exact replica and emergence profile of the patient's dentition.

Clinical case 1

A 52-year-old man presented to the Dental College of Georgia at Augusta University, Augusta, Georgia, U.S., with the chief complaint of 2 missing posterior teeth (Fig. 3). During the first appointment, clinical and radiographic examinations were completed for proper diagnosis and formulation of treatment plan. The periodontal condition was stable, no endodontic lesions were found, and the patient reported good hygiene. After proper diagnosis, it was determined that the patient could be a candidate for dental implant therapy. Digital impressions were taken using the Medit i500 intraoral scanner (Medit), along with a CBCT scan. With the diagnostic information acquired, the data were imported into the free implant planning software used in this case (Blue Sky Plan, Blue Sky Bio) and the STL model aligned to the DICOM volume using match points (Fig. 4).

The following steps describe the technique of using digital libraries for a pre-surgical custom healing abutment or provisional restoration:

 A 3-D wax-up is fabricated in the implant planning software. In this case, the Brenes pontic library was used to recreate the natural emergence profile of the restorations (Figs. 5A & B).

Fig. 1

Contour Healer PEEK abutment.

Figs. 2A & B

VPI EPI system.

Fig. 3

Intraoral occlusal view of missing teeth #36 and 46.

Fig. 4

STL model aligned to DICOM 3-D reconstruction.

Fig. 5A

Digital wax-up using Brenes pontic library of tooth #35 owing to lack of mesiodistal space to replace tooth #36.

Fig. 5B

Digital wax-up using Brenes pontic library of tooth #46 to recreate the desired natural emergence profile.





- Proper implant planning and positioning is done. In this case, 2 NobelReplace Conical Connection implants (Nobel Biocare) were planned with their corresponding digital temporary abutments to visualize the final position of the screw access holes (Figs. 6A-C).
- The digital wax-up and temporary abutments are exported from the open architecture software (Blue Sky Plan) in STL format and the files imported into Meshmixer (Autodesk) or any software that allows for 3-D data manipulation (Fig. 7).
- A cylinder that has the same width of the temporary abutment is generated and positioned according the position of the restoration (Fig. 8).
- 5. The crown and the cylinder are selected and a Boolean difference function is performed to subtract the cylindrical shape from the crown (Figs. 9A & B).
- Alternatively, the provisional restoration is cut using the plane cut function to generate a healing abutment or a provisional restoration with flat anatomy that is not going to be in occlusion (Fig. 10).
- 7. The new restoration, with an occlusal access hole, is exported as an STL binary file to be manufactured.
- The restoration can be manufactured by means of milling technologies using PMMA, can be printed with biocompatible materials,

or printed and used as a scaffold for a composite healing abutment (Figs. 11A & B, 12).

Two surgical guides (1 for each side) were exported from Blue Sky Plan software and printed using the Asiga MAX printer (Asiga) and NextDent SG resin (NextDent; **Fig. 13**). The pre-surgical custom healing abutments were printed using NextDent C&B MFH resin and attached with premise flowable composite (Kerr Dental) to the temporary nonengaging abutments. The remaining metal structure of the temporary abutments was cut with a diamond disc and polished **(Figs. 14A & B)**.

Two horizontal incisions were made over the edentulous ridges after a proper anesthetic effect was achieved; no vertical incisions were required for a flapless approach. The surgical guide was used to create 2 guided osteotomies using a set of guided stoppers (Digital Dentistry Education) in conjunction with Densah drills (Versah) to place 2 4.3×11.5 mm implants (NobelReplace Conical Connection) in positions #36 and 46. Excellent primary stability was achieved and the 2 pre-surgical custom healing abutments screwed in place (**Fig. 15**).

Three months later, the custom healing abutments were removed for the final impression, the natural emergence profile of the tissue was created and the tissue was healthy **(Fig. 16)**. An intraoral digital impression was taken to capture the natural emergence profile of the soft tissue

Fig. 9B

Fig. 11B

Fig. 7

Fig. 6C









Fig. 6B



Fig. 10



Fig. 12





Fig. 11A





Fig. 6A

Implant planning of 2 implants (NobelReplace Conical Connection) in positions #36 and 46.

Figs. 6B & C

Proper implant planning with corresponding digital temporary abutments.

Fig. 7

Teeth with temporary abutments to visualize the final position of the screw access holes.

Fig. 8

Tooth with generated cylinder in Meshmixer.

Fig. 9A Hole created on tooth after Boolean difference operation.

Fig. 9B

Visualization of temporary abutment through the hole.

Fig. 10

Healing abutment created after cutting the tooth with the plane cut function in Meshmixer.

Fig. 11A

Occlusal view of printed healing abutments seated on the nonengaging temporary abutments.

Fig. 11B

Lateral view of printed healing abutments seated on the nonengaging temporary abutments and their emergence profiles.

Fig. 12

Alternative copy of printed pre-surgical custom healing abutment using putty and flowable composite to copy the emergence profile.

Fig. 13

Printed surgical guide with metal cylinder.

Fig. 14A

Pre-surgical healing abutment for tooth #46.

Fig. 14B

Pre-surgical healing abutment for tooth #36 with a premolar shape owing to lack of restorative space.

Fig. 15

Intraoral occlusal view of pre-surgical healing abutments immediately after surgical procedure.

Fig. 16

Intraoral occlusal view of the natural emergence profiles of the tissue 3 months post-surgery.

.com

Figs. 17A & B Lateral view of final restorations and Ti-bases.

Figs. 17C & D

Frontal view of final restorations cemented on Ti-bases.

Fig. 18

Intraoral occlusal view of final screw-retained restorations.

Figs. 19A & B

Lateral view of final screwretained restorations.





using the Medit i500 and Nobel-compatible intraoral DESS scan bodies (DESS). Two screw-retained crowns were designed using Exocad (Exocad) over 2 DESS Ti-bases and cemented with Maxcem Elite Chroma resin cement (Kerr Corporation; Figs. 17A-D).

At the delivery appointment, the final restorations were torgued following the manufacturer's recommendation, and the access screw channel was covered with PTFE tape and composite resin. The occlusion was checked and the patient was satisfied with the treatment outcome (Figs. 18, 19A & B).

Clinical case 2

A 56-year-old patient presented to the Medical University of South Carolina with the chief complaint of a missing anterior tooth (Fig. 20). After a thorough, but unremarkable health history and clinical examination, an intraoral digital impression was taken (Planmeca Emerald, Planmeca) at the consultation appointment and an ultralowdose CBCT scan (Planmeca ProMax 3D Max) was also taken (Fig. 21). A mirror of the patient's tooth #9 was waxed into site #8 using the mirror contralateral tooth feature in Planmeca Romexis Version 5.2 (Planmeca; Fig. 22). The intraoral scan and wax-up were merged with the CBCT scan and an Astra Tech OsseoSpeed EV implant 4. The contralateral tooth and root were then (Dentsply Sirona) was planned, the adjacent root segmented and a surgical guide created. All elements were exported into Meshmixer, and the

adjacent root was mirrored and then merged with the original wax-up of tooth #11. Boolean difference was then used to cut a perfect hole in the digital design. The restoration was then imported into the Planmill 30S (Planmeca) and milled out of a resin nanoceramic material (Lava U, 3M). Custom resin stains were used (Light Art, Bisco).

The guided soft-tissue emergence profile techniques using the segmentation approach can be done using the following steps:

- 1. A digital wax-up is produced on the basis of an intraoral digital impression. The digital wax-up in the edentulous space is made using an exact mirror image of the contralateral tooth in Planmeca Romexis Version 5.2 (Fig. 22).
- 2. The intraoral digital impression and the wax-up are merged with the CBCT scan using common data points and then a best-fit algorithm is utilized to merge the 2 data sets (Fig. 23). Proper digital planning and implant placement are performed. In this case, the implant was placed 3 mm apical to the cementoenamel junction of the wax-up and 2 mm palatal (Fig. 24). The corresponding manufacturer's temporary abutment was designed in the Planmeca Romexis abutment editor and attached to the digital plan (Fig. 25).
- The surgical guide is exported and then man-3. ufactured (Fig. 26).
 - isolated and segmented using a fairly automated tooth segmentation feature in Planmeca Romexis (Fig. 27).



Fit Model

Open a STL the los



Sel Classe



Fig. 20 Patient preoperative condition.

Fig. 21

Image captured from Planmeca Emerald scanning module.

Fig. 22

Mirror contralateral tooth feature.

Fig. 23

Software best algorithm alignment using the 3 common points of the intraoral impression STL and CBCT scan.



Fig. 24

Virtual implant placement.

Fig. 25

Abutment design in Planmeca Romexis abutment editor.

Fig. 26

Planmeca Romexis surgical guide module.

Fig. 27

Tooth segmentation feature in Planmeca Romexis.

Fig. 28

Segmented tooth and root mirrored and then overlaid in Meshmixer.

Fig. 29

Combined CBCT segmented tooth and digital wax-up.

Fig. 30

Sectioned tooth at the margin of the abutment.



Fig. 29



5. All elements are exported as STL files, 9. The new restoration is exported for additive including the implant location, abutment, surgical guide, intraoral scan, mirror tooth wax-up and contralateral root.

Fig. 28

- 6. Using Meshmixer, a mirror image of the segwith the digital wax-up (Figs. 28-30).
- 7. The new mesh is made solid and sliced right at the location of the margin in the exported abutment from the implant planning software (Fig. 31).
- 8. The crown and the cylinder are selected and a Boolean difference function is performed to subtract the cylindrical shape from the crown (Fig. 32).
- or subtractive manufacturing and the fit verified on the temporary abutment (Fig. 33). Owing to timing, the restoration is not attached to the abutment until the day of surgery.
- mented root is produced and then merged 10. Therefore, after the initial consultation and data collection, a surgical guide is printed and a pre-surgical provisional restoration is fabricated using a mirror image of both the clinical crown of the contralateral tooth and the root to gain a natural emergence profile.
 - 11. The surgical guide in this case was exported from Planmeca Romexis and printed using Dental LT Clear Resin (Formlabs) with the Form 2 printer (Formlabs).



Fig. 34

Fig. 35



During the surgical procedure the guide is evaluated for fit, and a flapless approach is taken (Fig. 34). After the osteotomy the implant is placed through the guide to the proper depth (Figs. 35 & 36). The manufacturer's temporary abutment is seated, the custom pre-surgical provisional restoration is seated and flowable resin composite is injected around the space of the provisional restoration and abutment (Figs. 37 & 38). The restoration is removed, polished and reseated for delivery (Fig. 39), and the access screw channel is covered with PTFE tape and composite resin.

Conclusion

Even though particular CAD/CAM systems were used in the workflow described, the user is able to use other open architecture systems and software to develop the techniques. The techniques described in this article can be used in every implant case to guide soft-tissue

emergence profiles to achieve adequate esthetics and function; an inadequate emergence profile can lead to food impaction, gingivitis and possible peri-implantitis. The use of CAD/ CAM technologies allows clinicians to have predictable results in a consistent manner allowing the clinicians to also reduce chair time and be more efficient.

Competing interests

The authors declare that they have no competing interests.

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Fig. 31

Transparent view in Meshmixer.

Fig. 32

Tooth with hole after Boolean difference operation.

Fig. 33

Printed and characterized tooth on stock temporary abutment.

Fig. 34

3-D printed surgical guide.

Fig. 35

The implant is placed after the manufacturer's osteotomy sequence has been performed.



Fig. 38



Fig. 36

Flapless approach and implant placement.

Fig. 37

Placement of temporary titanium abutment.

Fig. 38

Pre-surgical provisional restoration pressed to depth in the temporary abutment and picked up with flowable resin.

Fig. 39

Frontal view of restoration immediately after delivery.

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Implant-supported fixed full-arch rehabilitation without bone grafting in severely atrophic maxillae: A 10- to 12-year retrospective follow-up study

Abstract

Objective

Javier Aizcorbe Vicente, ^a David Peñarrocha Oltra, ^a Eugenia Candel Martí, ^a Fabio Camacho Alonso, ^b Luigi Canullo^{a, c} & María Peñarrocha Diago^a

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Aizcorbe Vicente J, Peñarrocha Oltra D, Candel Martí E, Camacho Alonso F, Canullo L, Peñarrocha Diago M. Implant-supported fixed full-arch rehabilitation without bone grafting in severely atrophic maxillae: A 10- to 12-year retrospective follow-up study. J Oral Science Rehabilitation. 2018 Dec;4(4): 18–25. The objective of this article is to assess the clinical, radiographic and patient-related outcomes of patients with severe atrophy of the maxilla (Cawood and Howell Class V) rehabilitated with fixed full-arch prostheses on dental implants placed in anatomical buttresses and remnant bone.

Materials and methods

An observational retrospective clinical study was performed with a minimum follow-up period of 10 years. An analysis of the following parameters was performed: (a) periimplant parameters (plaque index, modified gingival index, probing pocket depth and keratinized mucosa width); (b) marginal bone loss; (c) implant survival rate; and (d) patient satisfaction based on a visual analog scale (VAS).

Results

Ten patients and 71 dental implants were studied, with a mean follow-up period of 126 months (range: 120–144). The mean plaque index was 1.0 ± 0.5 , with a mean probing pocket depth of 2.3 mm (range: 1.0-4.0 mm). Sixty-one percent and 39% of the implants presented a modified gingival index of 1 and 2, respectively, and the mean keratinized mucosa width was 5.8 mm (range: 4.0-10.0 mm). The mean marginal bone loss of the implants was $0.7\pm0.4 \text{ mm}$ (range: 0.0-5.0 mm). The implant survival rate was 97.2%, and the overall mean patient satisfaction score was 90 (range: 0-100). Prosthesis cleaning ease scored lowest on the VAS.

Conclusion

In our limited sample of patients with severe maxillary atrophy (Cawood and Howell Class V), the placement of dental implants in anatomical buttresses and remnant bone, associated with rehabilitation with fixed full-arch prostheses, was found to be an adequate treatment option in the long term regarding implant survival, marginal bone loss, periimplant clinical parameters and patient satisfaction.

K e y w o r d s

Dental implants; atrophic maxilla; fixed prosthesis; full arch; long-term; graftless.

Introduction

Tooth loss gives rise to gradual resorption of the alveolar process, with a change in bone and muscle relations and in facial morphology.¹ While most of this resorption occurs in the first year after tooth loss, it continues throughout life and can often give rise to severe bone atrophy both vertically and horizontally.² Severe bone atrophy of the maxilla (Cawood and Howell Class V) is associated with certain problems, such as reduced perioral tissue support, the impossibility of wearing complete dentures, chewing and speech alterations, and difficulties in placing dental implants owing to the limited amount of available bone.³

Many surgical techniques have been proposed for the rehabilitation of this type of patient. These methods can be classified into bone grafting techniques (i.e., guided bone regeneration,⁴ onlay grafting with autogenous bone blocks,^{5,6} and inlay autogenous bone grafting⁷), distraction osteogenesis,⁸ crestal expansion techniques (i.e., split crest⁹), the use of special implants (i.e., short dental implants of < 6 mm or narrow dental implants of < 3 mm¹⁰) and the modification of the original implant insertion protocol to avoid bone grafting by using areas of residual bone or anatomical buttresses (i.e., zygomatic implants,^{11,12} pterygoid implants,¹³ implant insertion in the maxillary tuberosity,¹⁴ tilted implants,15 palatal implants16,17 and implants placed in the nasopalatine canal¹⁸).

The use of bone grafting to allow implant placement in atrophic maxillae is associated with more frequent complications and higher morbidity, especially when an extraoral donor site is required.¹⁹ The associated increase in financial costs and a longer treatment time can lead, sometimes, to limited patient acceptance of treatment. Additionally, the use of extraoral grafts (i.e., iliac crest) has a nonpredictable resorption pattern, which can be of almost the entire graft, especially in the edentulous maxilla.²⁰ The use of short and narrow implants is a promising alternative concept for the treatment of the atrophic maxilla, but the lack of trials for this specific situation with follow-ups of at least 5 years indicate caution regarding results.²¹

The use of anatomical buttresses and the residual bone is a predictable way to rehabilitate the atrophic maxilla with dental implants and fixed full-arch prostheses, and several studies detail these techniques.^{22–28} This approach

avoids complications and morbidity associated with bone grafting, reduces treatment costs and time, and results in a high patient satisfaction overall.^{29, 30} Nevertheless, these types of techniques are not free of complications and an expert surgeon is required, especially for zygomatic implants.^{12, 31, 32} Because the anatomy of the atrophic maxilla is different for each patient, it is usual in daily practice that only 1 graftless approach is insufficient, and the combined use of different techniques is essential. However, a lack of studies combining different implant approaches in the same patient exists. For this reason, we sought to study the combined use of different techniques to treat the Cawood and Howell Class V atrophic maxilla and their results in the long term.

The aim of this observational retrospective clinical study was to evaluate the implant survival rate, clinical and radiographic outcomes, and patient satisfaction in patients with severe atrophy of the maxilla rehabilitated with dental implants placed in anatomical buttresses and remnant bone and supporting a full-arch fixed prosthesis with a follow-up of at least 10 years.

Materials and methods

An observational, retrospective clinical study was performed in the Oral Surgery Unit of the University of Valencia, Valencia, Spain, from January 2017 to January 2018, involving patients with severe atrophy of the maxilla and subjected to dental implant rehabilitation. A retrospective chart review was performed to select potential candidate patients. The following inclusion criteria were established:

- (a) severe atrophy of the maxilla (Cawood and Howell Class V; the minimum amount of bone for implant placement was 8 mm in height and 3 mm in width, measured at crestal level) treated with dental implants placed in buttresses and in remnant bone;
- (b) rehabilitation with full-arch fixed prosthesis;
- (c) good general health; and
- (d) a minimum follow-up of 10 years after prosthesis delivery.

Before inclusion in the study, the patients received an explanation of the scope and purposes of the study and were asked to sign an informed consent and data confidentiality form.



Figs. 1A-D

Patient shows severe periodontal disease and maxillary atrophy. Treatment plan consists of the extraction of maxillary remnant teeth and the immediate installation of 6 implants for a fixed fullarch rehabilitation.

(A) Occlusal view of the maxilla before surgery.

(B) Initial panoramic radiograph before surgery.

(C) After flap elevation,
2 pterygoid implants and
4 anterior post-extractive palatal implants were placed.
(D) Panoramic radiograph after implant placement.

Surgical technique

Before surgery, a panoramic radiograph and a cone beam computed tomography or computed tomography scan was taken of all patients to assess the amount of remaining bone and the presence or absence of maxillary sinus disease. Phibo TSA dental implants with the Avantblast surface (Phibo Dental Solutions) were used. The implants were placed with a combination of drills and osteotomes and were all left submerged (**Fig.1** illustrates a representative clinical case). Sutures were removed 1 week after surgery, and all patients were included in a maintenance program with control visits involving professional prophylaxis every 6 months.

Prosthetic procedure

Healing abutments were connected 3 months after implant placement, and the definitive impressions were obtained 15 days later for preparation of the definitive full-arch screwretained fixed maxillary prosthesis. Implant loading took place 5–6 months after surgery. Fixed hybrid metal–ceramic or fixed hybrid metal–resin prostheses were used for the definitive restoration.

Study variables

Data were collected on patient age and sex, the number of implants and their dimensions, complications, and the date of prosthesis delivery. During the last follow-up visit all the prostheses were removed and the following parameters were recorded:

Clinical parameters: (a) plaque index; (b) modified gingival index according to the specifications of Mombelli;³³ (c) probing pocket depth (measured at 4 points for each implant and the average calculated); (d) width of keratinized mucosa in millimeters; and (e) the implant survival rate.

Radiographic parameters: Periapical radiographs obtained at prosthesis delivery and after at least 10 years were used to calculate bone loss. Radiographs were obtained with the XMIND intraoral system (Groupe Satelec-Pierre Rolland) and an RVG intraoral digital receptor (Dürr Dental). Periapical radiographs were taken using the paralleling technique with a film holder and an aiming device (Rinn XCP, Dentsply Sirona). If the bone level around the study implants was not clearly visible, a new radiograph was taken. Periimplant marginal bone levels were measured by the same operator, using CliniView software



(Version 5.1, Instrumentarium Imaging). Each image was calibrated using the known diameter of the implants. The vertical distance from the outer edge of the implant shoulder (reference point) to the most coronal bone-to-implant contact was measured to the nearest 0.1 mm. From this measurement, we subtracted the measurement of the polished neck of the implant (1.5 mm) to determine exactly the beginning of the treated part. Periimplant marginal bone resorption at the mesial and distal aspect of the implants was calculated from the change in bone level between the baseline (prosthesis delivery) and the last control radiograph available (at least 10-year control); for each pair of measurements, the largest value was used.

Patient-related outcomes: Patient satisfaction was subjectively scored with a visual analog scale (VAS; range: 1–100) used at the time of the study.^{34–36} This scale assessed patient satisfaction with the implant-supported prosthesis, measuring the following items: overall satisfaction, comfort and stability, ease of hygiene, ease of speech, esthetics, self-esteem, and function. The patients scored these aspects independently, though a dentist was present in case help or some explanation was needed.

Results

Ten patients with a mean age of 57 years (range: 33-72 years) were included. Of them, 5 were men and 5 women. A total of 71 dental implants were placed in the maxilla (between 6 and 8 implants per patient), with dimensions between 8.5 × 5.5 mm and 16.0 × 4.2 mm. Of these

71 implants, 32 were placed in residual alveolar bone, 3 in the nasopalatine canal, 16 in the pterygomaxillary region, 12 in a palatal position, and 8 simultaneous to a sinus lift procedure, just to obtain bicortical anchorage but without the use of any type of graft (1-stage sinus lift). The mean duration of follow-up was 126 months (range: 120-144 months). At the time of the study, 7 patients had been followed up on for 10 years, 1 patient for 11 years, and 2 for 12 years. None of the patients suffered postoperative complications. Nine patients received hybrid metal-resin prostheses and 1 a hybrid metal-ceramic prosthesis. Regarding prosthesis complications, resin fracture occurred in 2 patients (1 year after loading in 1 case and 4 years after loading in the other), and the problem was solved with simple composite repair (Table 1).

Table 2 shows the main findings of the study. The mean plaque index was 1.0 ± 0.5 , with a mean probing pocket depth of 2.3 mm (range: 1.0-4.0 mm). Sixty-one percent and 39% of the implants presented a modified gingival index of 1 and 2, respectively, and the mean keratinized mucosa width was 5.8 mm (range: 4.0-10.0 mm). One nasopalatine implant failed before prosthetic loading, and 1 implant placed in residual alveolar bone failed after loading. The implant survival rate was 97.2%. The mean marginal bone loss was 0.7 ± 0.4 mm (range: 0.0-5.0 mm), with no differences between implant positions. The overall mean patient satisfaction score was 90 (range of the VAS: 0-100). Comfort and stability, function and self-esteem items had the mean highest values (92, 95 and 91, respectively). Prosthesis cleaning ease scored lowest (mean: 72) on the VAS.

Figs. 1E & F

 (E) Occlusal view of the periimplant soft tissue before definitive prosthesis delivery.
 (F) Occlusal view of the fitted screw-retained hybrid metal– resin prosthesis.





Figs. 1G–I (G) Control panoramic radiograph showing correct

prosthetic fit. (H) Occlusal view of the periimplant soft tissue at the 10-year control.

(I) Panoramic radiograph at the 10-year control.



Discussion

Severe maxillary atrophy poses problems for conventional implant placement.³⁷ Bone grafts are an option in such cases, but are not popular among patients, owing to the long treatment times involved, the difficulties and complications related to the surgical procedure and an increase in the treatment cost.³⁸

Conventional dental implant placement in remnant bone is an effective alternative for the rehabilitation of these individuals. In this regard, the survival rate for implants in remnant bone is greater than for implants in grafted bone. Widmark et al. reported a survival rate of 87% with conventional implant placement in atrophic maxillae, versus 74% in the case of implants in grafted bone, after a follow-up period of 3-5 years.³⁹ Rosén and Gynther in turn conducted a study of 19 patients with a mean duration of follow-up of 8–12 years and reported a survival rate of 97%.³⁸ They concluded that implant placement in the remnant bone of atrophic maxillae is an adequate alternative to bone grafting procedures. In a study by Krekmanov

et al. involving 22 patients, the survival rate was found to be 95.7% after a follow-up period of 1–5 years.⁴⁰ More recently, Testori et al. reported a survival rate of 95.1% in a sample of 144 implants placed in atrophic maxillae with a follow-up of 10 years.¹⁵ In our study, the implant survival rate was 97.2% after a mean duration of follow-up of 126 months. Regarding implant position, the survival rate of the implants placed in the nasopalatine canal was especially lower. In the literature, the survival rate of this type of implant was between 84.6% and 100%.^{18,41} In our study, the survival rate in this regard was 66.66%. These results can be explained by the limited number of implants (n = 3).

Regarding bone loss, most authors have reported values similar to those of our own series. Aparicio et al. studied 101 conventional implants in 25 patients with atrophic maxillae and recorded a mean bone loss of 1.21 mm after 37 months of follow-up.⁴² A study by Toljanic et al. recorded a mean bone loss of 0.9 ± 0.8 mm in 46 patients after 1 year of follow-up.⁴³ This figure remained stable from fitting of the prosthesis to 1 year of follow-up. Testori et al.

Table 1	Patient	Age (years)	Sex*	No. of implants	Complications	Follow-up (months)
	1	55	Μ	6	None	120
	2	72	F	7	None	144
	3	61	F	F 7 Prosthesis fracture		120
	4	51	Μ	8	Prosthesis fracture	120
	5	33	F	8	None	144
	6	70	F	6	None	120
	7	65	Μ	7	None	120
	8	44	F	7	None	120
	9	61	Μ	7	None	120
	10	58	Μ	8	None	132

* M = male; F = female.

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.e 2	N	PI	PPD	GI	KMW	IS	MBL	PS
	71	1.0 ± 0.5	2.3 mm (range: 1.0–4.0 mm)	1–61% 2–39%	5.8 mm (range: 4.0–10.0 mm)	97.2%	0.7 ± 0.4 mm (range: 0.0–5.0 mm)	90

PI = plaque index; PPD = probing pocket depth; GI = modified gingival index; KMW = keratinized mucosa width; IS = implant survival; MBL = marginal bone loss; PS = patient satisfaction.

analyzed tilted and axial implants in 41 patients with atrophic maxillae; after a follow-up period of 12 months, they recorded a mean bone loss of 0.9 \pm 0.4 mm in axial implants and of 0.8 \pm 0.5 mm in tilted implants.⁴⁴ In our study, a mean marginal bone loss of 0.7 \pm 0.4 mm was observed, in accordance with the literature.

Patient satisfaction was very high, since the procedure proved less invasive and the treatment times were shorter than with other treatment options. In a study by Peñarrocha et al., patients with severe maxillary atrophy rehabilitated with angled and palatine implants showed very high satisfaction scores owing to the reduced time, cost and morbidity associated with the treatment provided.⁴⁵ Erkarpers et al. likewise recorded very high satisfaction scores in patients with atrophic maxillae rehabilitated with conventional implants and immediate loading.⁴⁶ The worst result in the present study was obtained for ease of cleaning (72 VAS). In this regard, it is important to ensure that the prosthesis design is easy to clean for patients that usually do not have adequate hygienic skills.

The major limitation of the present observational retrospective clinical study was the small sample of patients (N = 10). It is necessary to carry out studies with larger samples to confirm these results.

Conclusion

In our limited sample of patients with severe maxillary atrophy (Cawood and Howell Class V), the placement of dental implants in anatomical buttresses and remnant bone, rehabilitated with fixed full-arch prostheses, was found to be an adequate treatment option in the long term regarding implant survival, marginal bone loss and periimplant clinical parameters. Patient satisfaction was very high; however, it is important to design hygienic (flat or convex) prostheses to facilitate cleaning by the patient at home.

Competing interests

The authors declare that they have no competing interests.

Table 1

Description of the study sample.

Table 2 Results.

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A minimally invasive technique for transcrestal sinus floor elevation

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Abstract

Background

Transcrestal maxillary sinus floor elevation represents an effective surgical option to vertically enhance the available bone in the edentulous posterior maxilla.

Purpose

The purpose of the present study is to describe a minimally invasive technique for transcrestal sinus floor elevation, the Smart Lift technique, through a paradigmatic clinical case.

Conclusion

The Smart Lift technique is based on specially designed drills and osteotomes used with a stop device that restricts the working action to the residual bone, thus preventing the accidental penetration of instruments into the sinus cavity. Also, the use of a standardized sequence of instruments has been shown to limit the impact of the clinician's judgement and skill, thus allowing for rapid learning for inexperienced clinicians. The technique is effective to achieve endo-sinusal bone formation with limited post-surgical morbidity.

Introduction

In the posterior maxillary sextants, the insertion of implants of desired length and diameter may be limited by the dimensional alterations of the bone crest that occur after tooth loss,¹ partly due to the pneumatization of the maxillary sinus.² Transcrestal maxillary sinus floor elevation (tSFE) represents an effective surgical option to vertically enhance the available bone in the edentulous posterior maxilla.^{3,4}

Technique description

The Smart Lift technique was developed by the Research Center for the Study of Periodontal and Periimplant Diseases, University of Ferrara, Ferrara, Italy, and the Department of Odontostomatology, Ospedale "Casa Sollievo della Sofferenza," San Giovanni Rotondo, Italy.^{5, 6} The technique is characterized by transcrestal access to the sinus cavity by means of specially designed drills and osteotomes. The pristine bone at sites of implant placement is drilled up to the sinus floor with a trephine bur and then used to fracture the sinus floor by hydraulic pressure through osteotomes. In this respect, the procedure represents a modification of the technique proposed by Fugazzotto.⁷ One of the advantages of the technique lies in the use of all manual and rotating instruments with adjustable stop devices, which are selected in relation to the vertical amount of residual bone at sites where implants have to be placed. These stop devices have a variable length and may be adapted to all manual and rotating instruments. The use of the stop device restricts the working action of burs and osteotomes to the vertical amount of residual bone, thus preventing the accidental penetration of instruments into the sinus cavity. The determination of the working length (i.e., the distance from the bone crest to the sinus floor) where the osteotome and burs have to limit their working action is first diagnosed on 2-D and/or 3-D radiographs, and then verified intra-surgery by means of a specially designed osteotome. The second advantage relates to the standardized sequence of instruments used for the Smart Lift procedure, which has been shown to limit the impact of the clinician's judgment and skill, thus allowing for rapid learning for inexperienced clinicians.8

The Smart Lift technique shares its clinical indications with the other surgical procedures for tSFE:

- indications for implant-supported prosthetic rehabilitation, based on accurate diagnosis and treatment planning;
- systemic and local conditions that are compatible with implant placement and sinus floor elevation procedures;
- residual bone height (i.e., the distance from the bone crest to the sinus floor) that prevents the insertion of an implant of the desired length and residual bone height of at least 2 mm.

The Smart Lift technique must not be performed whenever systemic and local conditions contraindicate sinus floor elevation.

The Smart Lift technique: Sequence of instruments

According to the prosthetic treatment planning, the locations for implant placement are established, and the residual bone height at such locations is radiographically measured as the distance from the bone crest to the sinus floor (radiographic working length).

All instruments in the surgical set are characterized by laser marks at each millimeter to allow for precise control of the working length. In the conventional sequence (used with a residual bone height of at least 3 mm; Fig. 1), the first drill (locator drill) is used to perforate the cortical bone at the site where the implant is to be placed. A second drill (probe drill), with a diameter of 1.2 mm and cutting only at the top edge, is used to define the position and orientation of the implant. In order to minimize the risk of sinus floor perforation, this bur is used with an adjustable stop device that is set at least 1 mm shorter than the radiographic working length. The probe osteotome (Ø: 1.2 mm) is carefully inserted into the site prepared with the probe drill and gently forced in an apical direction through the cancellous bone until the cortical bone resistance of the sinus floor is met. Therefore, the probe osteotome provides the surgical working length, which is the true anatomical distance from the bone crest to the sinus floor in the exact location where the implant should be placed. Thus, the working action of all manual and rotating instruments that will be used in subsequent surgical steps must be set at the surgical working length using the proper adjustable stop device.

A radiographic pin (\emptyset : 1.2 mm) can be used to check direction and depth of the prepared site by means of a periapical radiograph. The radiographic pin handle has a diameter of 4 mm, thus



Fig. 1

Conventional sequence of the Smart Lift technique (residual bone height $\ge 3 \text{ mm}^{5, 6}$).

permitting evaluation of the spatial relationship between the prepared site and the buccolingual and mesiodistal dimensions of the alveolar ridge. This will help the clinician to determine the diameter of the implant to be placed.

A guide drill with a diameter of 3.2 mm (implant Ø: 3.75 - 4.50 mm) or 4.0 mm (implant Ø: 4.5 mm or larger) is then used. This drill follows the 1.2 mm diameter site preparation and creates a crestal countersink, where the trephine bur (Smart Lift drill) will be inserted. Such a countersink will force the trephine bur to follow the desired direction. The Smart Lift drill (Ø: 3.2 or 4.0 mm), set at the surgical working length, produces a bone core up to the sinus floor. The bone core and a variable amount of particulate bone substitute are condensed and malleted to fracture the sinus floor by means of a calibrated osteotome (Smart Lift elevator, Ø: 3.2 or 4.0 mm) that corresponds to the diameter of the trephine preparation. If the alveolar bone core is found to be inside the trephine, the bone core is gently removed from the trephine and replaced in the bone preparation. The osteotome is used under gently malleting forces to implode the trephined bone core over the sinus floor. In relation to the extent of vertical bone augmentation to be achieved, an autogenous cortical bone particulate or a particulate bone substitute can be further grafted and condensed into the sinus with the osteotome. Again, the Smart Lift elevator is used with the proper stop device at the surgical working length, thus preventing any unwanted

penetration of the instruments into the sinus cavity. Provided that the residual bone may ensure an adequate primary stability, an implant can be inserted during the same surgical session. Otherwise, a staged approach is recommended. If the residual bone height is 2 mm, a modified sequence must be adopted.⁹ The mean duration of the sinus floor elevation procedure (from cortical perforation to the completion of the grafting procedure), as reported in different cohort and randomized controlled trials, ranged between 19 and 32 min.^{6.8, 10–13}

In a recent study,⁸ patients treated with the Smart Lift technique by 3 operators with different levels of experience in implant surgery and inexperienced with respect to the Smart Lift technique, showed a substantial extent of sinus elevation in a limited operation time, along with minimal incidence of membrane perforation and post-surgical dosage of anti-inflammatory drugs.⁸

The clinical application of the Smart Lift technique is illustrated in **Figure 2**.

The Smart Lift technique: Clinical outcomes

The Smart Lift technique was first reported in 2008.⁵ During the last 10 years, several studies have been conducted, ^{5, 6, 8, 9, 11–16} reporting data on treatment outcomes and post-surgical morbidity of the procedure **(Table 1)**. Only in 1 case did the Smart Lift technique not allow for the placement of implant concomitant to tSFE¹³ and



Figs. 2B & C





Figs. 2D & E





implant insertion had to be delayed owing to the lack of primary stability. Implant survival shifted from 100% at 6 months in 8 studies^{5, 6, 8, 10–12, 15, 16} to 94% at 12 months in 1 study.¹³ The length of the inserted implants varied between 9.0^6 and 10.3 mm,¹⁰ and the height of the residual bone ranged from 4.5^{13} to 6.6 mm.⁵ The extent of sinus lift ranged from 5.3^8 to 7.7 mm.¹¹

The Smart Lift technique: Post-surgical morbidity

The mean scores for post-surgical pain and discomfort, as reported on a 100 mm visual analog scale,¹⁷ ranged from 0 to 62 mm and from 0 to 17 mm, respectively.^{8, 11} The level of pain significantly decreases, starting from the first day post-surgery, 13 and reaches very low levels (ranging from 1.0 to 2.1 mm) at the seventh day. $^{6,\,8,\,10-13}$

Six studies have reported data on intra- and post-surgical complications.^{10–13} Membrane perforation was the most frequent complication, with the incidence ranging from 0¹¹ to 13%.¹² In all cases, the perforation was managed with the insertion of a surgical hemostatic dressing (Gingistat, GABA Vebas) or a collagen matrix (Mucograft Seal, Geistlich Pharma). In all cases, the grafting procedure was completed and the implant was inserted. Rarely, other types of complications, such as transitory paresthesia in the suborbital area (1 case),¹⁵ tinnitus (1 case)¹⁵ and benign paroxysmal positional vertigo (1 case)¹² occurred. All these complications spontaneously subsided within the first week post-surgery.

Figs. 2A-E

A 52-year-old male patient presented with an edentulous area in the maxillary right quadrant. Neither systemic nor local conditions contraindicating implant surgery or sinus lift procedures were identified at the screening visit. The prosthetic rehabilitation plan included the placement of 2 implant-supported crowns in the region of the maxillary right second premolar and first molar, which had been extracted 3 years prior to the visit.

(A) Computed tomography scans showed a radiographic working length of 2.7 mm at the first molar site and 7.6 mm at the second premolar site.

(B) Lateral clinical photograph.(C) Occlusal clinical photo-

graph.

(D) The surgical working length assessed at the position of the second premolar was 6 mm as diagnosed with the probe osteotome. Therefore, a tSFE procedure was performed also at this site.

(E) A countersink was prepared with the guide drill.

Smart Lift technique for sinus floor elevation



Smart Lift technique for sinus floor elevation



Table 1

able 1							
Authors	Type of study		No. of patients	No. of implants	Follow-up period (months)	Implant survival (%)	
Farina et al. ¹³	RCCT (tS	FE group)	29	33	12	94%	
Franceschetti et al. ¹⁶	Retrospectiv	e case series	14	14	6	100%	
		Initial group	13	13	6	100%	
		Final group	13	13	6	100%	
Franceschetti et al. ⁸	Prospective	Expert operator group	20	20	6	100%	
	case series	Moderately experienced operator group	20	20	6	100%	
		Low experienced operator group	20	20	6	100%	
Trombelli et al. ¹²	RCCT	DBBM group	19	19	6	100%	
nombett et al		β-TCP group	19	19	6	100%	
Franceschetti et al. ¹⁵	Prospective cohort study	Smoker group	25	25	6	96%	
Franceschetti et al."		Nonsmoker group	20	20	6	100%	
Taranaka (11 - 4 - 1 11	RCCT	S-HA group	15	15	6	100%	
Trombelli et al. ¹¹		DBBM group	15	15	6	100%	
Trombelli et al. ¹⁰	Case series		11	14	6	100%	
Trombelli et al. ⁶	Case	report	1	1	6	100%	
Trombelli et al.⁵ Case report		1	1	6	100%		
			vetions DRPM - depretoinized beying bases	1		1	

RCCT = randomized controlled clinical trial; tSFE = transcrestal maxillary sinus floor elevation; DBBM = deproteinized bovine bone mineral; TCP = tricalcium phosphate; ND = no data; IR = interquartile range; S-HA = synthetic hydroxyapatite.

Table 1

Studies reporting data on treatment outcomes of the Smart Lift technique.

Implant length (mm) expressed as median (IR) or mean (± SD)	Residual bone height (mm) expressed as median (IR) or mean (± SD)	Immediate post-surgical extent of sinus lift (mm) expressed as median (IR) or mean (± SD)	Immediate post-surgical height of graft apical to implant apex (mm) expressed as median (IR) or mean (± SD)	
9.5 (9.5–9.5) (median) (IR)	4.5 (4.0–5.3) (median) (IR)	ND	0.9 (0.3–1.6) (median) (IR) (27 patients)	
9.8 (9.5–11.0) (median) (IR)	6.0 (5.6–6.8) (median) (IR)	6.8 (5.7–7.6) (median) (IR)	ND	
ND	6.3 (± 1.6) (mean) (SD)	6.6 (± 1.8) (mean) (SD)	2.9 (± 1.1) (mean) (SD)	
ND	5.8 (± 0.9) (mean) (SD)	7.0 (± 1.3) (mean) (SD)	2.5 (± 1.5) (mean) (SD)	
ND	5.4 (± 1.2) (mean) (SD)	7.2 (± 1.2) (mean) (SD)	2.6 (± 1.2) (mean) (SD)	
ND	6.4 (± 1.3) (mean) (SD)	6.0 (± 1.9) (mean) (SD)	2.3 (± 1.3) (mean) (SD)	
ND	5.2 (± 1.6) (mean) (SD)	5.3 (± 1.4) (mean) (SD)	2.0 (± 0.8) (mean) (SD)	
9.5 (9.5–11.0) (median) (IR)	5.4 (5.0–6.1) (median) (IR)	6.1 (5.6–6.9) (median) (IR)	1.5 (1.2–2.3) (median) (IR)	
9.5 (9.5–11.0) (median) (IR)	5.5 (5.2–6.8) (median) (IR)	6.8 (6.2–7.5) (median) (IR)	2.2 (1.6–3.1) (median) (IR)	
9.5 (9.5–10.3) (median) (IR)	5.3 (4.7–5.8) (median) (IR)	6.9 (6.0–7.7) (median) (IR)	2.5 (1.7–3.4) (median) (IR)	
9.5 (8.5–10.0) (median) (IR)	5.0 (4.2–6.1) (median) (IR)	6.5 (5.7–7.7) (median) (IR)	2.3 (1.3–2.8) (median) (IR)	
10.0 (8.75–10.50) (median) (IR)	5.25 (4.6–6.4) (median) (IR)	7.7 (6.70–8.55) (median) (IR)	3.0 (2.80–3.75) (median) (IR)	
9.5 (9.5–10.0) (median) (IR)	5.7 (4.33–6.35) (median) (IR)	6.5 (5.95–7.40) (median) (IR)	2.6 (2.30–3.45) (median) (IR)	
10.3 (± 0.9) (mean) (SD)	6.1 (± 1.8) (mean) (SD)	ND	ND	
9.0	5.0	ND	ND	
ND	6.6	ND	ND	

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Conclusion

In the edentulous maxillary posterior sextants, the vertical dimension of the residual bone crest may frequently call for bone augmentation procedures to allow for the placement of implants of adequate length and width. Among the techniques for tSFE that have been proposed in the literature, the Smart Lift technique represents

a simplified, user-friendly, standardized procedure that allows for a substantial extent of sinus lift with limited post-surgical morbidity.

Competing interests

The authors declare that they have no competing interests.

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The relationship between oral squamous cell carcinoma and dental implants: A literature review

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Rodríguez Caballero A, Romero Ruiz MM, Serrera Figallo MA, Gutiérrez Pérez JL, Torres Lagares D. The relationship between oral squamous cell carcinoma and dental implants: a literature review. J Oral Science Rehabilitation. 2018 Dec;4(4):36–44. The aim of this article is to provide a thorough review of the possible relationship between dental implants and the incidence of oral cancer, particularly emphasizing the clinical data, to allow an early diagnosis of cancer and avoid mistakes in diagnosing cancer or regular periimplant inflammatory conditions.

Abstract

Purpose

Materials and methods

A literature search on Medline/PubMed was performed. The criteria for consideration were articles published between 1999 and 2017, with the following MeSH terms: "oral squamous cell carcinoma," "dental implants," "osseointegrated," and "periimplant tumor." To be considered, they had to be

- 1. original studies;
- 2. clinical trials, meta-analyses, randomized controlled trials, or reviews;
- 3. on oral squamous cell carcinoma developed around osseointegrated implants;
- 4. papers published in English; and
- 5. studies done in humans.

The papers were selected by the authors of this study and validated by agreement.

Results

Initially, 143 papers were selected, of which only 12 were kept after excluding those not matching the inclusion criteria. An average of 2 implants were present in patients between 42 and 80 years old. Regarding the location of the tumors, 88.23% were located in the lower jaw, mainly (76.46%) in the posterior area. Only 2 out of the 17 (11.77%) were located on the edge of the tongue.

Conclusion

An appropriate preoperative study should be done on patients at risk, and the prosthesis should be designed to allow easy removal for tissue examination. A histopathological test should be performed in the case of inflammatory tissue in the periimplant area.

K e y w o r d s

Oral cancer; dental implants; relationship.

Introduction

Oral cancer represents 2% of all malignant tumors. Approximately 90% of oral carcinoma is squamous cell carcinoma of the oral epithelium (OSCC) of the oral epithelium, while the other 10% is tumors of other histological origin, being extremely rare malign odontogenic tumors and metastatic tumors from carcinomas located at distance.¹ Only 1% of oral carcinoma cases develop metastasis, although metastases in the hard tissue of the maxillofacial area are more common compared with those in the soft tissue (2:1 relation).^{1, 2} The etiology of OSCC is multifactorial. Oral hygiene and toxic habits such as alcohol- and tobacco-related factors have been proven to be involved.²⁻⁴ The risk of malignancy is increased in the presence of oral lesions like leukoplakia or erythroplakia, lichen planus or human papillomavirus lesions. Patients with a previous history of carcinoma also have a greater risk of developing a second primary neoplasm.^{4,5}

Implant placement for the oral rehabilitation of the partially or completely edentulous patient is nowadays a predictable treatment option and allows recovery of the loss of esthetics and function.^{6, 7} Long-term success rates have been reported, even in patients particularly difficult to treat. However, there is no lack of complications that may occur, and among the most common is a chronic inflammatory process of both soft and hard tissue, separately or at the same time.^{8–12}

At the 2008 European Workshop on Periodontology, 2 possibilities of diagnosis were defined: periimplant mucositis and periimplantitis.¹³ The former describes an inflammatory lesion located on the mucosa that is clinically reddened (erythematosus) and bleeds on probing, although with no bone loss. For periimplantitis, however, there is bone loss in addition to the other signs and symptoms, and it is commonly associated with suppuration and deep pockets. Periimplantitis and periimplant mucositis occur in up to 80% of patients and affect up to 50% of implants. Risk factors for periimplantitis are poor oral hygiene, a history of periodontitis, diabetes mellitus, tobacco use, alcohol use and genetic predisposition. Of all these risk factors, only poor oral hygiene and tobacco use have the best scientific evidence to support their connection to periimplantitis, the rest of the risk factors being insufficiently proven.13

There are few published cases on osseointegrated dental implants associated with OSCC; however, there is scientific evidence to support

that, in some cases, OSCC surrounding dental implants has a very similar appearance to that of periimplantitis, with mucosal reddening and bone loss.

The aim of this research is to perform a thorough review of the relationship between OSCC and dental implants, trying at the same time to identify the various clinical presentations and the eventual risk factors. It is also intended to identify at an early stage those clinical elements that can lead to OSCC, facilitating biopsy and early diagnosis.

Materials and methods

A search on Medline/PubMed was carried out on the relationship between dental implants and OSCC. Regarding the search strategy, papers published between June 1999 and March 2017, including these dates, were included. The MeSH resource was used, selecting as search terms "oral squamous cell carcinoma," "dental implants," "osseointegrated," and "periimplant tumor." The criteria for selection were

- 1. original studies;
- 2. clinical trials, meta-analyses, randomized controlled trials, or literature reviews;
- 3. OSCC developed around dental implants;
- 4. articles published in English;
- 5. articles of studies in humans.

The articles were selected by the researchers based on their titles and abstracts and validated by consensus.". All those articles related to OSCC in relation to dental implants (clinical cases with histopathological tests). Those articles where the patient's age, tumor location or type was not specified were excluded.

Results

Initially, 143 articles were selected, of which 132 did not meet all of the inclusion criteria and therefore were excluded. In total, 12 articles were selected^{14–25} and processed for collection of data. They were 4 literature reviews, involving 5 clinical cases;^{15, 23–25} 1 longitudinal randomized case–control trial;²⁰ 1 case series;¹⁷ and 6 well-documented case reports.^{14, 16, 18, 19, 21, 22} The total number of patients was 34, and a total of 17 case reports were analyzed.

The patients were aged between 42 and 80 years (mean: 66.3 ± 10.1 years). Of all the case

reports, 53% of the patients involved were men, while in the longitudinal randomized study, no significant differences regarding sex were found. An average of 4.58 ± 3.57 implants were placed per patient. In those documented case reports, a minimum of 2 implants were placed per patient, while in the longitudinal study, 56 implants were placed in 21 patients. The characteristics of those studies that meet the inclusion criteria are shown in **Table 1**.

Regarding the location, there was a clear predominance of the lower jaw (88.23%), specifically the posterior region (76.46%). The tumor was located on the lingual ridge in only 2 out of the 17 cases (11.77%). The average time between implant placement and diagnosis of OSCC was 0.25 months to 120 months (42.81 ± 37.73 months).

Prior to the implant placement, 76.47% of the patients presented 1 or more risk factors for developing a malignancy: 47.06% of cases had a previous history of oral carcinoma (squamous cells and verrucous carcinoma of the alveolar ridge) or cancer in other organs far from the oral cavity (lung cancer, pancreatic cancer or breast cancer); 11.76% had precancerous oral lesions, such as leukoplakia or lichen planus, while 35.3% had or used to have a tobacco addiction and 17.64% were regular alcohol consumers. In those cases considered for this review, OSCC developed very close to or directly in contact with the dental implants. In most of the cases, at the time of implant placement, there were 1 or more risk factors for the development of oral carcinoma.

Block and Scheufler in 2001 presented the case of a man aged 72, referred for the treatment of a progressive bone loss of 5 years of evolution surrounding 2 implants.14 This patient had proper oral hygiene and was a former smoker, having guit 16 years before, and had had a verrucous carcinoma removed from the alveolar bone of the lower jaw 3 years earlier. He had not undergone chemotherapy or radiotherapy. Two years later, after checking that the patient was in total remission, 2 implants had been placed in the left posterior region of his mandible. Six months later, the verrucous carcinoma reappeared on the periimplant mucosa. All of the affected tissue was removed, and a year later, 5 more implants were placed in order to support a fixed complete prosthesis. Five months after the placement of these implants, bone loss compatible with periimplantitis was found around 2 of the implants, with gingival hyperplasia and suppuration. After performing a biopsy, a welldifferentiated OSCC was diagnosed. The 2 affected implants were removed, and after 18 months of follow-up, the patient was free of cancer and wore a removable prosthesis retained on the remaining implants.

Czerninski et al. in 2006 reported a case series in which implants were placed to replace missing teeth and ulcers appeared around these implants after several years after treatment.¹⁵ Histological analysis of these lesions confirmed the presence of OSCC surrounding the implants. The first case was of a 52-year-old woman, a smoker for more than 20 years, referred for treatment of oral lichen planus 8 years before. She had 3 implants, which had been placed 3 years before, and presented with a reddened mucosa surrounding the implants with ulcers of up to 25 mm on the alveolar ridge, initially diagnosed as periimplantitis. Radiographic examination showed bone loss surrounding the implants and a biopsy was done on which superficially invasive OSCC was diagnosed. Mandibulectomy and lymphatic node dissection were performed. After 18 months of follow-up, the patient was still free of cancer.

The second case was of an 80-year-old man with a history of diabetes and chronic ischemic heart disease. This patient had previously been treated for OSCC by resection, with no radiotherapy or combined treatment. On clinical examination, the patient had 5 dental implants, which had been placed 5 years earlier, in the anterior region of the mandible and presented with a partly ulcerated exophytic mass surrounding the implants of around 15 mm in diameter. The radiograph showed an osteolytic lesion with nondefined edges located lateral to the implants on the right of the patient's mouth. Histological analysis confirmed OSCC affecting the mucosa and bone. This patient chose local extirpation of the tumor combined with palliative treatment and died a few months later because of cancer.15

In 2008, Eguia del Valle et al. published the case of a man of 76 years of age who wore a fixed prosthesis supported on 2 implants located in the mandibular right region.¹⁶ No toxic habits were present, and his general health was good. Three years after the implant placement, the patient presented with a white exophytic lesion of 6 mm in diameter and with superficial ulceration, located on the surrounding tissue of 1 of the implants. Radiographic examination showed cone-shaped bone loss surrounding this implant, and the biopsy confirmed the presence of a well-differentiated OSCC. Total resection of the

tumor was performed, as well as lymphatic node dissection, but metastasis was not found.

Kwok et al. described in 2008 3 cases of OSCC in patients of 62, 71 and 67 years of age.¹⁷ All of them previously had risk factors for the development of oral cancer prior to the implant placement (previous oral carcinoma, previous breast cancer, smoking and alcohol use.

Gallego et al. published in 2009 a case of a 70-year-old woman who wore an overdenture supported on 3 dental implants.¹⁸ Her medical history provided no data of interest. The patient had an ulcerated lesion of 1 month of evolution located where the bar of the prosthesis pressed on the mucosa, close to 1 of the 3 implants. Biopsy confirmed a diagnosis of OSCC, requiring immediate removal of the bar and resection of part of the mandible. One year later, the patient was free of disease.

In 2009, Gulati et al. described the case of a female patient of 62 years of age and a heavy smoker (more than 20 cigarettes per day) who had been referred owing to a white lesion on the alveolar ridge at the mandibular left first molar.¹⁹ Biopsy confirmed a diagnosis of well-differentiated OSCC, and a hemimandibulectomy was performed, plus radical dissection of neck nodes. One year later, implants were placed, but during the following 7 years, the patient suffered several episodes of periimplantitis of some of her implants. Several biopsies were done, all of them showed unspecific chronic inflammation, but no signs of dysplasia. However, 1 year later, another biopsy showed the presence of OSCC spread to the mouth floor. The treatment was radical dissection of the affected area, and 12 months later, 3 dental implants were placed in the anterior region. Again, 1 year after the implant placement, periimplantitis appeared again and biopsy confirmed the recurrence of the OSCC. Finally, the patient died because of other metastases.

The largest series of cases was published by De Ceulaer et al. in 2010.²⁰ Twenty-one patients were operated on with OSCC resection, and afterward implants were placed. In total, the patients had 56 implants placed. Sixteen of the patients had their implants placed in the same tumor resection surgery, and 5 of them in a second surgery. All of them underwent the same radiotherapy protocol. The results show that, in the group of implants placed in the same surgery, 3 patients had a tumor recurrence surrounding an implant; however, no recurrences were reported in the 2-stage surgery group.

Meijer et al. in 2010 reported the clinical case of a 69-year-old female patient with an overdenture on 2 mandibular anterior implants.²¹ Eight years earlier, she had been operated on for resection of OSCC on the floor of the mouth, and in the same operation, several implants were placed to rehabilitate the area. Radiotherapy was necessary, and 3 months post-irradiation, prosthetic rehabilitation was performed. Four years after the prosthetic rehabilitation, a new tumor was detected around the adjacent keratinized tissue of both implants. Radiographically, there were no signs of osteolysis, and a partial mandibulectomy with the removal of both implants was performed. After 2 years, new implants were placed, and the patient was free of disease 1 year later.

Agostini et al. in 2011 reported a case that they referred to as periimplant squamous carcinoma.²² The person affected was a 64-year-old male patient with 3 implants in the mandibular left quadrant. Two months after placement, a painful radiolucency appeared close to the second premolar. A week later, there was a spontaneous failure of the implant and the pain had spread to the other 2. After the biopsy, OSCC was identified, and the corresponding resection carried out. After 7 years of follow-up, the patient showed no signs of recurrence.

Jané-Salas et al. in 2012 presented 2 cases. The first was of a 42-year-old male with a history of morbid obesity, but without toxic habits, who had had implants since 2007 in the mandibular posterior region.²³ The patient had no prosthesis on the implants and was examined owing to the presence of a painless ulcer or bleeding at the right edge of the tongue, which he attributed to self-injury and for which he refused a biopsy. In 2009, the ulcer persisted, and after the biopsy, OSCC was found. Hemimandibulectomy with lymphatic node resection was performed, and 6 months later, there was no evidence of recurrence of the lesion. The second case was of a 79-year-old man with no relevant history or toxic habits who had worn a complete maxillary denture on 7 implants for 9 years. The patient came to be examined because of the presence of an ulcer on the side of the tongue suspected to have arisen from trauma due to the fracture of ceramics of their maxillary rehabilitation. After 8 days, the ulcer had improved considerably, although soon after a biopsy of the ulcer, which was still present, the diagnosis of OSCC was confirmed. The patient underwent hemiglossectomy and functional dissection of

Study	Age/Sex	No. of DIs	Localization of tumor	Medical history	
Block & Scheufler ¹⁴	72/ Male	8	Mandibular left posterior	Verrucous carcinoma of mandibular left alveolar ridge (1 recurrence)	
Czerninski et al. ¹⁵	52/ Female	3	Mandibular left posterior	Hypothyroidism, chronic hives	
	80/ Male	5	Mandibular left posterior, mandibular anterior	OSCC, colon carcinoma, DM II, ischemic heart disease	
Eguia del Valle et al. ¹⁶	76/ Male	2	Mandibular right posterior	Hyperuricemia, HBP, ventricular arrythmia	
Kwok et al. ¹⁷	62/ Male	14	Mandibular right posterior	Not relevant	
	71/ Male	2	Mandibular left posterior	Not relevant	
	67/ Female	2	Mandibular left posterior	No data	
Gallego et al. ¹⁸	70/ Female	3	Mandibular left posterior	Not relevant	
Gulati et al. ¹⁹	62/ Female	5	Mandibular left posterior, mandibular anterior	OSCC in mandible	
De Ceulaer et al. ²⁰	77/ Female	2	Mandibular right posterior	OSCC on floor of mouth	
	71/ Male	2	Mandibular right posterior	OSCC on floor of mouth	
	62/ Female	5	Mandibular left posterior	OSCC on floor of mouth	
Meijer et al. ²¹	69/ Female	2	Mandibular anterior	OSCC on floor of mouth	
Agostini et al. ²²	64/ Male	3	Mandibular right posterior	Not relevant	
Jané-Salaset al. ²³	42/ Male	4	Right side of tongue	Obesity, hypothyroidism	
	79/ Male	12	Left side of tongue	Not relevant	
Pfammatteret al. ²⁴	55/ Female	4	Mandibular anterior	Lung carcinoma, pancreatic carcinoma	

DI = dental implant; T = time from implant placement to OSCC diagnosis; DM II = diabetes mellitus type II; HBP = high blood pressure; rx = radiographic examination.

Risk factors	T (months)	Clinical appearance	Suspected diagnosis
Previous carcinoma, oral leukoplakia, ex-smoker	15	Alveolar bone loss, gingival hyperplasia, pain, suppuration	Periimplantitis
Oral lichen planus	46	25 mm ulcer after DIs, exophytic mass lingual to DIs, reddened mucosa. Rx: bone loss surrounding DIs	Periimplantitis
Previous carcinoma	60	Ulcerated exophytic mass of 15 mm surrounding DI, osteolytic lesion	Periimplantitis
None	36	White ulcerated exophytic lesion of 6 mm beside DI, chronic bone loss surrounding DI	Periimplantitis
Ex-smoker, alcohol use	3	Periimplant ulcerated lesion	Not mentioned
Ex-smoker, alcohol use	72	Inflammatory changes surrounding DI	Periimplantitis
OSCC, breast carcinoma, ex-smoker, alcohol use	12	Granulation area surrounding DI	Not mentioned
None	120	Chronic ulcerated lesion due to trauma	Traumatic ulcer
Previous carcinoma, smoker	96	Periimplantitis episodes, with biopsies over 7 years showing chronic inflammation	Periimplantitis
Previous carcinoma	24	Reddened periimplant mucosa, pain, suppuration, bone loss surrounding DI	Periimplantitis
Previous carcinoma	7	Mucosal inflammation surrounding DI	Periimplantitis
Previous carcinoma	6	Pain and inflammation surrounding DI	Periimplantitis
Previous carcinoma	48	Exophytic mass surrounding 2 DIs. Rx: no osteolysis	Not mentioned
None	10	Periimplant squamous carcinoma	Not mentioned
Ex-smoker	24	Nonpainful lesion, no bleeding, right side of tongue, contacting DI	Self-injury
None		Ulcerated lesion, left side of tongue	Traumatic origin lesion
None	12	Reddened periimplant mucosa, pain, suppuration, 2–3mm bone loss surrounding DI	Periimplantitis

Table 1

Clinical cases from the articles included in this review.



lymphatic nodes. The patient remained free of disease after 2 years of follow-up.

Pfammatter et al. in 2012 presented the case of a 55-year-old woman with a history of pancreatic carcinoma who was referred by her dentist during chemotherapy owing to periimplantitis around an implant in the mandibular right anterior region.24 The mucosa showed a smooth surface and typical signs of inflammation: pain, suppuration, erythema and a periodontal probing depth of 7 mm. Radiographic analysis showed distal and mesial bone loss of 2-3 mm around the implants in the mandibular anterior area. The area was mechanically debrided, and chlorhexidine and metronidazole gel were applied locally. Clinical signs decreased in the following 2 weeks, but 3 weeks later, the pain and suppuration appeared again and paresthesia of the lower lip was observed by the patient. Biopsy was performed in the implant area, revealing OSCC. The patient died 4 weeks after diagnosis.

Javed et al. in 2012 included in their review a total of 14 studies. Nine of these had a previous history of cancer, and 5 had toxic habits (tobacco and/or alcohol use).25

Discussion

Numerous studies have shown that dental implants can osseointegrate and remain functionally stable for long periods, both in healthy individuals and in medically compromised patients, including those who have undergone oncological therapy.⁶⁻¹¹ However, although the evidence demonstrates the success of implant treatment in terms of survival,^{8, 10, 12} it is also true that there are numerous cases in the literature in which OSCC has been diagnosed around dental implants.¹⁴⁻²⁵ Because of the multiple factors involved in the carcinogenesis process, it is very difficult to prove whether this relationship is purely coincidental or not.

Considering the cases evaluated in this review, several questions with difficult responses arise from current evidence: What exactly is the role of dental implants in the development of OSCC? And is it appropriate to treat a patient with implants if he or she has a previous history of carcinoma, premalignant lesions or another risk factor? Do implants alone increase the risk of the patient developing oral cancer?

as a hyperplasic and/or ulcerated red zone of oral in fats and low in fruits and vegetables) and

mucosa with alveolar bone loss, and is sometimes not distinguishable from periimplantitis when it develops around a prosthetic rehabilitation with dental implants, thereby presenting a possibility of misdiagnosis. Periimplantitis is a complication of implant treatment and typically shows alveolar bone loss around the affected implants, in addition to inflammation of the periimplant soft tissue.13 Since such inflammatory lesions around implants may manifest clinical and radiographic similarities to malignant diseases, in the case of gingival hyperplasia and/ or bone resorption around an implant, it is necessary to perform a thorough differential diagnosis. Under these circumstances, it is necessary to perform a detailed clinical and radiographic evaluation, accompanied by a biopsy and a histopathological test.

Thus, Block and Scheufler presented the case of a patient with periodontal bone loss around implants that initially was diagnosed as periimplantitis.14 The periimplant tissue that occupied the area of bone loss was debrided and sent for microscopic evaluation, and the histological results showed the presence of a well-differentiated OSCC.23 The authors suggest that the likely sequence of OSCC development was from the soft tissue into the bone through the implants. The tumor had arisen in the soft tissue, and the implants had created a similar environment to the periodontal sulcus, facilitating the progression to bone.

A review of the literature from 1980–2005¹⁵ found 4 articles describing 6 cases of OSCC associated with dental implants, which together with the 2 cases that the research group documented, brought the number to 8 cases. The mean age (72 years; range: 52-90 years) of the sample was higher than that of the present study (mean age: 66.3 ± 10.1 years), with a similar sex distribution. The location of the tumor was the lower jaw in all of the cases and only 1 of them had extension to the floor of the mouth. In the present review, there was also a clear predominance of mandibular occurrence (88.23%), particularly in the mandibular posterior area (76.46%) and mandibular anterior region (11.77%). Only in 2 out of the 17 cases did the tumor appear at the side of the tongue.

The etiology of OSCC is multifactorial, and it includes factors related to age, a previous history of oral and/or systemic cancer, toxic habits (tobacco and/or alcohol use) and infection with OSCC around dental implants may present the human papillomavirus.^{4,5} Nutrition (diet high hygiene (poor oral hygiene) factors are also associated with an increased risk of oral cancer.4 Although OSCC may appear directly, it is usually preceded by premalignant oral lesions such as leukoplakia, erythroplakia or lichen planus.⁴ Czerninski et al. found that 87.5% of the evaluated patients had risk factors for developing oral carcinoma (a previous history of cancer [50.0%], premalignant lesions [25.0%] and toxic habits [25.0%]).¹⁵ The time between implant placement and tumor diagnosis varied from 0.5 years to 13 years (median: 4.5 years). Similar data were obtained in the present review, in which 76.47% of the patients had 1 or more risk factors for malignancy prior to placement of the dental implants, 47.06% of the cases had a history of oral carcinoma (OSCC and verrucous carcinoma of the alveolar ridge) or systemic cancer in other organs far from the oral cavity (lung cancer, pancreatic and breast), 11.76% had premalignant oral lesions (leukoplakia or lichen planus), 35.3% had or had had a smoking habit, and 17.64% were regular alcohol consumers. The average time between placement of the implants and diagnosis of OSCC in this review ranged between 0.25 months and 120 months (mean: 42 months). Smoking is the major known risk factor for the development of both premalignant oral lesions and oral cancer. It also has a negative effect on long-term implant success, as smoking cessation has shown significantly better outcomes.²⁶ There are reported cases in which the patient had no identified risk factor for developing oral carcinoma, and in all of them, the tumor was developed in close contact with the implants.^{18, 22, 23} Some authors consider chronic trauma as resulting in a precancerous lesion if the cause of the trauma is not properly addressed.^{18, 27}

In all of the cases described but 1,²¹ the tumor spread quickly into the bone and radiographic evidence of bone loss around the implant was found. OSCC begins in soft tissue and tends to invade the bone.^{2,3}

De Ceulaer et al. concluded that there is a higher recurrence of oral carcinoma in cases in which implants are placed in the same surgical procedure in which the tumor is removed.²⁰ They stated therefore that it would be advisable to wait for a second stage for implant placement once the tissue has healed and become stable.²⁰

It is suggested that good periodontal health could provide a natural barrier against tumor progression, delaying bone infiltration.¹⁶ Otherwise, the implant could provide an environment conducive to the rapid progression of the tumor to the bone in those cases in which the cancer originated in the epithelium of the adjacent mucosa.

In those cases in which the decision to place implants in a patient at high risk of developing oral carcinoma (smoking and a previous history of a tumor and/or premalignant lesion) is made, careful monitoring and appropriate clinical and radiographic follow-up will be indicated. The prosthesis should be designed to facilitate easy and regular removal, allowing regular control of the tissue.¹⁸

Conclusion

In relation to the published evidence, definitive conclusions cannot be reached, although it can be said that, in patients with risk factors for oral carcinoma, an appropriate individualized risk– benefit assessment should be considered before making the decision to place implants.

In patients with risk factors who have been treated with dental implants, regular clinical and radiographic examination will be extremely necessary. The prosthesis should be designed to permit removal of plaque and facilitate adequate examination of the tissue. In the case of inflammatory changes or any kind of periimplant lesion, a biopsy should be taken and histopathologically analyzed urgently. In cases of patients who have developed an oral carcinoma, if implant placement is decided on, the surgery should be performed in a second phase, and not in the same tumor resection surgery, because a higher number of recurrences have been recorded for the latter.

Further studies are needed with larger series of cases and in collaboration with various cancer centers in order to explore further any direct relationship between OSCC and dental implants, as well as the possible role of the risk factors involved.

Competing interests

The authors declare that they have no competing interests.

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The effect of autoclavable polytetrafluoroethylene strips as adjuvant to hemostatic material in periapical surgery: A technical note

Abstract

Purpose

An adequate hemostasis is of utmost importance for the success of apical

surgery, because it not only improves operative visibility, but also pro-

vides a dry environment within the bony crypt, ideal for an adequate

retrograde obturation. This article describes a new approach for the

successful management of hemostasis during apical surgery through

the use of autoclavable polytetrafluoroethylene (PTFE) strips as an

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adjunct to epinephrine-impregnated gauze as the hemostatic material. Materials and methods

The treatment protocol entailed the application of PTFE strips as an adjunct to epinephrine-impregnated gauze in the apical microsurgery approach, using mineral trioxide aggregate as retrograde obturation material and advanced platelet-rich fibrin plus (A-PRF+) membranes as filling material of the bony crypt.

Results

A synergistic effect of the application of PTFE strips adjunct to epinephrine-impregnated gauze was found, yielding good intraoperative visualization and hemostasis. PTFE strips work as a mechanical barrier, and the material is easily adapted to the bony crypt size and feature by compression. Moreover, PTFE strips are easy to remove without leaving residues that may impair healing.

Conclusion

PTFE strips and epinephrine-impregnated gauze demonstrated a good synergistic effect on hemostasis. PTFE strips are a simple, innocuous and cheap means of enhancing bleeding control during apical surgery.

K e y w o r d s

Apical surgery; PTFE; hemostatic agent; oral surgery; advanced plateletrich fibrin plus.

Introduction

The use of an adequate hemostatic agent is considered of utmost importance among factors related to clinical success in apical surgery. Bleeding control improves vision at the surgical site, reducing operating time, and preventing hemorrhage and postoperative swelling.¹Different techniques and materials have been used to control hemostasis in apical surgery, the most used being bone wax, collagen membranes, ferric sulfate, epinephrine and aluminum chloride.

Kim and Rethnam in 1997 described that a good hemostatic agent should stop the hemorrhage in a short period, be easy to handle, be biocompatible, be relatively cheap and secure, and not complicate or delay the wound healing.² An optimal surgical dry environment is necessary to achieve the best results regarding material properties during retrograde obturation (e.g., MTA, Biodentine and super EBA). Nowadays, the search for an ideal hemostatic agent continues, and different agents (e.g., calcium sulphate, ferric sulphate, collagen plus epinephrine, and aluminum chloride-based paste Expasyl) have been tested and documented in clinical studies.³

A recent adequate sample size clinical trial demonstrated the superiority in terms of bleeding control of aluminum chloride-based paste Expasyl over a gauze impregnated with epinephrine, but without statistically significant differences. Nevertheless, to date, there is no consensus about which of them is the best option.⁴ Moreover, translational evidence suggests that Expasyl plus ferric sulphate or electrocauterization are superior regarding bleeding control compared with other hemostatic agents in rabbit calvaria.⁵ However, they were accompanied by unfavorable tissue reactions, such as necrotic bone, presence of inflammatory cells and absence of bone repair.⁵ To reduce these effects, it has been suggested that bone defects should be freshened with a rotary instrument before suturing.

Several hemostatic agents are liquids (e.g., epinephrine and ferric sulphate) and carriers are used for their delivery (e.g., resorbable collagen sponges and cotton pellets).⁶ The ideal carrier material should be able to be removed without leaving traces that impair healing.

Polytetrafluoroethylene (PTFE) or plumber's tape is used for multiple applications in dentistry because it is a nonstick, inert and pliable material.⁷ In dental implant-supported prosthodontics, it is used like a sealer material for implant abutment screw holes,8 minimizing the risk of screw head damage during retrieval procedures.7 PTFE is nonfilamentous and thus easier to remove compared with cotton pellets, which tear easily during removal. PTFE tape is also used as a spacer beneath temporary restorative obturation material in root canal therapy, yielding less bacterial leakage.9

PTFE strips can be compacted against the walls of the bony crypt after ostectomy. The material can be adapted to the defect size and through compression works as a mechanical hemostatic barrier. Hence, the present article was aimed at introducing a novel approach to managing the bleeding during periapical surgery, through the use of PTFE strips as a mechanical hemostatic material adjunct to epinephrineimpregnated gauze.

Technical report and clinical case

A brief description of the periapical surgery technique is first given to depict the use of PTFE strips as an adjunct for establishing hemostasis, based on a clinical case and its postoperative care. The case is detailed thereafter.

Materials and methods

The surgery was carried out under local anesthesia with 4% articaine and 1:100,000 epinephrine (Inibsa). The flap approach entailed making a paramarginal incision. Once the flap had been elevated, the inflammatory tissue surrounding the root apex, forming a bone crypt, was debrided using manual curettes. Hemostasis was achieved using epinephrine-impregnated gauze, subsequently reinforced with PTFE strips previously sterilized by autoclave, and compacted using an amalgam ball burnisher-plugger within the bony crypt surrounding the tooth apex. The root ends were inspected using a rigid endoscope (Möller-Wedel). The root-end cavities were prepared with sonic-driven microtips and ultrasonic tips (Piezon Master 400, EMS Electro Medical Systems), and then were retrofilled with mineral trioxide aggregate (MTA; Dentsply Tulsa Dental Specialties). Finally, the quality of the retrograde fillings was inspected using a rigid endoscope (Möller-Wedel).

The bony crypts were regenerated using an autologous platelet concentrate. Membranes of advanced platelet-rich fibrin plus (A-PRF+;

PTFE strips as adjuvant in apical surgery

Fig. 1

Intraoral view. Maxillary anterior region without swelling or pathological signs.

Fig. 2

Periapical radiograph of the anterior incisors that had undergone root canal therapy. Apical radiolucencies can be observed surrounding the root apices.

Figs. 3A &B

CBCT images.

(A) Panoramic view of the maxilla, where apical lesions can be more clearly seen around the incisal apices.

(B) The CBCT sagittal slice confirmed that the apical defects were related to the root canal retreatment.





Process for PRF, Nice, France) were prepared from the patient's venous blood, collected in 3 × 10 mL sterile glass vacuum tubes (plain vacuum tube A-PRF™+; Process for PRF, Nice, France) and centrifuged at 1,300 rpm × 8 min (200 × g). This process allows one to obtain a 3-D fibrin mesh enriched with platelets, and growth factor released from platelet alpha granules after a slow activation without additives. This mean of production provides a source of biological signals and growth factors that enhances wound repair and angiogenesis.¹⁰⁻¹²

Clinical case

A 57-year-old female patient was referred to our clinic because of an asymptomatic apical lesion involving single-rooted teeth in the anterior maxilla. The patient reported no relevant systemic condition or allergies. The clinical exploration found good oral hygiene and periodontal status. The patient reported that she smoked 11–15 cigarettes per day, and no softtissue alterations in the region of interest were observed (**Fig. 1**). In an intraoral radiograph, the 2 central incisors and 1 lateral incisor that had undergone root canal therapy showed apical

radiolucencies surrounding the root apices. One central incisor showed a previous periapical surgery **(Fig. 2)**. The CBCT study confirmed that not only the central but also the contiguous lateral and central incisors were affected, as verified in the panoramic view and sagittal slices **(Fig. 3)**. No pathological periodontal pockets were present but a slight gingival recession in the buccal side was present, of type I according to Miller.¹³

A paramarginal incision was performed to reach the affected area, and a full-thickness surgical flap was raised at the buccal side, followed by ostectomy and apicoectomy (Fig. 4). Hemostasis was then performed using epinephrineimpregnated gauze and PTFE strips, and the retrograde cavity was prepared and sealed with MTA (Fig. 5). Excess material was removed with manual curettes and rotary instruments (Fig. 6). The root integrity and apical filling were ascertained using a rigid endoscope (Fig. 7).

The bony defects of the affected apical areas were filled with pieces of A-PRF+ membranes (**Fig. 8**). After cleaning the intervention area with saline solution, primary wound closure was accomplished with multiple interrupted sutures (**Fig. 9**). A postoperative periapical radiograph was taken (**Fig. 10**).

PTFE strips as adjuvant in apical surgery

Fig. 6







Figs. 7A-F



Figs. 8A & B





Fig. 4 Buccal lesions were accessed through a paramarginal flap. The apical lesions were accessed after osteotomy and granulation tissue debridement.

Fig. 5

Bony crypt bleeding was controlled by applying epinephrine-impregnated gauze and PTFE strips packaged with pressure against the bony walls. The cavity preparation was done using an ultrasonic tip, then MTA filling material was used to obturate the retrograde cavity. Good bleeding control can be observed.

Fig. 6

MTA excess was removed using a surgical curette.

Fig. 7

Rigid endoscopic images. Apical preparation and root canal integrity were ascertained.

 (A-C) Retrograde obturation quality was inspected.
 (D-F) The good bleeding control can be appreciated.

Figs. 8A & B

Regenerative procedure with platelet concentrate.

(A) Before flap repositioning, the bony crypt was filled with pieces of autologous fibrin matrix, A-PRF+ membrane.

(B) A-PRF+ membranes were placed inside the apical bony crypts.

Fig. 9 Flap suturing with resorbable material.

Fig. 10 Postoperative periapical radiograph.



Postoperative care

The patient was prescribed amoxicillin (500 mg/8 h) for 5 days after the intervention, ibuprofen (400 mg/8 h) for 4 days, a 0.12% chlorhexidine rinse (twice a day) for 7 days, and paracetamol (500 mg on demand) in the event of intense pain. The sutures were removed after 1 week.

Discussion

Achieving success in apical surgery requires adequate bleeding control to reduce the surgery time, enhance operative vision and diminish postoperative complications such as swelling and patient discomfort. Most importantly, it allows us to guarantee optimal conditions for the setting of the retrograde sealing material.

Hemostatic agents and materials by definition are classified according to their properties. They can be chemical or mechanical, working as a barrier, such as bone wax. Bone wax has been used for many years and is easy to handle, though remaining traces of this material can cause adverse tissue reactions.¹⁴ Similar problems have been observed with ferric sulfate: When not completely eliminated from the surgical site, it gives rise to foreign-body reactions that complicate healing.¹⁵

The hemostatic efficacy and the tissue reactions of bone wax, ferric sulfate, aluminum chloride, and a combination of aluminum chloride and ferric sulfate were assessed previously by an experimental report.¹⁶ The authors indicated that Expasyl alone or in combination with ferric sulfate was the most effective agent.¹⁶ Another study compared 5 hemostatic techniques following the same preclinical design reported by von Arx et al. in 2006 and found that the most effective methods for reducing bleeding were



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Expasyl + Stasis and electrocautery.¹⁶ However, this bleeding control efficacy was accompanied by unfavorable tissue reactions, such as necrotic bone, inflammatory cells and the absence of bone repair.⁵ Using impregnated gauze with epinephrine showed good hemostatic results, but inferior to those obtained with Expasyl.⁴ The advantage of this method is that it does not leave residues that might affect wound healing after apical surgery.

Available evidence is not conclusive regarding the best hemostatic agent, but denotes that being cheap and easy to handle are among the desirable characteristics.² PTFE tape is cheap, easy to handle and to remove from the bony crypt, leaving no residues, and autoclavable. For the above-mentioned reasons, we tested sterilized PTFE strips as a new means of enhancing the already good bleeding control usually achieved with epinephrine-impregnated gauze.

The use of PTFE strips combined with epinephrine-impregnated gauze might provide bleeding control comparable to that of Expasyl without the drawbacks of this method, difficulty of removal and risk of postoperative tissue reactions.

Conclusion

PTFE strips and epinephrine-impregnated gauze demonstrated a good synergistic effect on hemostasis. PTFE strips are a simple, innocuous and cheap means of enhancing bleeding control during apical surgery. Clinical studies should be done to evaluate this technique.

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Unlikely case of submasseteric abscess originating from a maxillary molar: The skipping lesion

Abstract

Objective

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Lim MJ, Muhamad Husin A. Unlikely case of submasseteric abscess originating from a maxillary molar: The skipping lesion. J Oral Science Rehabilitation. 2018 Dec;4(4):52–55. We report a case of submasseteric abscess originating from a maxillary tooth, complicated by underlying diabetes mellitus and a multidrugresistant organism.

Materials and methods

A 61-year-old male patient with uncontrolled diabetes mellitus presented with swelling on the left cheek of 2 weeks in duration with rapid progression to trismus, dysphagia and rupture of swelling with pus discharge. Culture and sensitivity testing revealed the presence of multidrug-resistant *Klebsiella pneumoniae*. Based on the patient's history and clinical presentation, a diagnosis of submasseteric abscess originating from the maxillary molar was made. Antibiotic administration, control of systemic disease and wound dressing were done as treatment.

Result

The patient made a full recovery, with scarring on the ruptured region.

Conclusion

Submasseteric abscess is a rare case of infection that can occur in the submasseteric space. As is commonly known, infection of the submasseteric space originates from mandibular third molars; hence, maxillary molars seem to be an unlikely source of infection. Diagnosis of submasseteric abscess that originates from maxillary molars can be difficult owing to its rarity and thus the unlikeliness of being the first diagnosis that comes to mind.

K e y w o r d s

Submasseteric abscess; maxillary molar; skipping lesion.

Introduction

Submasseteric abscess is a rare complication that commonly has dental origins, particularly the mandibular third molars.¹ However, the development of a submasseteric abscess from maxillary molars is scarcer. We could find only 1 case report in our literature search.² Owing to the rarity and late symptomatic manifestation of such cases, diagnosis may not be easy for the general practitioner. Management of submasseteric abscess can be further complicated in patients with impaired immune systems or infected with multidrug-resistant organisms. In this article, we would like to highlight the case of a patient who presented with a rare submasseteric abscess from an unlikely origin, complicated by uncontrolled diabetes and a multidrug-resistant organism.

Case report

A 61-year-old male patient with underlying diabetes mellitus presented to the Dental Department with the chief complaint of swelling on the left cheek with a duration of 2 weeks. The patient claimed that the swelling had begun at the left angle of the jaw and had been increasing in size. The swelling was accompanied by severe throbbing pain and difficulty in swallowing. Upon further probing, the patient said that he had undergone a difficult and unsuccessful extraction of the maxillary left second molar 2 weeks prior.

Upon physical examination, there was a large, diffuse swelling on the left face involving the left masseter region and extending to the left submandibular region with the loss of palpable mandibular angle (Fig. 1). The swelling was firm, tender, warm and erythematous. The patient was also experiencing trismus, with mouth opening of 20 mm interincisally. Intraoral examination revealed poor oral hygiene and a retained root of the maxillary left second molar, which was tender to percussion. The gingiva surrounding the retained root of the maxillary left second molar was assessed to be sufficiently healed, without any signs of infection. The teeth and the gingiva on the opposing arch were healthy. An immediate diagnosis of submasseteric cellulitis with possible involvement of the lateral pharyngeal space was made. The patient was immediately warded and given intravenous crystalline penicillin 4 mega units statim, followed by 2 mega units every 6 h. The patient was also referred to the medical department for management of underlying diabetes mellitus. The patient was prescribed a 500 mg metformin oral tablet once daily. Aspiration was done with a size 16 syringe needle, but yielded no product. It was regrettable that a CT scan was not available at that time.

On day 5 after admission, there was a breakdown of the overlying skin with pus discharge at the left posterior submandibular region, extending to the submasseteric region. The margin of the wound was friable and necrotic. However, the patient claimed that the pain had subsided with the absence of dysphagia. Wound debridement was done, and it was irrigated with chlorhexidine and normal saline. A rubber tube was placed to allow further drainage (Fig. 2). Topical metronidazole was placed on the wound and covered with gauze. A swab was taken and sent for culture and sensitivity testing. The result was penicillin-resistant Klebsiella pneumoniae with sensitivity to cefuroxime. Hence, cefuroxime was chosen as a replacement for penicillin. Daily wound dressing was done, together with the placement of topical metronidazole.

On day 13, the swelling over the left submandibular and submasseteric region had subsided. The patient did not have any dysphagia or trismus. There was no more pus discharge from the wound or from the rubber drain, and only a raw wound was exposed **(Fig. 3)**. After the rubber drain had been removed, a wound dressing was done and the wound was left to heal by secondary intention. A full-mouth scaling and removal of the retained root of the maxillary left second molar were done. The patient was then discharged with a weekly appointment for review and wound dressing.

The patient was followed over a 2-month period. At the last follow-up, the patient presented with scarring of the area posterior to the left angle of the mandible that was slightly darker than the surrounding skin, but with minimal contracture **(Fig. 4)**.

Discussion

In 1948, Bransby-Zachary described a potential space that constitutes a masticator space known as the submasseteric space.³ He mentioned that the common cause of submasseteric space infection was pericoronitis of the third molar.³ The submasseteric space is a potential space



Fig. 1

Swelling of the left of the face involving the left masseter region.

Fig. 2

A rubber drain was placed for pus drainage.

formed between the lateral wall of the mandible and the medial aspect of the masseter muscle and its investing fascia. Submasseteric abscess is often not the foremost diagnosis when a patient complains of swelling of the jaw owing to its rarity.¹ A study has shown that the most commonly involved orofacial space is the submandibular space, followed by the buccal space and lastly the submasseteric space.⁴ It is often thought to be trismus, as its first sign is spasm of the masseteric muscle, resulting from the irritation of the muscle fiber by the infection. Extraoral examination cannot determine its severity, as the swelling is often firm and mild in the early stages, owing to its being confined by the masseteric muscle. The swelling is isolated, involving the angle of the mandible, and tender and diffuse in nature. Once the infection penetrates the muscle fibers, the swelling becomes fluctuant and erythematous.⁵

The submasseteric space is connected to other spaces, including the buccal space, submandibular space, pterygomandibular space and infratemporal space. However, the submasseteric space is by no means directly connected to any maxillary teeth. It would seem rather impossible for the maxillary molar to be the origin of the submasseteric abscess. We postulated that, according to the patient's history, an infected hematoma may have formed in the buccal space or infratemporal space, owing to the traumatic and unsuccessful extraction. However, the healing of the gingiva at the extraction site proceeded normally, without any signs of infection. This meant that there was a formation of an isolated and infected hematoma. The infected

hematoma was presumed to have extended into the submasseteric space, without having infected the buccal space or the infratemporal space tissue. This gave an impression of the infection skipping through the aforementioned space to the submasseteric space.

We were only able to find 1 other similar case, which was reported by Gallagher and Marley, for which they hypothesized that an infected hematoma was formed at the infratemporal region before extending into the submasseteric space.²

K. pneumoniae is frequently isolated as a major infective organism in diabetic patients. Empirical antibiotic therapy of amoxicillin with clavulanic acid together with metronidazole, coupled with surgical drainage, should provide a satisfactory outcome.⁴ However, in this patient, owing to the presence of penicillin-resistant K. pneumoniae, the patient's condition did not respond to the administration of penicillin and rapidly deteriorated. By the time we had obtained the microbiology results, the abscess had ruptured through the overlying skin. After changes were made in the antibiotic administration, there was a significant improvement of the wound. We noticed a significant reduction in pus discharge from the wound and an increase in healthy granulation tissue formation. It is regrettable that, owing to the rapid progression of the infection, we could not prevent the breaking down of superficial tissue, leading to permanent scarring.

The control of the patient's diabetic condition was a major concern in our management. Diabetes has been considered a factor reducing host response, as it may lead to hyperglycemia,

Submasseteric abscess



disrupt cellular immunity and complement We would like to thank the Director General of activation. Complication of deep neck infection is also frequently reported in patients with diabetes.4

The management of this patient would have been greatly improved if a CT scan had been available. The diagnosis of submasseteric abscess would have been made much earlier. With CT imaging as a guide, a proper incision and drainage would have been done to provide an outlet for the abscess, preventing a breakdown of the overlying tissue.

Conclusion

This case highlights what seems to be an impossible diagnosis. While the submasseteric space is not a neighboring space of maxillary teeth, the possibility of the spread of infection exists. At present, no paper addresses the risk level of such a complication of the extraction of maxillary teeth. Severe systemic disease or a multidrug-resistant organism could be the culprit of such a seemingly impossible diagnosis. It is hoped that, from this paper, practitioners will be made aware of such complications and prompted to investigate further to manage such a case in a timely manner.

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Competing interests

The authors declare that they have no competing interests.

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Fig. 4

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Healing of the perforated

Scarring at the area posterior

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