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Article

SPLINTING AND ROOT AMPUTATION: AN ALTERNATIVE SOLUTION FOR MANDIBULAR ANTERIOR "HOPELESS" TOOTH

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ABSTRACT

In case a "hopeless" tooth is to be extracted in the anterior mandibular arch, the clinician could plan multiple therapeutic solutions. Out of them, intra- and extra-coronal splinting of such elements and associated root amputation find indication. The present case series describes the operative and surgical phases, thus proposing an immediate, minimally invasive and easy therapeutic solution that can satisfy the patient. This solution, therefore, aims to eliminate the etiologic factor while preserving the patient's aesthetics. Moreover, in many cases, such a therapeutic alternative can be a temporary or permanent solution, prolonging the survival of elements otherwise doomed to extraction.

KEYWORDS: *Splitting, root, periodontitis, tooth, gingiva, surgery*

INTRODUCTION

In 1984 Becker and co-workers described the parameters for considering a tooth "hopeless" (1). The concept was later resumed by Harrison, et al. (2), who defined a lost tooth as no more restorable and with no periodontal support, consequently no more maintainable.

Despite advances in the periodontal field, Tonetti et al. also consider tooth loss in the presence of radiographic bone loss greater than 80% (3).

After radiographic evaluation and periodontal probing, the clinician faces challenging therapeutic choices in the presence of highly compromised teeth. In some cases, the only possible solution is extraction, especially not to jeopardize adjacent teeth integrity or periodontal support. Indeed, as the retrospective study by Macthei et al. (4) shows, in the absence of periodontal treatment, the retention of "hopeless" teeth has a negative effect on the periodontium of adjacent teeth, and the extraction is appropriate.

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In most cases, also based on the functional and aesthetic needs of the patient, the clinician has to plan a therapeutic solution following extraction, especially in areas with aesthetic relevance, such as the anterior mandibular area. Extraction of these teeth mainly leads to aesthetic and phonetic difficulties, besides some functional disabilities. Irrespective of the permanent treatment options offered, patients usually refuse delayed replacement, requesting an immediate alternative solution following extraction with the primary aim of restoring the aesthetics. Temporary removable resin partial dentures in the immediate post-extraction period are unsightly due to retention clasps, bulky, nonfunctional, and uncomfortable for the patient, and may even impair the healing process or compromise the periodontal health of the remaining dentition (5-7). The option of placement of immediate implants following extraction may be suggested to the patient if there is no residual infection in the socket or adequate bone and soft tissue for coverage.
In these cases, a straightforward and minimally invasive therapeutic solution could be to perform intra- and extra-coronal splinting and, at the same time, root removal with a minimally invasive approach. The purpose of this article is to describe the adhesive-conservative procedure and the surgical step involving a full-thickness lingual flap for compromised root removal.

MATERIALS AND METHODS

Twenty healthy patients, aged 53-86 years, with a hopeless tooth in the anterior mandibular region, were included. Diagnosis was made based on patient-reported symptomatology, periodontal biometric parameters and periapical radiographic evaluation (Fig. 1). In all cases, extensive bone loss was detectable on x-rays, highly pathologic circumferential probing, and in many cases, also detecting grade II or III mobility. The adjacent teeth presented a better clinical situation. Based on the collected data, tooth extraction was indicated. All possible therapeutic options were discussed with the patients, who accepted intra- and extra-coronal splinting, followed by periodontal surgical root removal. The two therapeutic phases took place on the same day or, in some cases, at different times, depending on the patient's availability.

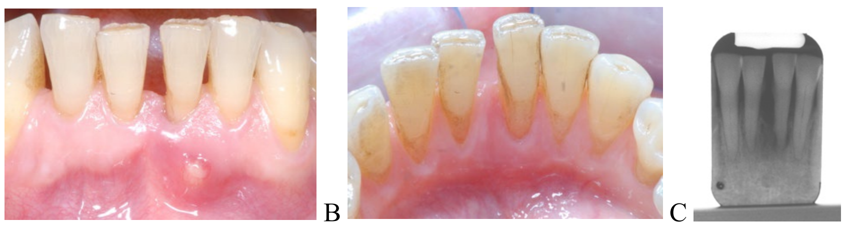
A B C

Fig. 1. ***A)*** *Baseline buccal view.* ***B)*** *Baseline lingual aspect.* ***C)*** *Baseline periapical radiograph.*

Operative dentistry phase

Local anaesthesia was administered using Mepivacain 20mg/ml with adrenaline 1:100000 (Optocain). The 2P tungsten carbide bur creates a 2 mm incisal groove in the mandibular four incisors (Fig. 2), corresponding to the bur's working portion. The rubber dam placement eases the dentist's work while preventing hazards to the patient. For intra-coronal splinting, long orthodontic metal ligature wires (diameter 0.10) are used, previously intertwined with each other.

Fig. 2. *The 2P tungsten carbide bur outlines an incisal groove in the mandibular four incisors.*

Four small pieces are cut out and inserted in the created incisal groove (Fig. 3a), and their complete passivity is checked in addition to the desired length; this is an essential feature to avoid unwanted or unsafe forces on adjacent elements. It is recommended to bond the teeth two by two for the following reasons: complete force passivation in splinting, and if a small portion breaks off, it can be quickly restored. Once pleased with the wire position and its length, the usual bonding steps are carried out. 37% orthophosphoric acid (ENAetch, Micerium S.p.A., Avegno, GE, Italy) (Fig. 3b) is applied and subsequently rinsed off prior to universal adhesive usage (Prime&Bond Active, Dentsply Sirona, Rome, Italy) (Fig. 3c). When the adhesive is cured, a flow composite is applied, embedding orthodontic wires (Fig. 3d). Final polymerization is obtained in about 1 minute. Following the initial stability of the compromised element, a second extra-coronal splinting is executed to improve firmness further. Next, with a coarse-grain diamond bur, the lingual enamel of the hopeless tooth and the adjacent healthier element are

made coarse. Finally, using the same adhesive-restorative sequence, a lingual orthodontic retainer is positioned (Fig. 3e) and then submerged by flow composite.
Then intra- and extra-coronal splinting are completed, and the rubber dam is removed. Occlusion is adequately controlled, and polishing steps are completed with fine-grained diamond, Arkansas white stone and polishing burs (Fig. 4a, 4b)

Surgical phase

A single-flap approach is planned and limited to the lingual side. The 3.1 surgical root removal begins with an intrasulcularly incision at the base of the papillae of the adjacent teeth (Fig. 5a). Extending the flap to at least two adjacent teeth is recommended mesially and distally to have adequate access to the surgical site and better defect identification. Next, a full-thickness flap is lifted and limited to the lingual side only, using a CTGO bone chisel in the first few millimetres (Fig. 5b). With small rotational movements, alveolar bone cleavage is achieved. When the first millimetres of tissue is detached, the bone chisel helps to widen the full-thickness lingual flap (Fig. 5c). Following defect visualization, the granulomatous tissue is removed with a tungsten carbide multiblade bur or a Hirshfield file to gain better access to the root surface. With the Prichard elevator # 3, the lingual flap is protected during root amputation. A very fine, coarse-grained diamond flame bur mounted on a high-speed handpiece, the root is amputated. The goal will be to separate the root mesially to distally or vice versa. The 45° inclined bur, with the tip oriented apically (Fig. 5d), is a key factor for satisfying clinical aesthetic surgical outcomes. Thanks to such inclination, the etiologic factor and the infected root are removed from the socket, leaving it supragingival in its lingual portion, but buccally 2-3 millimetres of root surface are

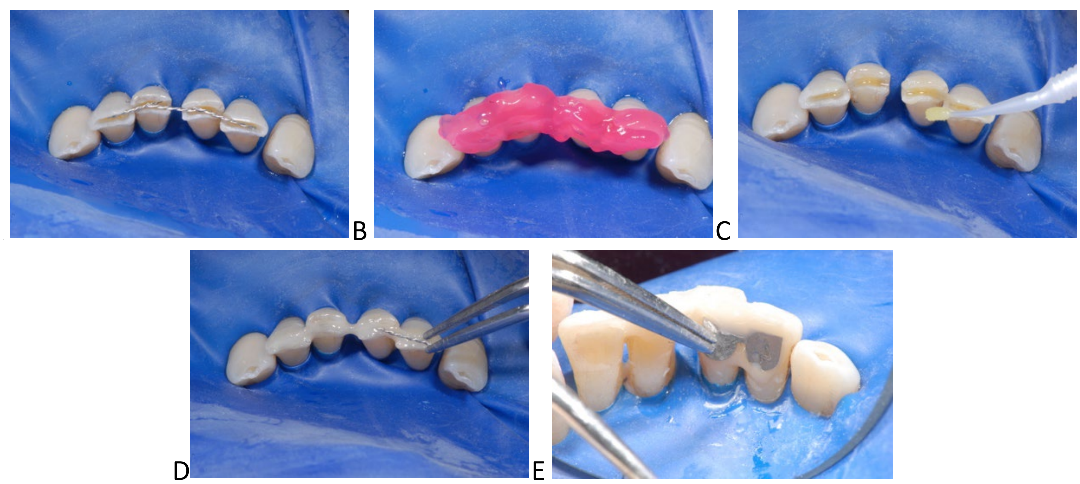

Fig. 3. ***A)*** *Four small fragments are cut out and placed into the incisal groove to achieve proper passivity.* ***B)*** *37% orthophosphoric acid application.* ***C)*** *Universal adhesive application with a micro-brush.* ***D)*** *Orthodontic wires are submerged by the composite flow.* ***E)*** *The lingual orthodontic retainer is located on the lingual site of the mandibular incisors and submerged by the composite flow.*

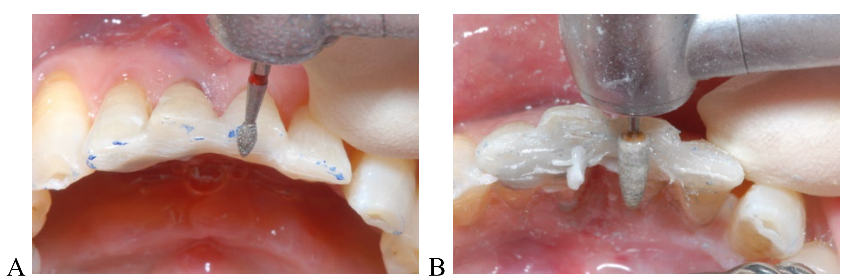

Fig. 4. ***A)*** *With a diamond football bur any interferences detected by the occlusion paper are eliminated.* ***B)*** *The Arkansas bur effectively smooths the site.*

maintained in contact with the gingival tissue. The purpose is to “deceive” the buccal gingiva, leaving root support for the gingival tissue and preventing excessive shrinkage during the healing phase. To ensure complete root resection, the probe can retrace the cut made with the bur from the mesial to the distal side. The most apical part of the root is separated and removed using the CTGO (Fig. 5e) or a curette very easily.

Intraoperative periapical x-ray (Fig. 6) is recommended to assess the complete removal of the root fragment and to ensure that the residual root portion is coronal to the bone crest. Next, the lingual flap is sutured in its original position with simple detached stitches (Fig 7).

Antibiotics were prescribed: amoxicillin and clavulanic acid, 1g every 12 hours, two days before surgery and for the next 4 days, and pain medication as needed. As a result, the patient is motivated to appropriate home care, especially using an interproximal brush after two weeks from surgery.

RESULTS

All patients were pleased with the achieved clinical aesthetic outcomes. No symptoms or abscess episodes that were initially reported occurred anymore. From a psychological point of view, the patients mainly appreciated keeping the

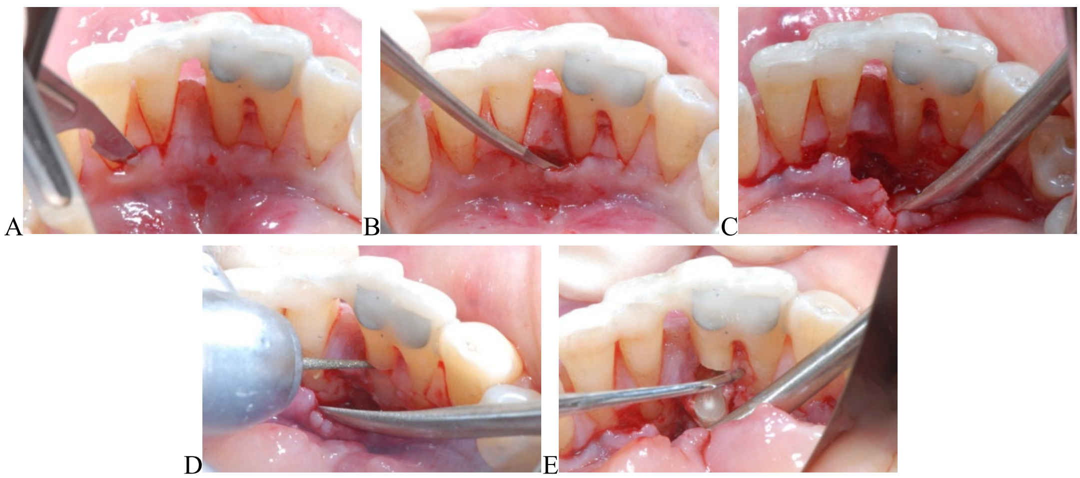

Fig. 5. ***A)*** *The intrasulcular incision is executed at the base of the papillae of the adjacent teeth.* ***B)*** *CTGO chisel raises a full thickness lingual flap.* ***C)*** *The Prichard elevator #3 completes flap elevation and protects it during the root resection steps.* ***D)*** *The fine, coarse-grained diamond flame bur is initially placed near the root to be resected. The inclination of the bur is 45° with the tip oriented apically.* ***E)*** *Root fragment removal with the CTGO chisel.*

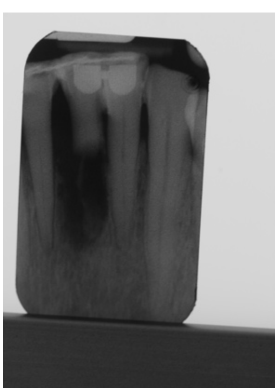

Fig. 6. *X-ray post root amputation.*

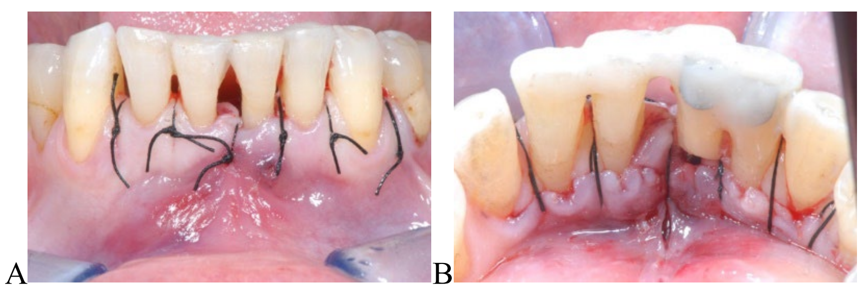

Fig. 7. ***A)*** *Suture with simple detached stitches. Buccal view.* ***B)*** *Lingual view: coronal part of the root coronal to the lingual soft tissue.*

compromised tooth which also preserves the masticatory function. As documented in the comparative pictures (Fig. 8a-d), at a 5-year follow-up, a moderate shrinkage of the buccal tissue is observed without compromising the aesthetic aspect. Out of 20 patients treated, only in 3 cases did a minor splint fracture occur, making the dental element slightly mobile on one side. In these cases, the patient immediately received restorative treatment. None of the treated patients required a therapeutic change or a definitive treatment plan.

DISCUSSION

A hopeless mandibular anterior tooth, combined with bony defects of the edentulous area and/or periodontal disease of adjacent teeth, makes implant-supported or traditional fixed dental prostheses restorations quite challenging (8, 9).

At the same time, there are other important aspects to be evaluated in the treatment plans decision, such as the economic aspect, timing, clinical aspect of the other elements in the dental arch, and the general clinical situation of the patient. The patient's aesthetic expectations must also be respected, understood and evaluated to formulate an appropriate treatment plan. Splinting and root amputation is an economical and sufficiently aesthetic therapeutic solution that is easy to propose, primarily because of the quick timing. It can also be proposed as a temporary solution allowing the patient to opt for a more permanent and more invasive solution in the future while removing the etiologic factor. Another significant advantage is keeping the same tooth as the patient, which makes it more psychologically acceptable than a complete tooth extraction. (10, 11)

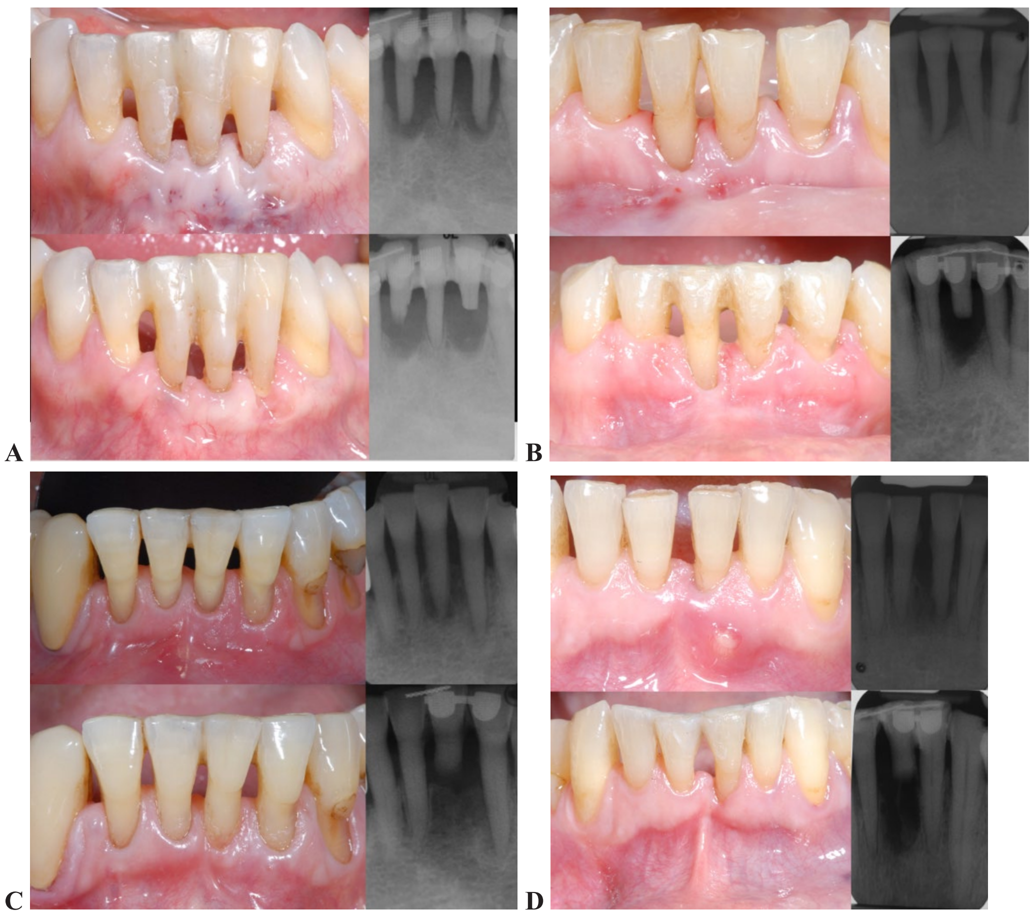

Fig. 8. ***A)*** *#PT1 Comparative clinical and radiographic pictures pre and 5 years post treatment.* ***B)*** *#PT2 Clinical and radiographic documentation pre and 5 years post treatment.* ***C)*** *#PT3 Comparative clinical and radiographic pictures pre and 5 years post treatment.* ***D)*** *#PT4 Clinical and radiographic documentation pre and 5 years post treatment.*

A reduced number of case reports and case series are reported in the literature on splinting combined with root amputation (5, 7, 8, 10, 12-18). In most articles, however, the technique always involves extracting the tooth and shortening the root extra-orally, then repositioning and splinting it (7, 8, 12-18). In some cases, additional endodontics is performed, again extraoral to seal the canal and the addition of composite resin to give the most apical part an ovoid shape (18). According to the technique reported instead, the ovoid shape is performed as a consequence of the 45° cut of the root, and the necrosis of the most coronal part does not negatively affect the patient's symptomatology. In contrast, tooth extraction and subsequent tissue shrinkage would significantly negatively affect the final aesthetic result.

As reported in the case report of Badhari et al. (18), an additional issue for splinting the natural tooth post-extraction is the presence of dental malposition or crowding, which complicates the repositioning of the extracted tooth in the arch. Therefore, the authors suggest that minor interproximal modifications be performed in such cases to facilitate its repositioning (18). Conversely, if, as described earlier, splinting is performed before the surgical stage of root removal, the problem does not exist. The dental elements are stabilized and bonded already in their position, and following root amputation, they remain fixed in their original position.

A brief parenthesis concerns the material used for splinting. According to a 2016 review, various materials are used for extra-coronal splinting, such as stainless-steel wires (most commonly used), fibre-reinforced composite, composite alone, and cast splints (19). Also, about the intra-coronal splints, the review suggests that composite resin restorations can be placed in adjoining teeth and cured to eliminate any interproximal separation. These restorations can be further reinforced with metal wires, glass-reinforced fibres or pins. In any case, the goal must be to reduce the mobility of adjacent teeth without exerting harmful forces so as not to compromise their periodontal integrity. The consensus then shifts toward glass fibres and composite to achieve stability but adequate elasticity and greater esthetics (19). However, the author believes that the material should also be chosen according to the available coronal space. A slight downside is that splinting makes oral hygiene procedures difficult.

For this reason, metal material submerged in composite require less adhesion surface than glass fibre, which is essential for interproximal cleaning with interproximal brushes. Therefore, to ensure the longevity of the connected teeth, special attention must be given to instructing the patient about enhanced measures for oral hygiene after placement of the splint. In addition, effective personal plaque control, professional caries risk assessment, and periodontal maintenance are crucial to the splint's longevity and the splinted teeth' health.

CONCLUSION

The splinting of natural teeth can be considered a temporary or permanent therapeutic alternative depending on the patient's expectations. A major advantage is eliminating the etiologic factor and source of infection lying in the root while preserving the patient's aesthetics and maintaining the tooth crown. Hence, if splinting was only planned in the transitional phase as a temporary solution, once removed, the clinician still has the option of proposing a definitive treatment plan to the patient with a healthy periodontal condition. In most cases, it can be a definitive treatment choice, invariably considering the patient's needs. Key factors include the ease and promptness of implementation, the immediate aesthetic benefit, and the lower cost compared to any other prosthetic rehabilitation. Obviously, the patient must enter a proper, ''tailored'' maintenance protocol and be thoroughly instructed on proper home care.

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Review

ORAL LICHEN PLANUS TRANSFORMING IN ORAL SQUAMOUS CELL CARCINOMA: A CASE REPORT

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ABSTRACT

Oral lichen planus (OLP) is a chronic T-cell-mediated inflammatory disease. There are several clinical presentations of OLP, reticular, atrophic, plaque, erosive and bullous. OLP is classified in the group of potentially malignant disorders according to the World Health Organization; its most serious complication is transformation into oral squamous cell carcinoma (OSCC). The risk of malignant transformation in OLP has been controversial for a long time and is estimated to be between 0.4% and 3.7%. The present work reports a case of OLP transforming in OSCC.

KEYWORDS: *lichen, carcinoma, tongue, oral cavity, risk*

INTRODUCTION

Oral lichen planus (OLP) is a chronic T-cell-mediated inflammatory disease affecting 1-2% of the general population (1). OLP manifestation ranges from asymptomatic reticular white lesions in the atrophic mucosa to erosive-ulcerative areas (2). The same time, the most characteristic feature is the presence of white lines called Wickham striae (3, 4). To analyse the histopathologic appearance of the disease, evidence of a banded lymphocytic infiltrate at the interface between the epithelium and connective tissue is important, as well as signs of destroying the basal layer. Most patients with OLP are middle-aged (over 40 years), and females account for at least 65% of patients (5). OLP is classified in the group of potentially malignant oral disorders, according to the World Health Organization (6, 7). Several authors analysed the OLP progression to oral squamous cell carcinoma (OSCC), trying to find the main actors of carcinogenesis. The most investigated are the microenvironmental changes resulting from the expression of inflammatory cells such as tumour-associated macrophages, mast cells, and fibroblasts; the altered balance of cytokines such as the overexpression of Tumour Necrosis Factor (TNF), interleukin-1 (IL-1), IL-6; the suppression of cell-mediated immunity and the hyperactivation

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of humoral immunity (8). The risk of malignant transformation in OLP has been controversial for a long time and is estimated to be between 0.4% and 3.7% (5, 9). The present work reports a case of OLP transforming in OSCC.

CASE REPORT

The patient is a 64-years-old woman with a history of OLP diagnosed by biopsy in 2009. After the biopsy, which confirmed the diagnosis of lichen, the patient underwent medical therapy with cyclosporine and fluconazole. After several follow-ups, the patient stopped the medical treatment and did not attend the follow-up visits until 2018, when the patient presented to our attention. On physical examination, the patient presented with an exophytic, warty, non-ulcerated, non-bleeding lesion on the right lateral dorsal surface of the middle third of the tongue (Fig. 1). Blood tests and an ultrasound of the neck were requested. Incisional biopsy surgery was scheduled after finding that all values were within normal range and the absence of cervical adenopathy. The patient was a non-smoker but affected by hypertension and was medically treated with nebivolol, valsartan, and hydrochlorothiazide. Her surgical history highlighted a previous thyroidectomy for which she took levothyroxine. The patient underwent a surgical incision of the lesion. The wound was then closed primarily. The sample was analysed and revealed invasive, well-differentiated OSCC of the tongue arising in pre-existent OLP. After two weeks, the complete surgical excision with adequate resection margins was performed. Six months after surgery, the patient had scarring but no signs of recurrence.

DISCUSSION

Koberg was the first author to describe OLP's malignant transformation (10). Since the publication of Koberg's study, a series of case reports and cohort studies that reported an association between OLP and OSCC have been published (11). Although it is still unclear how the transformation happens, OLP is considered an independent risk factor (12). Nevertheless, it is recommended that patients avoid some additional risk factors, such as tobacco and alcohol (13). The literature does not give a complete and straightforward overview of whether OSCC arose in the OLP due to different risk factors. OLP is a CD8+ T lymphocyte-mediated autoimmune disease affecting the basal keratinocytes. Alterations in the expression of various factors, including p53, COX-2, Smad3, Bmi1, CD133, and Myc-1, have been reported to be significant predictors of malignant transformation (14). In addition, many theories state that there is a correlation between chronic stimulation by inflammatory mediators released from infiltrating T cells and subsequent oxidative stress and neoplastic change (15).

According to literature (16, 17), the most frequent side of malignant transformation in a patient with OLP Is the tongue, especially in women, as reported in our case. Furthermore, studies (15, 16) have reported that the increased risk of developing OSCC in OLP lesions compared with the general population reaches 0.07-5.3%.

Fig. 1. *A) Dorse tongue in 2009, with OLP lesions; B) Dorse tongue in 2018, with an exophytic, warty, non-ulcerated, non-bleeding lesion.*

In conclusion, this clinical case shows the need for close follow-up because OLP is a common pathology and a risk factor for OSCC onset. Follow-ups are mandatory in all patients with symptomatic and asymptomatic lesions. It is not well understood which factors led to its transformation into OSCC till now.

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Review

IN-VITRO CROWN-DENTIN INTERFACE ANALYSIS OF A NEW MINI-INVASIVE TOOTH-PREPARATION TECHNIQUE FOR MONOLITHIC CERAMIC CROWN RESTORATIONS

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ABSTRACT

Modern restorative dentistry developed safe adhesive bonding techniques, which improved invasiveness minimally in restoring compromised teeth. However, ceramic restoration failures result from a combination of several complex factors, such as the geometry of teeth preparation, mechanical properties of the material, cementum and function and parafunction of the patients. The present study investigated differences between a new technique (anatomical, functional geometry - AFG) and a standard preparation technique (ST) in the crow-dentin area. Sixty human-extracted teeth were duplicated, prepared and digitized to analyze the preparation area. The difference was statistically significant as in the ST group; the crown-dentin surface was 112,16 ± 25,51 mm^2, while for AFG was 138,89 ± 39,06 mm^2 (p = 0.001). The proposed preparation technique could be a reliable option to provide a more uniform and mini-invasive reduction of restored teeth when performing a monolithic ceramic restoration.

KEYWORDS: *tooth preparation, mini-invasive, adhesive restoration, monolithic crown*

INTRODUCTION

Preserving healthy tooth structures is essential to provide longevity of teeth. If caries, attrition, or erosion affects teeth, preserving the remaining tooth structure is crucial, avoiding extended post-and-core reconstruction or tooth replacement through dental implants (1). Modern restorative dentistry developed safe adhesive bonding techniques, which improved invasiveness minimally in restoring compromised teeth (2). All-ceramic systems were developed in response to the increasing concern in dentistry for superior esthetics, biocompatibility, translucency and optical properties and to meet the growing needs of patient expectations. Because of their natural appearance, translucency, biocompatibility, and optical

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properties, ceramics have become increasingly popular in dentistry. Composite resin direct restorations are the most commonly used treatment for posterior dentition to restore premolar and molar areas (3). The improved strength and marginal adaptation of all-ceramic restorations become more important for posterior areas of the mouth, where the forces are much higher than for the anterior region. Several studies reported that the preparation of teeth could weaken the cusp's stiffness (4). Two clinical failure types are reported: occlusal surface fracture originating from the contact site and bulk fracture initiating from the cementation surface directly beneath the contact. Factor under the control of the clinician includes (A): crown and luting materials, (B): tooth reduction with the associated implications in crown thickness, (C): cement space and (D): tooth-supporting structure in situations where a build-up restoration is placed beneath the crown and/or the tooth has been treated endodontically. It has been documented that there is a direct correlation between tooth structure removal and tooth weakness (5). The adaptation of restorations, including marginal and internal adaptations, is essential for clinical success (6). To achieve an ideal reconstruction, the clinician must consider the physical properties of ceramic and their variations near enamel, mechanical stresses, and the tooth preparation's geometry to comply with a minimally invasive restoration.

Ceramic restoration failures result from a combination of several complex factors, such as the geometry of teeth preparation, mechanical properties of the material, cementum and function and parafunction of patients (7). Metal-ceramic crowns have been employed successfully in dentistry (8). However, the metal-ceramic crowns may result in non-aesthetics because of the need to camouflage the grey metal of the core with an opaque layer of ceramic. For this reason, replicating natural tooth substance is always a complex challenge because of the limited translucency of metal-ceramic crowns (9). Nowadays, lithium disilicate has an estimated survival probability of 87.1% over 8 years in function (10). However, several clinical and finite element analysis studies are required to overcome this issue. Minimally preparing the teeth can lead to more mini-invasive restorations of monolithic materials such as lithium disilicate. In addition, clinicians and dental technicians have recognized benefits in teeth uniformed reduction concerning esthetic and reliability resistance over time. The pyramidal preparations provided increased resistance. Therefore, it is essential to preserve the ''corners'' of a tooth preparation whenever possible; in order to overcome the above-mentioned problems, a technique was designed to perform a uniform thickness preparation. The current *in-vitro* study aimed to investigate the difference in the crown-dentin area between the new Anatomical Functional Geometry (AFG)-based preparation, and standard technique (ST)-based preparation for monolithic ceramic restorations. The null hypothesis was that there was no difference between the two preparation techniques.

MATERIALS AND METHODS

Strict criteria were adopted for the inclusion of the teeth in the study. Therefore, chipped or restored teeth, as well as the ones presenting caries, enamel erosions or abrasions, and/or cusps with compound fractures, were excluded. After disinfection and sterilization, each selected tooth was duplicated using a stainless-steel master die filled with polymethyl-methacrylate resin. This way, it was possible to restore each tooth and its duplicate by using two different preparation techniques: group A (comprising ST samples) and group B (comprising AFG samples).

Fig. 1. *Anatomical build-up of compromised tooth following the AFG principles.*

In group A, teeth were prepared following the preparation technique proposed by Burke and Watts. First, a 1 mm groove was cut along the central fissure. Then, a line was marked on buccal and palatal cusps. This line was connected to the bottom of the groove prepared in the first step with a tapered diamond bur. Next, a wall taper of 6 degrees was applied to the preparation until the cementum-enamel junction was reached. The preparation was afterwards completed with a finishing margin.

In group B, the following steps were done in order to perform the new mini-invasive preparation technique:

1. Anatomical references were marked: cusps, cusps ridges, oblique ridges, marginal ridges, and primary and secondary grooves following the Anatomical Functional Geometry (AFG) (23) criteria (Fig.1).

2. A guide cut on primary grooves was made using a cylindric diamond bur with a flat head 1 mm Ø (125 µm grit size) (Komet 6836 314 014, Komet Italia, Milan, Italy) and highline primary cusps ridges (Fig.2).

3. Using the same cylindric diamond bur, a guide cut of 1 mm depth on cusps ridges was made (Fig.3).

4. All the occlusal guide cuts were connected and refined with a fine grit size bur (Komet 8836 314 012, Komet Italia) (Fig. 4A-4B).

5. Interproximal walls were separated utilizing a separation bur (Komet 6878 314 010, Komet Italia). Then guide cuts of 1 mm depth were performed on the buccal, mesial, distal and palatal/lingual walls using a cylindric modified chamfer diamond bur (Komet 2979 314 012, Komet Italia). (Fig.5).

6. The last diamond bur connected all the circumferential guide cuts. Special care was applied not to push too much while connecting all the guide cuts to achieve a uniform tooth reduction (Fig. 6).

7. Tooth preparation was ended using a fine cylindric modified chamfer diamond bur 1 mm Ø (40 µm grit size) (Komet 8879 314 012, Komet Italia) (Fig. 7A, 7B).

Fig. 2. *Guide cuts onto the primary grooves and primary cusps ridges high lined.*

Fig. 3. *Guide cuts onto the primary cusps ridges.*

All the preparations were manually executed by a single specialized operator, who used a constant water spray and the same specific sequence of burs. In order to obtain solid geometries, teeth were reconstructed by optically scanning. Starting from the real samples, 3D teeth solid models were generated through a semiautomatic procedure based on optical scan acquisition (Open Technologies Deluxe, Open Technologies, Brescia, Italy). In detail, data were imported in a CAD environment (SolidWorks, 2013, Dassault Systèmes, Tennessee) and optimized by a standard smoothing process (Fig. 8).

The preparation area was measured in *mm*^{2} for both groups with CAD software (3Shape Dental Lab, 3Shape, Copenhagen, Denmark). Descriptive statistics (mean ± standard deviation) were performed for each group and each tooth position. In addition, a *t-test* at α=0.95 was performed.

RESULTS

From a pool of 112 human teeth extracted, 60 dental elements (20 first premolar, 20-second premolar and 20 first molar from each quadrant) were selected for the investigation, duplicated, prepared and digitized. In group A, the crown-dentin surface was 112,16 ± 25,51 mm^2, while in group B was 138,89 ± 39,06 mm^2 (Table I).

The difference between the two crown-dentin areas was statistically significant (*p = 0.001; CI −27.10; −26.35)*; therefore, the null hypothesis was rejected.

An example of final prosthetic rehabilitation is reported in Fig 9 and 10.

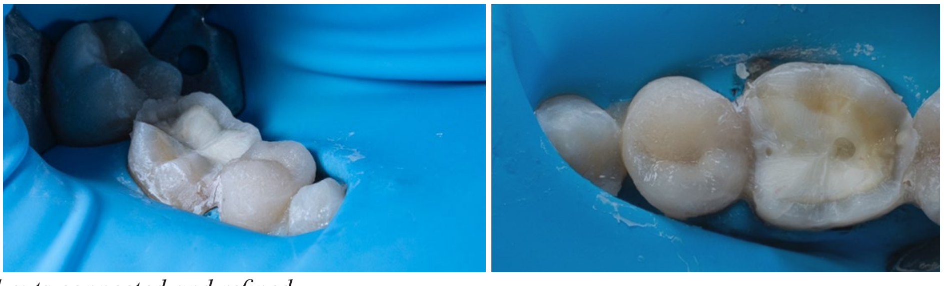

Fig. 4. *Occlusal cuts connected and refined.*

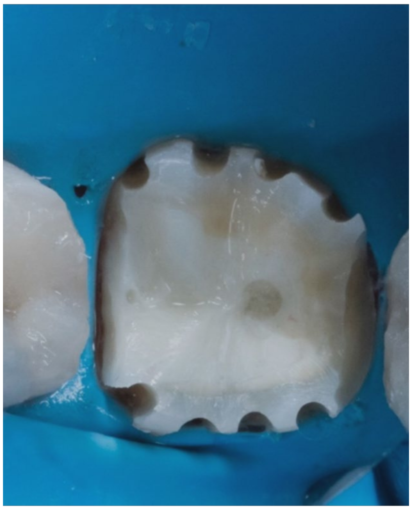

Fig. 5. *Interproximal separation and circumferential guide cuts.*

Fig. 6. *Circumferential guide cuts connected.*

(**a**) (**b**)

Fig. 7. *Tooth preparation finished and polished.*

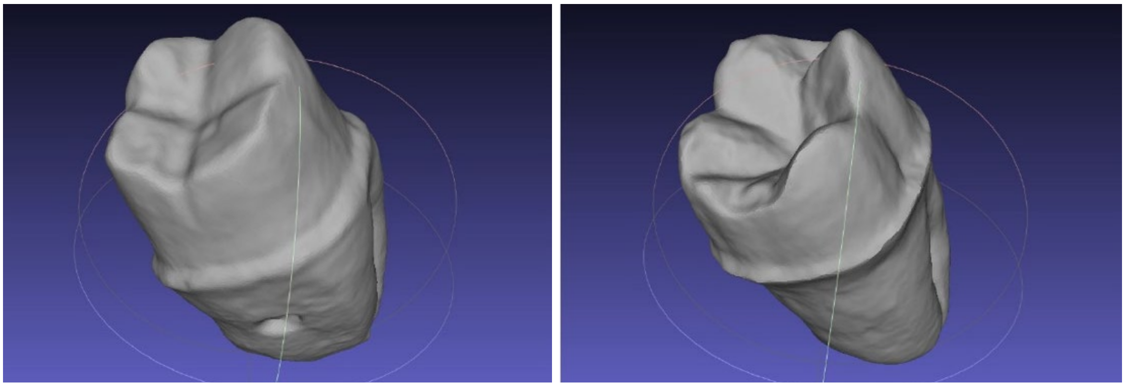

Fig. 8. *A) ST-based digitized tooth; B) AFG-based digitized tooth.*

Fig. 9. *Definitive crowns*

Fig. 10. *Definitive crowns*

Table I. *Areas in mm2 of each prepared tooth from group A and group B.*

Tooth	ST	AFG
2.4	124.1	138.5
2.5	108.6	133.8
2.6	136.7	186.3
3.4	92.94	105.7
3.5	73.82	101.9
3.6	141.8	187.8
4.4	91.07	99.59
4.5	81.89	107.5
4.6	126.8	169.5
1.4	118.5	120.9
1.5	95.3	106.8
1.6	154.4	208.4

DISCUSSION

This in-vitro study investigated the difference in crown-dentin area between the new AFG-based and ST-based preparation for monolithic restorations. The null hypothesis was that there was no difference between the two techniques. The application of this technique requires a learning curve by the clinicians to spot immediately the anatomical reference points which guide tooth preparation. In daily practice, most teeth requiring prosthetic rehabilitation are affected by caries, erosion, and endodontically treatment, all factors destroying the main part of the anatomical reference needed to perform the preparation. In these cases, building up the tooth to give back the proper anatomical shapes is essential. The clinician needs to remove all decayed dental tissue and take an impression to make a wax-up according to the AFG modelling principles. Then the compromised tooth can be built-up utilizing composite light-curing resin using silicon to reproduce a wax-up model so the clinician can spot the anatomical references to perform the described preparation technique achieving a natural appearance and functional fixed restoration. The mean crown-dentin area resulting from the new AFG-based preparation technique was significantly augmented; therefore, the null hypothesis was rejected. In this sense, the proposed technique led to a more uniform and minimally invasive teeth reduction, removing geometric inhomogeneities that may cause breaking in the ceramic structures (11). Core design modifications can increase the support of the porcelain (12). The shape of the preparation and the cement layer may influence the restoration's resistance to fracture and adhesion (13). Adequate preparation guidelines are therefore of paramount importance and should be based on sound data, considering all possible parameters (14).

Concerning the finish line, it must be pointed out that the discussed preparation technique does not include any preferred finish line type (15). However, it is mandatory to remember that this technique aims to restore compromised teeth by means of metal-free bonded crowns with a uniformed tooth reduction (16). Cortellini et al. (17) reported no statistically significant differences in fracture strength values between disilicate lithium crowns with either knife-edge or chamfer finish line after cycling loading. Nevertheless, the knife-edge finish line transferred slightly higher stress values on the roots than the chamfer finish line.

CONCLUSIONS

Within the limitations of this *in-vitro* study, the AFG preparation technique is a reliable and predictable option when full-crown coverage is needed to restore compromised teeth.

Author contributions

Conceptualization: CL, PC and DS; methodology: CL; validation: DS, PC and CL; formal analysis: CA; investigation: CL; resources: AP; data: VM; writing and original draft preparation: PC; writing, review and editing: CL; visualization: AL. The authors declare no conflict of interest.

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Case Report

PHOTO-BIO-MODULATION AND BIO-ENGINEERING TO PROMOTE THE REGENERATION OF PERI-IMPLANT SOFT TISSUE: A CASE REPORT

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ABSTRACT

Several factors compete for both achievement and the long-term maintenance of osseointegration; among these, of importance is the width and integrity of the peri-implant soft tissue. Many authors have already underlined the importance of maintaining a good biological seal with a low bacterial loading for achieving long-term success in implant-prosthesis rehabilitation. The aim of this work is to present, through a clinical case, a new technique that focuses on the regeneration of soft tissue around an implant inserted in a post-extractive socket. A post-extractive implant surgery was performed in an inferior molar site in conjunction with three-dimensional collagen matrices, equine spongy bone granules, and dye-free photodynamic therapy. This combined technique allows the creation of new gingiva around the implant.

KEYWORDS: *Soft tissue, regeneration, dental implant, laser, photobiomodulation.*

INTRODUCTION

The surgical technique for inserting dental implants has a rigorous protocol to ensure predictable results since the nineties (1). However, surgical protocols are changing nowadays since clinical evidence contrasts with what was thought previously.

Several factors compete for both the achievement and the long-term maintenance of osseointegration; among these, of paramount importance is the width and integrity of the peri-implant soft tissue. Many authors have already underlined the importance in implant-prosthesis procedures to have a good biological seal and a low bacteria loading around fixtures to have a healthy periodontium (this is also valid for a natural tooth with an undamaged periodontium) (2).

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When an implant is inserted, a second surgery is needed to place a trans-mucous element (i.e., the healing cap). Then the body adapts to create a barrier that avoids bacteria from entering. The mucous surrounding the implant is then covered in keratinized tissue supported by supracrestal connective tissue, which mimes the periodontium structure (2, 3); this structure is called biological width.

Once this concept was recognized and supported by clinical studies, new techniques were introduced to improve the prosthetic procedures, such as gingiva translation or roll-flap technique, to keep part of the gingiva around the implants or to increase its thickness. These techniques are usually employed during implant insertion (4, 5).

The lack of quality and quantity of the peri-implant soft tissue is generally due to bone loss in the same area. The bone loss can be restored before or while the implant is placed with reconstructive interventions to restore the normal bone morphology (6). If a wrong evaluation of initial clinical parameters is done or the implant is wrongly placed, bone loss and the subsequent collapse of soft tissues happen during the healing phase; the outcomes will be evident in the second surgical phase (7, 8).

In these situations, the second surgical phase becomes an important step because the correct use of soft tissue could cover the underneath bone loss (9-11). This work describes a new technique of soft tissue regeneration combined with a laser protocol without thermal stresses.

Fig. 1. *Initial Orthopantomography.*

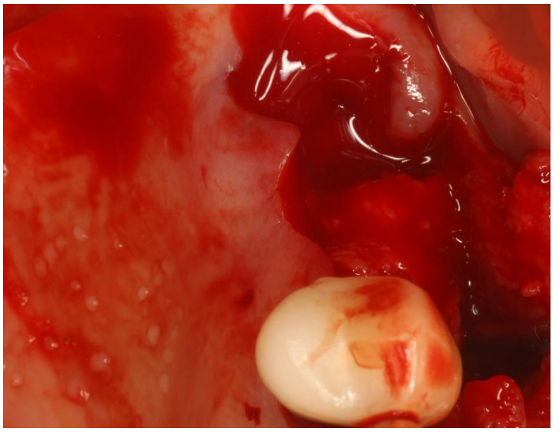

Fig. 2. *Post extractive alveolar sack.*

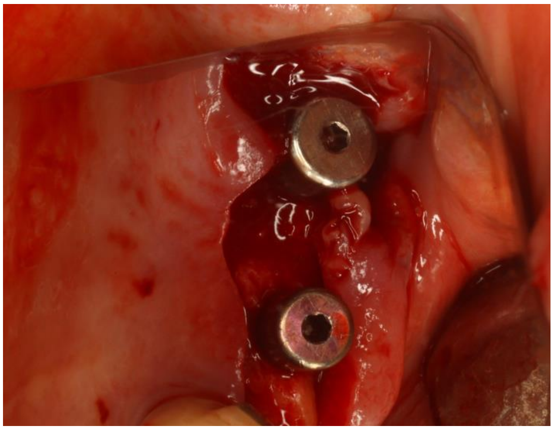

Fig. 3. *Atraumatic detachment of tissues and implants insertion.*

CLINICAL CASE

The patient M.M., 47 years old, had a clinical evaluation for a grade 2 mobility and percussion sensitivity of the 2.6 tooth (Fig. 1). At the probing test, a buccal bone loss on the mesio-vestibular root of 2.6 was detected. In the orthopantomography, radio-transparent damage on the mesial and palatal roots was evident. The patient was examined both from a prosthetic and surgical point of view to obtain the best esthetical and functional rehabilitation. After evaluating different therapeutic options, it was choosen to extract the element, replace it with two implants, 2.5 (already missing) and 2.6, and regenerate the tissue using a collagen matrix and equine granular biomaterial. The patient was informed and signed a written consent form. Treatment was performed in accordance with the Declaration of Helsinki of 2013.

Surgical protocol

After root separation and atraumatic extraction, we came across bone loss, and the alveolar sack was removed without damaging the papilla (Fig. 2). Flap was elevated at 2.5 in an atraumatic manner (Fig 3). Afterward, the surgical site was irrigated with SiOxyl+

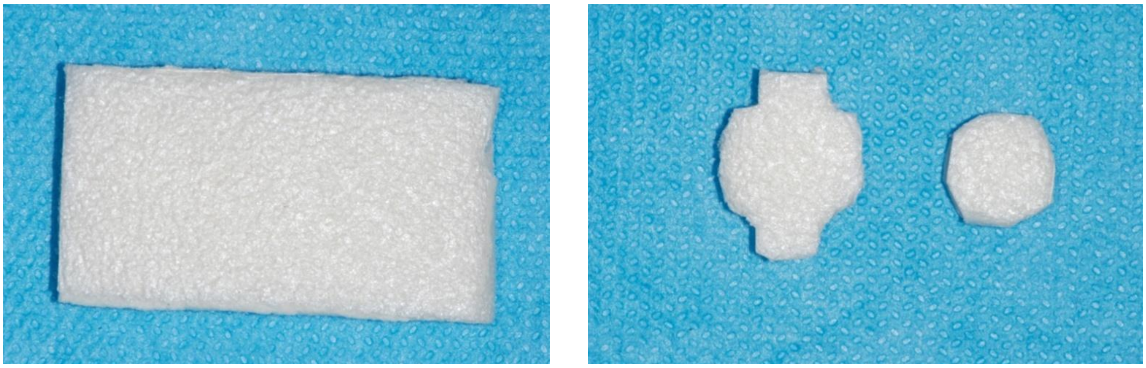

Fig. 4. *(**a**): Three-dimensional collagen matrix (Bioteck); (**b**): three-dimensional modeled collagen matrix (Bioteck).*

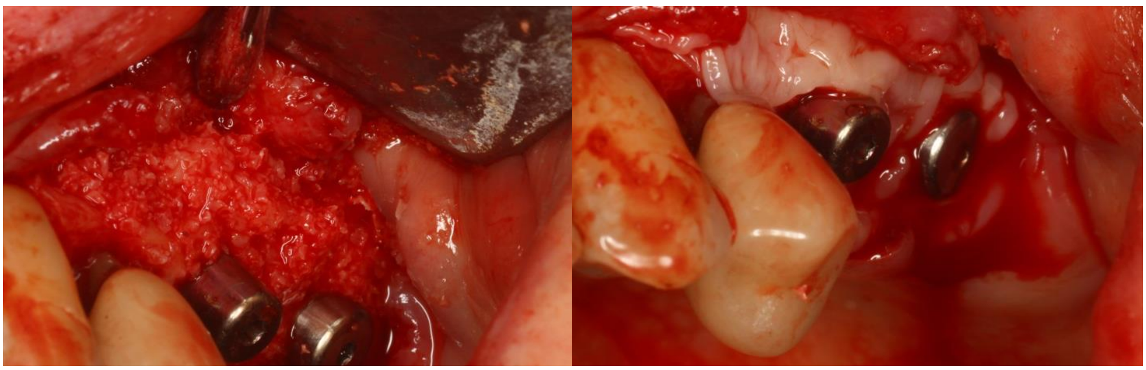

Fig. 5. *(**a**): In situ implants, heterologous biomaterial placed in surgical site; (**b**): Collagen matrix inserted in the buccal portion.*

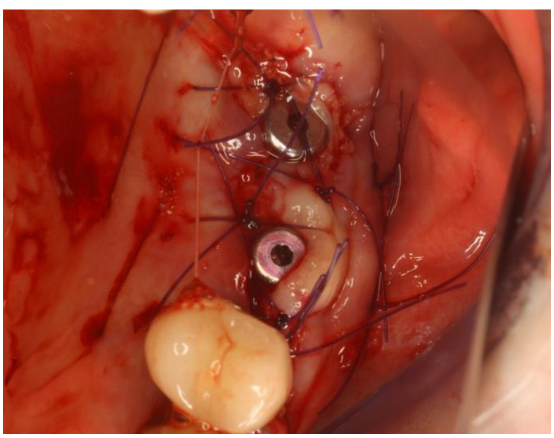

Fig. 6. *Suture.*

Fig. 7. *Healing evaluation after 7 days: occlusal view..*

solution, and a diode laser irradiated for 60 seconds the cavity (2,5 W Peak Power, 0,5 W Average Power, T-on 20 micron, T-off 80 micron, Frequency 10.000 Hz, tip 400 microns), in order to decontaminate the area and to improve the bone regeneration.

Implants were then inserted, guided prosthetically (Intralock 4.0 mm, 13 mm height), and the alveolar sack was filled with heterologous biomaterial (OX Bioteck, Vicenza, Italy). Two little wings modeled the collagen matrix: the first oval, which is cork, the second has an oval shape, and two wings, which are then placed between detached periosteal and bone (Fig. 4).

The buccal wing is shut down to cover the bone loss over the extracted medial root, previously probed (Fig. 5). The matrix is stabilized with a suture (Fig. 6). After seven days of healing (Fig. 7), a strip of soft tissue spreads through the superior portion of the matrix. This phenomenon is remarkable after 3 months (Fig. 8). At the end of the healing process, good quality and quantity of soft tissue around the implants were gained without any additional intervention.

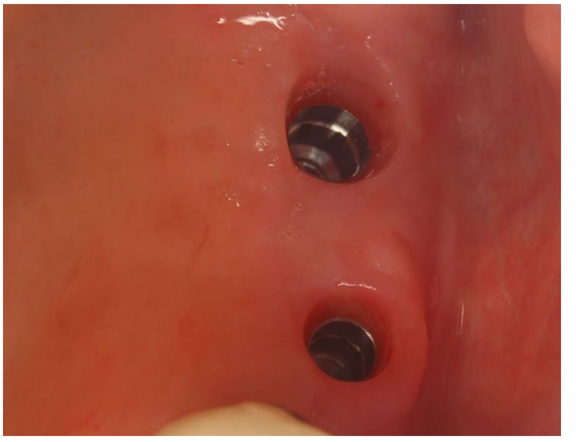

Fig. 8. *Healing evaluation after 3 months: occlusal view.*

Prosthetization

An X-ray was made after 3 months (Fig. 9). Then, a precision impression was obtained using an individual impression tray. A titanium stump with a shoulder height of 1 mm was then realized with a prosthetic crown made of zirconia-ceramic (Fig. 10).

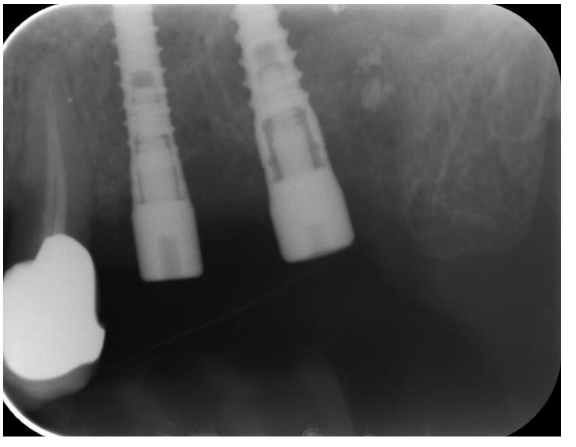

Fig. 9. *An X-ray was carried out after 3 months.*

DISCUSSION

The possibility of regenerating lost tissues is well known in Dentistry. Two types of tissue regeneration are known: Guided Bone Regeneration (GBR) and Guided Tissue Regeneration (GTR). They are considered the starting point of tissue engineering (TE). GBR is used for bone regeneration so that a patient will need a second surgery to graft soft tissues; GTR is the regeneration of the entire periodontium (cementum, periodontal ligament, alveolar bone proper, and gingiva).

It is also to be considered that the matrix, absorbable or not, must be entirely covered by the gingiva to avoid an unsuccessful outcome (12). Generally speaking, TE aims to achieve soft tissue regeneration. Several types of tissues can be regenerated with TE starting from mesenchymal stem cells (MSC), and indeed this is one of the most promising frontiers in biomedical research. However, when MSC are used, no regenerative procedures at the periodontal level offer predictable clinical results till now (13). Moreover, time is longer in TE because it needs several steps like cell-factory to isolate, expanse, and differentiate (in a cell factory), to replace missing tissues (14).

Fig. 10. *Definitive ceramic prosthesis.*

This report is based on the nature of the human body: during a person's life, the organism needs to continuously generate new cells to replace lost, old or damaged tissues. Stem cells guarantee tissues' homeostasis: they can selfrenovate and generate progenies which differentiate and become tissues. Besides, MSC are the main actors during the healing process.

This process is easy to observe in epidermis wounds: the skin is a system with a high regenerative capacity and is considered the best tissue for studying the regenerative role of the stem cells. Combining this procedure with a laser protocol gets a better soft and hard tissue regeneration (15-16) and decontamination of the surgical site (17-21).

Heterologous collagen was used to fill bone gaps. This material can be used in the wound while rebuilding to favor the tissue healing process. The matrix is the starting point of neovascularization and new tissue formation. It is well tolerated by the organism and replaced by the new tissue. Furthermore, collagen can be used in case of substantial bone tissue loss when a spongy bone transplant is not possible. This material plays a fundamental role in the reparative process and can improve the surgeon's everyday practice. This technique allows the surgeon to create new gingiva around an implant easily.

Regarding bone substitutes, they have to be of a biological matrix; the presence of native collagen makes bone substitutes a perfect base for regeneration. This matrix contains all characteristics that have been described by Hardwick et al. in 1994 (9):

biocompatibility: they need to be made with materials that will not trigger cytotoxic and/or immunogenic reactions;

occlusive: avoiding connective tissue and bacteria to go under it but allowing at the same time nutrients to pass through it and reach the blood flow;

integration in a different tissue;

space maintenance: stabilization of blood cloth with the subsequent tissue regeneration;

easy to handle: to help the surgeon deal with different anatomic situations.

CONCLUSIONS

This case report demonstrates that secondary surgery could be avoided (i.e., soft tissue grafting). In addition, the surgeon can stimulate bone regeneration, effectively reducing the treatment period and the patient's discomfort.

Author Contributions

GC designed the research study. GC performed the research. PC and GC wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

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Conflict of Interest

The authors declare no conflict of interest.

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Case Report

COMPUTER-GUIDED IMPLANT PLACEMENT AND IMMEDIATE LOADING: A CASE REPORT

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ABSTRACT

3D computerized implant planning has become an important diagnostic and therapeutic tool in the dentistry of the new millennium. This case report illustrates how the combination of virtual planning and guided surgery allow implant insertion and immediate loading with fixed prostheses. Computer-assisted implantology, including three-dimensional virtual implant planning, guided surgery and CAD / CAM fabrication of provisional and final restorations, enabled a precise and reproducible treatment workflow with predictable aesthetic and functional results in this case of full maxillary arch rehabilitation. The combination of immediate implant placement and immediate loading was considerably more complex and required a high level of organization between the implantologist, technician and patient. After using a tooth-supported surgical guide and subsequent extraction of supporting teeth, a fixed prosthesis was delivered.

KEYWORDS: *guided surgery, implant, fixture, loading, immediate*

INTRODUCTION

Computer-assisted implantology is one of the greatest innovations of modern implantology. It simplifies surgical implant insertion and avoids anatomo-functional intraoperative complications such as injury to the nerve, sinus perforations, fenestrations or dehiscence (1–4). These objectives are reached thanks to an accurate instrumental diagnosis using advanced technologies such as computed tomography (CT) and computer planning. The ideal implant positions from a prosthetic point of view can be virtually planned with the help of guided surgery software that allows three-dimensional visualization before implant surgery (2, 5, 6). The innovation consists of the possibility of transferring the virtually planned implant position into the real clinical situation through a surgical guide (3, 7). Although the current state

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of 3D technology is advanced, inaccuracies in implant placement may still occur; it depends on various factors such as incorrect anatomical support of the template (bone, mucosa, teeth, implants), some intrinsic factors of the surgical guide (diameter tolerance between drill and guide, wrong manufacturing) and human-related factors during the digital workflow (7). Through computer-guided implantology, the immediate positioning of the implant after tooth extraction and the immediate loading of the implant with a fixed temporary reconstruction allows the patient to solve the aesthetic and functional problems during time of osseointegration. Furthermore, in guided surgery protocols, postoperative morbidity is significantly reduced compared to traditional surgery. With the following case we demonstrate the feasibility of immediate implant placement and loading approach by rehabilitating a patient with partially edentulous maxilla.

CASE REPORT

The 72-year-old patient coming to our clinic with grade III mobility on the residual teeth in the upper arch, horizontal bone loss, destructive caries (Fig. 1-2). The patient, a smoker without allergy reported, has hypertension and chronic atrial fibrillation. A direct approach to the jaw was followed. The diagnosis, the decision tree and the therapeutic approach are based on clinical examination and detailed three-dimensional virtual planning of implant insertion. Initial panoramic radiography revealed a good amount of crestal bone that could be proper to the insertion of more implant units. Various treatment options have been proposed to the patient, including a removable dental prosthesis. Finally, it was decided for a fixed prosthesis with immediate loading. A cone beam computed tomography (CBCT) was performed not only to obtain a precise diagnosis but also to produce a maxillary template and surgical guide (Fig. 3). Based on the anatomical conditions and the prosthetic planning, six implants were virtually planned using RealGuide 3.0 software in positions 16, 14, 12, 23, 25, 27 (Fig. 4-5). A temporary fixed dental prosthesis was prepared on the basis of the same digital file before surgery. To improve the stability of the template, 3 vestibular anchoring pins were inserted. The day of surgery, a single dose of antibiotic (2 g amoxicillin and clavulanic acid) was administered one hour before surgery according to international guidelines. An oral cavity asepsis was performed with clorexidine 0.2% for one minute. Local anesthesia was induced using a 4% articaine solution with 1:100,000 epinephrine. The two-stage approach included guided flapless insertion of the six Prama implants (Sweden & Martina, Padua, Italy) with a surgical guide supported by teeth 25 and 13. (Fig. 6). The template was then removed and the two residual supporting teeth were extracted. Then a new surgical guide was dressed to patient a the remaining implant inserted. All implants were placed with a torque of 48 Ncm and had good primary stability (Fig. 7). After removal of the surgical guide, the standard titanium abutments were mounted on the implants with a torque of 15 Ncm (Fig. 8). The post-operative panoramic radiograph (OPT) showed the parallel axes of the six implants (Fig. 9). The provisional prosthesis was mounted and spaces between abutments and prostheses were filled with dual composite resin (Fig. 10). The occlusion required only minor adjustments due to careful digital preoperative planning. After six months fixtures successfully osseointegrated without complications. The provisional prosthesis was disassembled and a conventional impression was taken to fabricate the final prosthesis. Oral mucosa was healthy. The final prosthesis in cobalt-chromium and composite veneer material was screwed in with 25 Ncm and the screw access area was covered with composite material. The patient followed a regular maintenance program. Healthy mucosal conditions and stable peri-implant crestal conditions were observed at the one-year follow-up appointment.

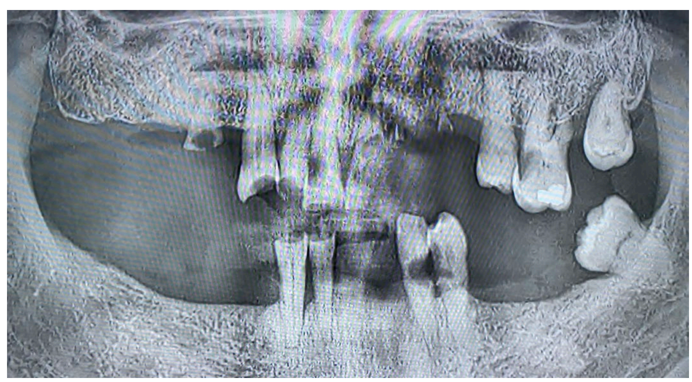

Fig. 1. *Pre-operative RX orthopantomography: the radiography demonstrates an unstable and compromised situation of the dental elements present in the arch.*

DISCUSSION

Computer-assisted implantology allowed precise, guided and immediate positioning of implants and proved to be particularly advantageous in the presented case to restore maxillary arch (8-14). The

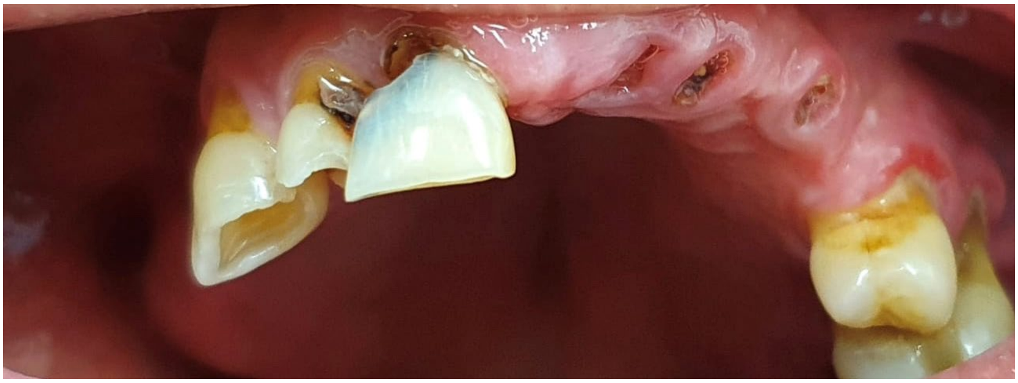

Fig. 2. *Pre-operative maxillary arch: objective examination shows destructive caries, retained root residues, dental elements with a high degree of mobility.*

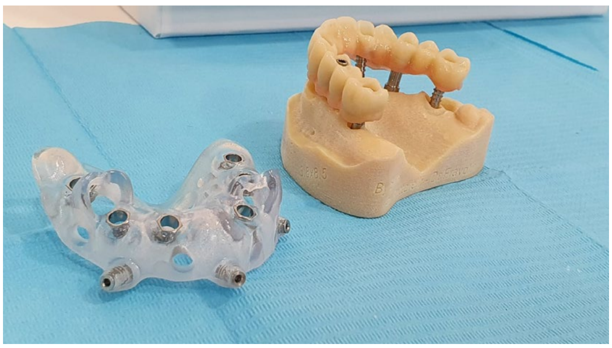

Fig. 3. *Surgical intervention components: surgical guide, pmma screw-retained prosthesis. The surgical guide has mixed dental and mucous support. It also has 3 pins to increase stability. The temporary prosthesis will be screwed on the temporary abutments.*

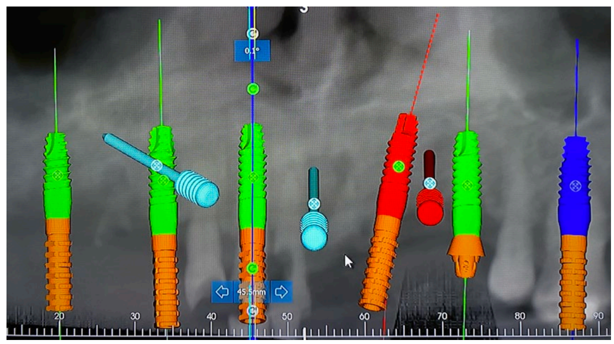

Fig. 4. *Guided implant design: CPR section. Placement of 6 transmucous implants. In position 2.3 a post-extraction has been chosen. The red color in the design phase confirms the surgical type of this implant.*

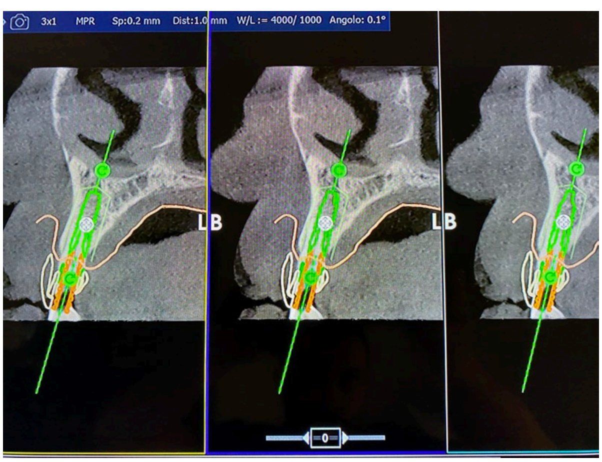

Fig. 5. *Guided implant design: cross sections: the correct position of the implant between the two corticals is confirmed.*

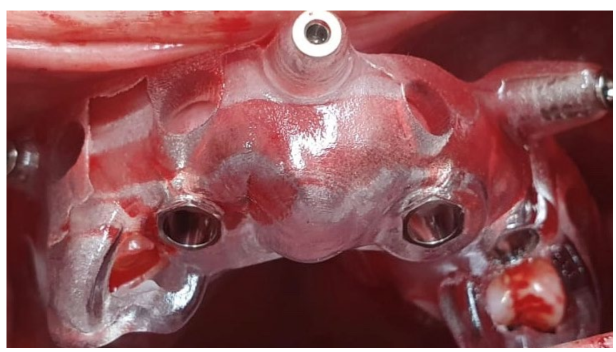

Fig. 6. *Intraoperative procedure: surgical guide positioning.*

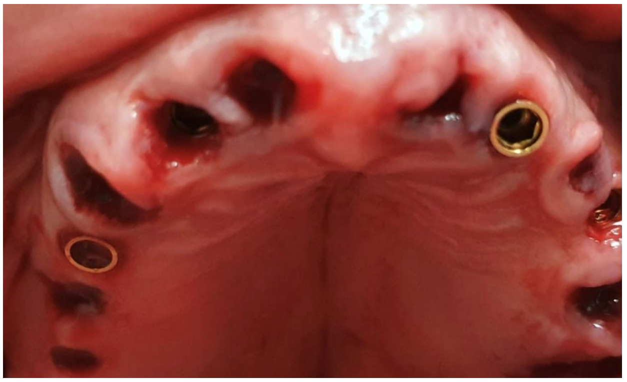

Fig. 7. *This intraoperative photo demonstrates the efficiency of the guided technique: the implants are inserted in flapless mode, which significantly reduces damage to the bone cortical.*

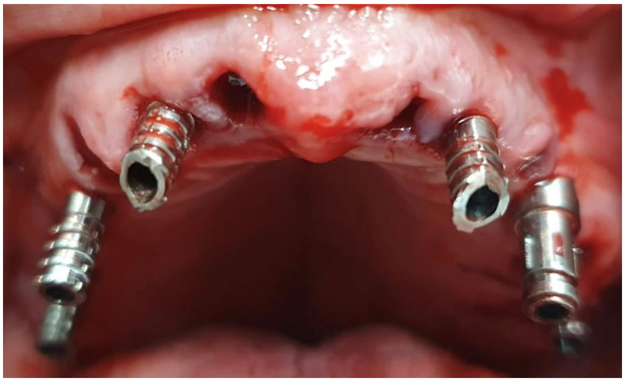

Fig. 8. *Positioning and intraoperative screwing of temporary abutments: the prosthesis is then positioned on the abutments, the occlusion is registered and then abutments are screwed with a torque of 35 n.*

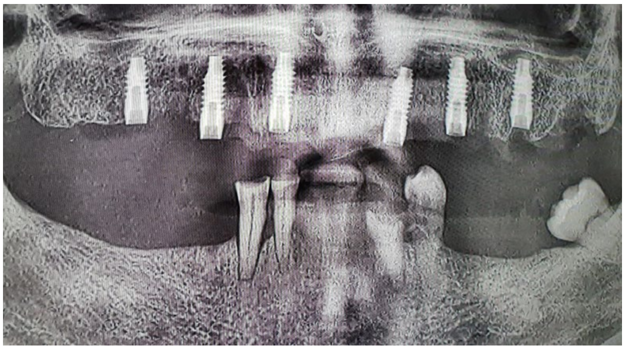

Fig. 9. *Post-operative RX orthopantomography.*

Fig. 10. *Final situation: screw-retained prosthesis in PMMA.*

significantly more complex combination of immediate implant placement and immediate loading required a high level of organization between implantologist and technician, minimizing patient compliance. Previously Pozzi et al. (15) is obtained excellent results with CAD/CAM zirconia bridges on immediately loaded implants inserted with computer-assisted / template-guided surgery. Several investigated factors that primarily influence accuracy in implant were analyzed as well as effectiveness of prosthetic rehabilitation after guided implant insertion (16-18). Preoperative communication between dentist and technician during the decision and planning phase is essential save time in the clinic, ensuring the highest surgical and prosthetic level performance. This case report supports the need for flapless surgery, optimal implant placement and immediate loading, as summarized in a recent review of randomized controlled trials (19).

CONCLUSION

The reported case highlights how the use of 3D software for planning implantology is predictable and repeatable. It fulfils the aesthetic and functional patient's requests.

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