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Review

THE BONE-IMPLANT CONTACT AND OSSEOINTEGRATION OF DIFFERENT IMPLANT SURFACE TREATMENT: THE FINDINGS FROM A SYSTEMATIC REVIEW OF LITERATURE

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ABSTRACT

The dental implant is associated with high long-term predictability for fixed rehabilitation in edentulous patients. The aim of the present review was to evaluate the state-of-art of dental implant surface treatment and their effect on osseointegration. The Pubmed/Medline, EMBASE, Cochrane Library databases has been screened to identify the histologic studies regarding the dental implant surfaces *in vivo*. The screening process revealed a total of 3173 papers with a total of 24 articles obtained by the manual search. A total of 482 duplicates have been removed and 2691 papers were assessed for the full-text evaluation. A total of 2527 articles were removed after the eligibility process and 149 articles were evaluated for the descriptive analysis. The implant osseointegration process is a complex combination of events that is oriented to an intimate interface between the dental implant surface and the host peri-implant tissues that oriented to produce a functional ankylotic relationship between the components under the masticatory loading.

KEYWORDS: *implant, fixture, surface, osseointegration, bone*

INTRODUCTION

The dental implant osseointegration represents the turning point for edentulous ridge rehabilitations due to the more

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recent advances in titanium biocompatibility, enhanced surface treatment and novel high hydrophilic/bioactive materials (1), with a long-term implant success rates over 90% (2). The osteoconduction process is involved with the recruitment and migration of osteogenic cells to the implant surface determines the early events correlated to the dental implant osseointegration. This phase produces a mineralised osteoid matrix deposition representings the main non-functionalised new bone formation at the level of the bone-implant interface. These events are strictly correlated with several factors including the dental implant microtopography (3). Other key factors are represented by the implant material, macro design, surface chemistry, bone density, surgical technique, and implant loading protocol (4). In literature, the bone-implant contact (BIC) percentage represent one of the most reliable parameter for dental implant osseointegration, while values >50% are considered optimal for a long term stability findings (5). On the contrary, the main disadvantage of this parameter is dynamic and could potentially vary over time. In addition, the BIC% is a bidimensional parameter that could be determined only with retrieved biopsies and is not replicable.

Also, the torque removal force has been suggested as an additional technique to assess the implant anchorage for research purposes evaluating the biomechanical behaviour of osseointegration (6). In this way, the roughness of a surface is one of the major factors contributing to implant stability, based on the assessment of the surface peaks and valleys. For this purpose, the arithmetic mean height deviation from a mean bi-dimensional plane (Ra); the Sa is considered in the case of a three-dimensional evaluation (7). The "osseointegration" concept was introduced by Branemark et al. (1) as the direct contact between living bone and a functionally loaded implant surface without interposed soft tissue at the light microscope level (8).

Today, titanium is the most common material for dental implants due to its low weight, high strength/weight ratio, low elasticity modulus, corrosion and wearing resistance, and biocompatibility (9). The most frequent titanium alloy (Ti6Al4V) is composed of 6% of aluminium and 4% vanadium (10). Lincks et al. (11) reported that the osteoblasts-like cells responded differently to cpTi and Ti6Al4V materials due to the alloy mosaicism and the surface chemistry. A passive surface oxide film around the titanium core (12) determines the interface generation between the titanium surface and the surrounding hard tissue. The oxide layer produces hydroxyl functional groups when exposed to the air environment (13). The hydroxyl functional groups dissociate when exposed to body fluid to generate an electric charge that is correlated to the pH of the fluids (13). In this way, the point of zero charge of rutile is 5.3, while the anatase point of zero charge is 6.2 (14, 15). The TiO2 shows reported a neutral property. The hydroxyl concentration of TiO2 is relatively large, representing an advantage for the proteins and cytokines adsorption promotion (12). The machined surfaces of the implant device are provided only by decontamination after the turning procedure.

Various treatments were proposed to improve the surface properties, taking advantage of rough interfaces with high implant stability and the surface contact area (6, 16, 17). In addition, rough surfaces seem to be effective in improving the osteogenic cell's behaviour (18, 19), proliferation and differentiation (20, 21) due to the release of signal mediators, transforming growth factor beta, and prostaglandin E2 (PGE2) (21-24). The optimal roughness for dental implant surfaces range is approximately 1.5 μm (25). Several methods have been suggested, such as modified surfaces, additive coating protocols, and subtractive methods, while today, the optimal surface type has not been defined. The present systematic reviews aimed to investigate the recent updates of bone-implant contact (BIC) effectiveness of different implant surface treatments.

MATERIALS AND METHODS

Article search methodology

The screening phase was conducted according to the Standards for Reporting Qualitative Research principles (SRQR) and the PRISMA guidelines (26). The selection was based on a keyword strategy synthetised in Table I.

Table I. *Boolean search and keyword strategy.*

	Search Strategies
Keywords	Advanced keywords search: ((dental AND (implant OR implants OR implantation OR implantology) AND (surface OR surfaces OR surface topography) AND (Histo*))
Databases	Pubmed/Medline, EMBASE, Cochrane Library

The papers' title and abstracts were assessed for an initial screening, and the manuscripts were limited to histological studies with bone-to-implant contact (BIC) outcomes. The full texts were finally collected and evaluated to assess the eligibility for the descriptive analysis.

Inclusion and exclusion criteria

The inclusion criteria for the eligibility synthesis were limited to histological studies that assessed bone-to-implant contact (BIC) outcomes from 1995 to today. The exclusion criteria were systematic and literature reviews, letters to the editor, *in vitro* and laboratory simulation, pilot studies, preliminary reports, no loading outcomes and early follow-up. The articles written in non-English language were excluded from the review.

RESULTS

Screening process

The electronic database identification process revealed a total of 3173 and 24 articles screened trough a manual search. A total of 482 duplicates have been removed from the articles list, and 2691 articles have been submitted for the full-text screening process. A total of 2527 papers were excluded for the following reasons: 1302 for the wrong outcome, 668 for the wrong device, 259 for wrong study design, 147 for wrong publication type, 101 written in a foreign language, 34 for wrong study duration and 16 for the wrong study population.

Sandblasted surfaces

The sandblasting procedure was proposed by sandblasting the metal surface with gritting agents. The number and rotations speed, the flux pressure, and the granulometry of the agent particles (10, 27) determine the treatment. The sandblasting procedure increases the surface irregularity and the implant biomechanical characteristics. The most common sandblasting agents are aluminium oxide/alumina (Al2O3) and titanium oxide (TiO2). The primary studies concerning the sandblasted surfaces are summarised in Table II. The procedure can influence the adhesion, proliferation, and differentiation of osteoblasts (20, 28).

Moreover, the fibroblasts result in a more difficult adhesion to the implant surface and a lower soft tissue proliferation around the implant in favour of the new bone formation (27, 29). Using surfaces blasted with Al2O3 particles was investigated compared to turned titanium surfaces. In the literature, the sandblasted implants showed higher BIC than the machined (30). In another study, the machined implants with Sa of 0.96 μm were compared to different blasting sizes, and after 12 weeks, all blasted surfaces demonstrated higher BIC compared with machined surfaces.

The blasting procedure leaves residual particles over the implant's surface, which can modify the bone healing process. Some authors support that the presence of remaining particles may benefit osseointegration, catalysing this process (31); others support that aluminium ions are suspected to impair bone formation by a possible competitive action to calcium (32-35). TiO2 particle blasting was proposed to promote bone contact (27). Dental implants with TiO2 surface were compared to machined implants with a statistically significant higher removal torque compared to machined implants. No differences in BIC were detected (25). A combination of TiO2 blasted surface with fluoride ions has been proposed to improve the early osseointegration of dental implants (36). This method reported a bone-to-implant contact mean of >48% after 2 months of healing, which was higher than the blasting procedure alone (36).

At the same time, the precise nature of multinucleated giant cells is not thoroughly investigated, while a histological study suggested a priming effect on osteoblast activity similar to the hypothetic role of osteoclasts (37). Additional studies focus on sandblasted implants (38-40).

Plasma sprayed and plasma-chemical vapour surface

The plasma-sprayed treatments were studied in orthopaedics (41) and dental implants with no histological evidence of connective tissue infiltration at the interface level (42). Plasma-sprayed implants are obtained by spraying heat molten metal on the implant core, producing irregularly sized and shaped rounded particles and splats with valleys, pores and crevices (43). This treatment improves implant stability, bone growth (44), and higher surface contact area (10).

This treatment has been successfully investigated in rabbits (45), monkeys (46, 47), and humans (48-51), in different functional loading conditions (52). *In vivo,* no significant differences were detected between plasma-spray vs. machined implant, with a BIC percentage ranging between 55.9% and 56.2% (53). An alkali modification of the plasma-spraying

Table II. *Comparative studies which used sandblasted implants.*

Author	Implant surface	Results	Findings	Experimental design
Piattelli et al. (1998) [30]	**(1) Al_2O_3 blasted** **(2) Turned**	**BIC values** (1) 60%±1.4% (2) 51%±1.9%	The blasted sites presented BIC values statistically higher in comparison to turned.	Implants inserted in the femoral articulation of rabbits. Healing period: 8 weeks
Piattelli et al. (1996)[37]	**(1) Al_2O_3 blasted** **(2) Turned** **(3) Plasma-spray**	**ACP, ALP activity** **(1), (2) and (3)**	No MGS activity was reported for (1) and (2). At 2 weeks, Plasma spray revealed MGS activity.	Healing period: 2, 4 and weeks
Wennerberg et al. (1998)[38]	**(1) Al_2O_3 blasted** (25µm, 75µm, and 250µm particles) **(2) Turned**	**BIC values** (1) Ranging from 31 to 47% (2) Ranging from 18 to 23%.	Blasted surfaces demonstrated more bone in contact to implant surface compared to turned surface.	Implants inserted in the tibia of rabbits. Healing period: 12 weeks
Wennerberg et al. (1996)[31]	**(1) Al_2O_3 blasted** (25 µm particles) **(2) TiO_2 blasted** (25 µm particles)	**BIC values** (1) 49.2 % (2) 47.6 % **Removal torque** (1) 26.5 Ncm (2) 24.9 Ncm	No statistically different values concerning torque removal BIC values between the surfaces blasted with the same size of particles.	Implants inserted in the tibia of rabbits. Healing period: 12 weeks
Wennerberg et al. (1995)[25]	**(1) TiO_2 blasted** (25 µm particles) **(2) Turned**	**BIC values** (1) 40.9 % (2) 34.5 % **Removal torque** (1) 35.4 Ncm (2) 29.2 Ncm	BIC values were not significantly different between the implants. However, TiO_2 blasted implants demanded a statistically significant greater removal torque force than turned implants.	Implants inserted in the tibia of rabbits. Healing period: 12 weeks
Gotfredsen et al. (1992)[39]	**(1) TiO_2 blasted** (10-53 µm particles) **(2) Turned**	**Removal torque** (1) 150 Ncm (2) 60 Ncm	BIC not significantly difference (data not shown), but, blasted implants presented higher removal torque values in comparison to turned sites.	Implants were immediately placed, in dogs. No prosthetic rehabilitation was performed. Healing period: 12 weeks
Ivanoff et al. (2001)[40]	**(1) TiO_2 blasted** (25 µm particles) **(2) Turned**	**BIC values** (1) 37 % (2) 9 %	The analysis of the results revealed a significantly higher BIC for the blasted implants than turned groups.	Microimplants were inserted in the ridge of 27 patients. Mean healing period ranging from 3.9 to 6.3 months.
Rocci et al. (2008)[36]	**(1) TiO_2 blasted** (25 µm particles) **(2) TiO_2 blasted with fluoride ions**	**BIC values** (1) 24.8 % (2) 48.3 %	The implant surfaces grit-blasted seems to produce a positive effect on osseointegration, the adding of fluoride ions could produce a sensible bioactive effect on the integration process.	A total of 7 implants positioned in human mandible. Mean healing period 8 weeks.

technique by sodium hydroxide solutions at 40°C for 24 h can determine an oxide layer Ra = 17.6 μm) and 20 nm thickness (44). The main reported disadvantage of plasma-spray is the detachment of titanium after implant insertion. Franchi et al. (54) reported the particle detachment of plasma spray, sandblasted and acid-etched, and machined implants in sheep. The authors reported that the titanium particles were detected only in plasma-sprayed implants. This phenomenon can be related to the friction between the implant surface and host bone cavity during implant placement, but its implications are unclear. Recent non-thermal and argon-based plasma applications have been proposed for dental implants, reporting no significant changes in new bone formation compared to sandblasted dental implant (55-58).

On the contrary, a significant increase in argon-based plasma-spray implant-bone contact was reported by Qiao et al. compared to sandblasted and acid-etched fixtures (59). Several studies increased the new bone formation of hybrid titanium-zirconia dental implants obtained through a novel plasma spray technique (60, 61). The microwave plasma-chemical-vapour deposition (MWP-CVD) of diamond-coated Ti-Al6-V4 dental implants compared to Ti-Al6-V4 implants have been investigated (62, 63). No differences in BICs, delamination, or particle-dissociation due to shearing forces have been detected (62).

Acid-etched surfaces

The acid-etch implant was proposed to avoid the residues released from sandblasting, a non-uniform surface modification of the implant body (10). For this purpose, different acid-etching solutions have been proposed, such as chloridic (HCl), sulfuric (H2SO4), hydrofluoric (HF), and nitric (HNO3), in different combinations. The acid-etching process effectiveness is by the baseline roughness, acid composition, temperature, and etching time. The histologic assessment results have been evaluated in Tables III and IV. A study compared two different etching of solution HCl and H2SO4, reporting that the surfaces presented a homogeneous distribution of small 1-2 μm peaks and valleys and a removal torque 4 times higher for acid etched (6). The dual acid-etched procedure was proposed to obtain a macro- and micro-texture of the titanium surfaces (6) and higher platelet and osteogenic molecular signals (64, 65). Degidi et al. (66) reported histologically a mean BIC percentage of 61.3%, with no gaps or fibrous tissues present at the interface. Similar BIC results were reported after four months of healing on non-loaded implants (67).

In immediate loading protocols, the mean BIC levels ranged between 78% and 85% in vivo in humans (68). In the posterior maxilla after 6 months of healing, the BIC values of dual acid-etched sites were statistically higher than in turned sites (~70%) (69). Different acid concentrations were evaluated by Cho et al. (70), reporting a removal torque for dual acid-etched implants statically higher compared to the machined surface. The removal torque of 2mm diameters triple-etched micro-implants has been investigated by Pontes et al. (71), who reported an increase of the strength resistance >6Ncm after 8 weeks of healing. In a sheep study, Jinno et al. (72) reported that the dual-acid etch technique produces similar BIC findings to dual etching-sandblasting surfaces. Some authors associated the main findings for bone response to the dental implant macro-geometry (72-74). Halldin et al. reported that nano- and microtopography indicted by dual etching can potentiate the initial biomechanical behaviour, while for a more extended osseointegration period, the surface interlocking capacity seems more effective (75). On the contrary, several studies reported that the roughness scale seems to be effective for new bone formation (76, 77).

A similar outcome was reported by Yoo et al. that highlighted higher BICs and removal torque resistance of dual-acid etched implants compared to grit blasted/acid etch with low bone remodelling rates (78). Also, others obtained similar results (79).

Sandblasted and acid-etched surfaces

The combination of sandblasting and acid-etching technique has been suggested to produce uniform scattered gaps and hole distribution and slightly less rough than the plasma-sprayed surface, which is characterised by profoundly irregular micro-texture and less favourable substrate for cell proliferation (80). The histological studies have been summarised in Tables V and VI. Higher torque removal values of sandblasted/acid-etch surfaces have been reported (+75%-125%) compared to acid-etched implants (81). Abrahamsson et al. (82) reported that the BIC values in dogs were significantly higher in sandblasted/acid-etched implants compared to machined surfaces. Similar results were observed in the comparative evaluation of sandblasted/acid-etched compared in plasma-sprayed implants(83). Sandblasted and acid-

Table III. *Comparative studies which used acid etched and plasma-sprayed implants.*

Author	Surface treatment	Results	Findings	Experimental design
Klokkevold et al. (1997)[6]	**(1) Acid-etched** (HCl / H_2SO_4) **(2) Turned**	**Removal torque** (1) 20.50 Ncm (2) 4.95 Ncm	The resistance to torque removal was 4 times greater for acid etched implants in comparison to the turned surfaces.	Implants were inserted in the femur of rabbits. Healing period: 2 months
Cho et al. (2003)[70]	**(1) Acid-etched** (HF and HCl / H_2SO_4) **(2) Turned**	**Removal torque** (1) 34.7 Ncm* (2) 15.2 Ncm	Dual acid etched implants required a higher removal torque average force than the turned surface implants.	Implants were inserted in the tibia of rabbits. Healing period: 12 weeks
Weng et al. 2003[67]	**(1) Acid-etched** (Osseotite®) **(2) Turned (ICE®)**	**BIC values** (1) 62.5 % (2) 39.5 %	BIC values were significantly higher in dual acid-etched sites in comparison to turned sites.	Implants were inserted in areas with poor bone quality in the mandible of dogs. Healing period: 4 months
Klokkevold et al. (2001)[79]	**(1) Acid-etched** (HCl / H_2SO_4) **(2) Plasma-spray** **(3) Turned**	**Removal torque** (1) 27.40 Ncm (2) 59.23 Ncm (3) 6.73 Ncm	Statistically significant differences were observed between acid-etched and turned implants, and between plasma-sprayed and turned implants. However, differences between acid etched and plasma-sprayed were not statistically different.	Implants were inserted in the femur of rabbits. Healing period: 3 months**
Pontes et al (2015) [71]	**(1) Triple Acid-etched**	**Removal torque** (1) 3.3 ± 1.7 Ncm (2) 2.2 ± 1.3 Ncm (3) 6.7 ± 1.4 Ncm	The triple acid etching can create a promising and efficient surface for the process of osseointegration.	Healing period: 8 weeks Implants were inserted in rats.
Rezende de Jesus et al. (2017) [73]	**(1) Acid-etched** **(2) Sandblasted and Acid-etched**	**BIC values** 2 weeks (1) 19.57±13.57% (2) 20.33±7.99% 4 weeks (1) 40.25 ± 9.45% (2) 42.80± 4.48%	Bone-to-implant contact and BD increased with time in both surface treatments implants	Implants were inserted in dogs Healing period: 2 and 4 weeks.
Carr et al. (2000)[53]	**(1) Plasma-spray** **(2) Turned**	**BIC values** (1) 55.9 % (2) 56.2 %	No significant differences could be observed between groups concerning the BIC percentage.	Implants were inserted in the mandible of baboons. No prosthetic rehabilitation was performed. Healing period: 6 months.

etched surfaces reported increased osteoconductive cell proliferation characteristics compared to plasma-spray implants (80, 84, 85). The histological findings of sandblasted/acid-etched reported after six months of healing in humans a mean BIC of 76.6 % (86). After 40 months, a 75.4 % BIC mean was observed on retrieved human implants (87).

Some studies reported sufficient bone volume and density that sandblasted/acid-etched surfaces can present a success rate of 99 % after two years (88). The combination of acid-etching and ZrO2 particles sandblasting produces an increased bone deposition compared to plasma-sprayed and machined implants (54). Several authors reported that the depth and distribution of irregularities, the cavity morphology, and contaminating elements derived from the treatment procedures

Table IV. *Histologic studies in which acid etched implants were retrieved from humans.*

Author	*Surface treatment*	*Results*	*Findings*	*Experimental design*
Testori et al. (2001)[68]	**Acid etched** (Osseotite®)	**BIC values** ranging from 78% to 85%	Implants were successfully used in immediately loaded protocol.	Histologic analysis of two retrieved immediately loaded implants. Healing period: 4 months.
Degidi et al. (2003)[66]	**Acid etched** (HCl and H_2SO_4)	**Mean BIC value** 61.3%	No gaps or fibrous tissues were observed at the interface.	Histologic analysis of two retrieved implants. No prosthetic rehabilitation was performed. Healing period: 6 months.
Trisi et al. (2002)[69]	**(1) Acid etched** (Osseotite®) **(2) Turned**	**BIC values** (1) 72.35 % (2) 35.32 %	BIC values in dual acid-etched sites were statistically higher than in turned sites.	Histologic analysis of implants inserted in the posterior maxilla of 11 patients. Healing period: 6 months.

play an important role in cell behaviour (89). In different animal study models, the sandblasted and acid-etched surfaces seem to produce in animals very similar BICs (~60%) compared to RBM, acid treatments and micro-arc procedures with no significant differences (90-96). At the same time, Marinho et al. reported a significantly higher new bone contact compared to the comparison of machined implant surfaces (97). Similar results were obtained by Buser et al. (98).

Nodized surfaces and micro-arc treatment

The oxidation technique has been proposed to modify the oxide layer properties and the surface biocompatibility (99), avoiding the deposit of grit particles (100). The anodised surfaces are obtained by a voltage application on the titanium surface in an electrolyte bath. The treated surface appeared with micro-pores of variable diameters without cytotoxicity (101). The removal torque of different thicknesses of anodised surfaces was investigated, which was significantly higher than that of smooth surfaces (99).

In the rabbit model, anodised, anodised and hydrothermally treated, and machined implants were investigated, reporting BIC values ranging between 40% and 50% and removal torque differences between the study groups (102). Authors reported that differentiation and calcification occurred on rough and smooth surfaces, indicating that the porous microstructure could enhance cell proliferation (43). In literature, it was demonstrated that the voltage for the anodising technique could produce a sensible influence on osseointegration properties, while the optimal value seems to be at ~550 V (103). In this way, the micro-roughness generated by anodic oxidation seems to significantly ameliorate BICs compared to sandblasted surfaces (104, 105) and machined implants (106). Moreover, using a super-hydrophilic surface of anodic oxidation implants has been proposed to potentiate this histological finding (107), while using biologically-derived triterpenoids adjuvant coating seems to produce no significant effect on this parameter 108).

In addition, the electrochemical anion sulphuric acid and phosphoric acid incorporation significantly affect BICs with an increase of ~200% histological bone contact (109). The micro-arc surface oxidation treatment has been proposed to improve the titanium dental implant. The biocompatibility of micro-arc oxidation has been tested by several authors, producing an acceleration and enhancement of the fixture's osseointegration (90, 110–113). Dundar et al. (90) reported similar BIC means (~60%) comparing different surfaces RBM, SLA, micro-arc, and sandblasted-micro-arc treatment with no significant difference.

Hydroxyapatite-coated surfaces and ceramic-coating implants

Hydroxyapatite implants have been studied to improve bone-implant fixation due to an increased osteoblast activity to this contact and adhesion, proliferation, and differentiation (114). Histological findings of hydroxyapatite implant

Table V. *Comparative studies that used sandblasted and acid-etched implants.*

Author	*Surface treatment*	*Results*	*Findings*	*Experimental design*
Abrahamsson et al. (2004)[82]	**(1) Sand-blasted and acid-etched** **(2) Turned**	-	BIC values (data not shown) were significantly greater in sandblasted and acid-etched sites than in turned surfaces	Implants were inserted in the mandible of dogs. No prosthetic rehabilitation was performed. Healing period: 1, 2, 4, 6, 8 and 12 weeks.
Marinho et al. (2003)[97]	**(1) Sand-blasted and acid-etched** **(2) Turned**	-	The SLA surfaces revealed a higher bone response vs. machined surfaces.	Implants were inserted in rats. Healing period: 5, 15, 30, and 60 days
Coelho et al (2011) [57]	**(1) alumina-blasting** **(2) biologic blasting** **(3) plasma** **(4) microblasted RBM** **(5) Sand-blasted and acid-etched (AB/AE)**	**BIC values** (1) 40.13± 2.54% (2) 37.23 ± 2.14% (3) 38.56 ± 2.49 % (4) 39.65± 2.27% (5) 38.72± 1.44%	No significant differences of BIC were detected at 4 weeks. An higher reoval torque was detected for RBM implants.	Implants were inserted in dogs. Healing period: 4, weeks.
Cochran et al. (1998)[83]	**(1) Sand-blasted and acid-etched** (250-500μm corundum particles, and etched with HCl / H_2SO_4) **(2) Plasma-sprayed**	**BIC values** (1) 71.68 % (2) 58.88 %	The sandblasted and acid etched implants had a significantly greater BIC percentage than did the plasma-sprayed. However, no qualitative differences in bone tissue were observed between groups.	Implants were inserted in the mandible of dogs. Loading period: 12 months Healing period: 15 months
Buser et al. (1999)[98]	**(1) Sandblasted and acid-etched** (0.25–0.50 μm particles, etched with HCl / H_2SO_4) **(2) Plasma-sprayed** **(3) Turned**	**Removal torque** (1) 1.43 Ncm (2) 1.54 Ncm (3) 0.26 Ncm	Statistically significant differences were observed between sandblasted and acid-etched and turned implants, and between plasma-sprayed and turned implants. However, differences between sandblasted and acid etched and plasma-sprayed were not statistically different.	Implants were inserted in the maxilla of miniature pigs. No prosthetic rehabilitation was performed. Healing period: 12 weeks*

**Data from the 1st and 2nd healing periods were not included in this table.*

Table VI. *Histologic studies in which sandblasted and acid-etched implants were retrieved from humans.*

Author	**Surface treatment**	**Results**	**Findings**	**Experimental design**
Hayakawa et al. (2002)[86]	**Sandblasted and acid-etched** (Straumann®)	**BIC value** 76.6 %	Bone surrounding the implant was uniformly and maturely structured.	Histologic analysis of one retrieved implant that was inserted in the palatal bone of the maxilla of a patient as anchorage for orthodontic treatment. Healing period: 6 months
Sakakura et al. (2005)[87]	**Sandblasted and acid-etched**	**BIC value** 75.4 %	The surrounding bone healed in a well-organized pattern and could not be differentiated from the original alveolus.	Histologic analysis of one retrieved implant of a patient. Loading period: 40 months

indicated a BIC range between 87.5%-97.4% (115). This coating technique reported high survival rates at medium- and long-term follow-ups (2, 116, 117). After 12 years of loading, the survival rate of hydroxyapatite implants was 93.2%, statistically increasing compared to titanium implants (2). After 10 years of loading, the hydroxyapatite implants reported a BIC range between 70.74%-86.23% (118).

Piattelli et al. (119) reported a localised chronic suppurative bone infection associated with peri-implantitis in a hydroxyapatite-coated implant, where the coating appeared detached from the titanium surface. Different methods can be used for hydroxyapatite coating, such as coating/sintering, electrophoretic deposition, immersion coating, hot isostatic pressing, solution deposition, sputter coating, and thermal spraying techniques (120). Hydroxyapatite plasma-spraying was indicated to combine the hydroxyapatite characteristics and the bone-implant mechanical interlock associated with the plasma-spraying procedure. Higher BIC values were reported for hydroxyapatite implants than titanium plasma-spray implants and machined fixtures (121). The Resorbable Blast Material (122) also known as the technique of ion-beam-assisted deposition (IBAD) (123, 124) has been proposed to improve the coating quality properties.

In vivo, the BIC values were significantly higher in IBAD surfaces compared to blasted and machined implants. The authors suggested that the advantages of the HA-coated implants in the early healing period could be apparent, while the separation or fracture of the coating layer could be prevented. However, the resorption needs to be further investigated123. Svanborg et al. (125) investigated different hydroxyapatite (HA) nanocoating thicknesses on titanium grade Ti-6A1-4V implants of 15 mm in length and 3.85 mm in diameter in rabbits.

The single layer-HA coating reported a mean Sa 0.91 (0.20) µmm while the double layer-HA coating showed a mean Sa 0.77 (0.19) µmm125. After 9 weeks of healing, the single layer-HA coating reported higher values of removal torque ($p<0.05$) and at 2 weeks reported an increase of almost 5% of new bone formation compared with the control and the double layer-HA coating. After 9 weeks, the BIC for both groups was similar (~60%) (125). The advantage of ceramic-coating implants has been described due to the high osteoconductivity of the surfaces, while these techniques can produce a surface biofunctionalisation that can increase the implant osseointegration (126-167).

The surface functionalisation seems to maintain the implant roughness, while Jimbo et al. reported no significant differences between the smooth bioceramic surface and the rough bioceramic coated implants (142). In addition, other studies investigated different ceramic coatings such as calcium carbonate, ceramic brushite, glass fibres, phosphate-containing polymers, magnesium-containing polymers, and calcium-phosphate (126-167). Granato et al. investigated the coating thickness and demonstrated that the optimal Ca- and P-derived bioceramic coating layer ranged between 300-500

Table VII. *Comparative studies which used anodized implants.*

Author	Surface treatment	Results	Findings	Experimental design
Sul et al. (2002)[99]	**(1) Anodized** (oxide thickness approximately 200, 600, 800 or 1000 nm) **(2) Turned** (oxide thickness: 17.4 nm)	**Removal torque** (1) Ranging from 0.113 to 0.129 Nm (2) 0.075 Nm	The preliminary results of this study suggest that the oxide thickness influence the bone tissue formation.	Implants were inserted in the tibia of rabbits. Healing period: 6 weeks
Son et al. (2003)*[102].	**(1) Anodized** **(2) Turned**	**Removal torque** (1) 51.35 Ncm (2) 35.28 Ncm	Difference between groups was not statistically significant concerning removal torque and BIC values (data not shown).	Implants were inserted in the tibia of rabbits. Healing period: 12 weeks
Ivanoff et al (2003)[113]	**(1) Anodized** **(2) Turned**	**BIC values** (1) 34 % (2) 13 %	BIC values were statistically higher in oxidized than in turned sites.	Histologic analysis of implants inserted in the ridge of 20 patients. Mean healing period: 6.6 months

** Data from the 1st healing period, and an experimental group were not included in this table.*

nm (150). Moreover, the fluorapatite and heated-hydroxyapatite coatings present a decreased respiration rate compared to hydroxyapatite implant surfaces (167).

Thermal oxidation and heat surface treatment

The investigation of innovative procedures able to contrast surface wearing and successful bioactivity and osseointegration represents the current breakthrough in implantology. Thermal oxidation aims to create a highly crystalline oxide coating able to potentiate the interaction between the titanium surface and the host surrounding bone (168, 169). A 700°C exposure for 1 hour by a controlled furnace of Ti6Al4V alloy can induce the formation of a rutile oxide layer that could improve the osteoblast attachment on the implant surface in vitro (170). In addition, the heat treatment at 800°C in the air for 1 minute also seems to increase the BICs in vivo of acid significantly etch Ti6Al4V implants (171). The Al obtained similar results (2) (3) abrasive particle blasting with thermochemical treatment in minipigs compared to SLA (shot blasting surface) (172).

Quameya et al. reported that adding a supplemental fluoridic acid etch to the thermally oxidised surface did not significantly affect osseointegration compared to standard SLA surface implant (173). The heat-derived oxide layer has been studied by Kim et al. (174), which compared different oxide layer thicknesses of 20nm to 80nm and the additional treatment of CaP coating. The same authors detected no significant differences in BICs and ISQ at 5 weeks on dogs (174).

Zirconia implants and acrylic materials

Zirconia (zirconium oxide, ZrO2) is a ceramic material purposed as dental implant material due to its biocompatibility, esthetic properties, and mechanical behaviour, which are better than alumina (60, 61, 175-188). Zirconia is reported to present a bone contact similar to titanium implants189,190. The interface is composed of a proteoglycan layer that is thicker than titanium (191, 192). Zirconia implants are biocompatible, bioinert, and radiopaque, with high corrosion and wearing resistance, flexion and fracture (193-197).

In rabbits, the BIC value of zirconia implants was 68.4% after 4 weeks with no foreign bone reaction and fibrous tissue infiltration at the level of the interfaces (198). Loaded zirconia implants were evaluated in monkeys, with BIC values ranging between 66%-81% (199). Zirconia implants submitted to Al2O3 sandblasting were compared to titanium (Al2O3 sandblasting followed by H2O2 and HF etching reporting BIC values of 67.4% for zirconia, and 72.9% for titanium surfaces with no statistically significant differences (190). Various types of zirconia implants have been investigated in the literature, while the most investigated are yttria-stabilised tetragonal zirconia polycrystalline (3Y-TZP) and ceria-stabilised zirconia-alumina nanocomposite (NanoZr) (176).

Mijhatovic et al. investigated three different roughnesses of zirconia implants compared to sandblasted large grit and acid-etched titanium implants, showing no significant differences in total BICs after 10 weeks on dogs. The hybrid hydrophilic titanium-zirconium alloy (TiZr1317) revealed a lower removal torque at 2 weeks compared to standard titanium implants, while no differences were detected at 4 and 12 weeks. At 4 weeks, hybrid hydrophilic titanium-zirconium alloy (TiZr1317) showed significantly higher BICs in the marrow area of 19.25% (179). Very few studies investigated in vivo the properties of plastic and acrylic resin implants (200). Okamatsu et al. (200) studied the hybrid titanium-plastic implants and evaluated a homogeneous 150- to 250-nm acrylic layer coating. The authors reported new bone formation in the test and control groups, with no direct bone contact with the plastic implant.

UV and biologically functionalised surfaces

In literature, photodynamically functionalised implant surfaces have been investigated (201-204). Mehl et al. (201) reported no significant differences between BICs and ISQ in a split-mouth study model using a high-energy UV-irradiation in epicrestally titanium implants. On the contrary, a significant increase in removal torque and BICs was reported by Shen et al. (203). The authors evaluated a different combination of SLA-surfaces treated by UV-bactericidal irradiation at 15-20W, 0.1mW/Cm2 and 0.2mW/Cm2 (203). The UV photo-functionalisation seems effective, especially in the early phases of osseointegration (202), with a significant increase in bone contact and dental implant stability. This treatment seems to take a significant advantage when combined with biologically functionalised treatment with fibronectin and osteopontin (204, 205) due to a significant increase in the hydrophilicity of the surface.

DISCUSSION

Several authors investigated the biological properties of dental implant surfaces under *in vitro* conditions. At the same time, this kind of research is consistent in investigating the specific cell response, the clinical relevance of these results is discussible, and the development of long-term clinical evaluations is fundamental. Different implant topographies seem to influence the outcome of dental implants, but the magnitude and clinical relevance of this influence are still being investigated.

On the other hand, many studies are being published to investigate the viability of modified surfaces. Regarding the titanium alloy, a study performed in rabbits reported that the removal torque was statistically different after 6 months and 12 months, where the cpTi implants were significantly more stable. The BIC means presented no significant differences between the materials (206). In another investigation, cpTi and Ti6Al4V dental implants were positioned in baboons, reporting that BIC means were significantly higher in cpTi and Ti6Al4V implants, but differences after six months were not significantly different (207).

Even if the use of the alloy represents a mechanical advance compared to cpTi, biomechanical tests revealed that cpTi presented an increased stability. Moreover, the titanium implants, after the air exposure, can form an oxide layer all over the surface of 2–5 nm thickness. The oxide layer (208, 209) plays a key role in corrosion resistance, biocompatibility and implant osseointegration (210-212). The layer is mainly formed by TiO2 (213), and the crystalline structure, the thickness and stability of this layer varies according to the surfaces of the implant (99, 214, 215).

Promising findings for dental implants concerning nitride titanium (TiN), nanostructured texture, laser-treated surfaces, and ceramic materials have been recently reported (188, 216). The nanostructured surfaces (1-100nm) could improve the early interface and bone-implant contact (217, 218). Authors reported that dogs presented a higher percentage of newly formed bone in contact with nanostructured implants than plasma-spray and machined implants (219, 220), and BIC values ranged between 55 and 96% in humans (221).

Nitride titanium (TiN) was proposed to produce a surface less susceptible to the ions release. For this purpose, the physical vapour deposition technique can produce a thin TiN layer (~1μ) for an osseointegration quality similar to standard titanium implants. This layer increases corrosion resistance, lower bacterial adhesion, and a golden aspect of the implant surface (222-227). The laser ablation is a reproducible procedure for a controlled, micron-sized surface with topographical features on the flanks of the threads. Lasered implants demonstrated significantly higher BIC and removal torque peaks than machined implants (228, 229). Calcium phosphate and ceramic coating are correlated to a high chemical bonding property, similar to hydroxyapatite (86). Biphasic calcium phosphate (162, 230, 231) or tricalcium phosphates have been investigated as implant coating (232, 233).

In conclusion, proper long-term studies have been published for TiO2 surfaces, but other surfaces are documented with a medium-term follow-up period (234). While clinicians should consider that several new treatment surfaces are constantly purposed and currently available in the market, long-term findings are necessary to comprehend their long-term biological response.

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Retrospective Study

A RETROSPECTIVE MULTICENTRIC STUDY OF 56 PATIENTS TREATED WITH 92 PTERYGOID IMPLANTS FOR PARTIAL/ FULL ARCH IMPLANT SUPPORTED FIXED REHABILITATION: IMPLANT AND PROSTHESIS SUCCESS RATE

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ABSTRACT

In the case of severe atrophic patients, the search for native bone can be extended beyond the anatomical limits of the oral cavity. So remote anchorage solutions could involve the pterygomaxillary complex composed of the maxillary tuberosity, the pyramidal process of the palatine bone and the pterygoid pillar. Pterygoid implants are typically placed in this zone to rehabilitate patients affected by severe maxillary atrophy. This study's aim consists of the surgical and prosthetic success rate evaluation concerning the pterygoid implants placed to support fixed partial or full arch rehabilitation without a cantilever. All team members designed and conceived this retrospective multicenter study (performed in three different clinical offices) to evaluate the reliability and predictability of this anatomically guided surgical tecnique without immediate loading. The study was successful with 100 per cent surgical success and all torque values >=45 N/cm considered as a threshold value. The series comprised 56 people who underwent 92 procedures. The male-to-female ratio

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was close to one (27 men, 29 women). The mean age (± SD) was 64.0±9.3 years (range 41-85 years). Only one prosthetic failure was recorded in a woman aged 67 years receiving a full arch pterygoid implant. Pterygoid implants supported by fixed rehabilitation represent a reliable strategic solution for treating severe atrophic posterior maxilla.

KEYWORDS: *pterygoid implants; cantilever free, insertion torque, fixed rehabilitation, atrophic maxilla, graftless surgery*

INTRODUCTION

Osseointegrated implantology represents a reliable treatment solution to solve edentulism in jaws (1) in daily clinical practice. Insufficient bone amount and closeness to important anatomical landmarks could prevent implant placement. Each anatomical area is characterized by features and limitations (bone quality and quantity, nerve course, maxillary sinus cavity), which certainly conditioned/impacted this surgical procedure.

Among all, the atrophic posterior maxilla represents a critical and demanding area in the patient's rehabilitation through the insertion of integrated bone implants (2, 3) since it often lacks both in height and in thickness, thus preventing the placement of implants without adjunctive strategies (4).

The presence of the maxillary sinus, an inadequate bone in terms of quality or amount, a large fatty marrow space or the rare presence of cortical bone covering the alveolus represent some of the critical aspects that surgeons could meet during the surgical approach. Regenerative techniques such as maxillary sinus elevation, block grafts, or Customized Bone Regeneration allow bypassing these anatomical criticalities, even if they are not free from long healing periods or donor site morbidity (5-8). In implant surgery, it is mandatory to minimize patients' morbidity, especially if implant patients are getting older. Consequently, therapeutic, surgical procedures must be tailored to them and their ingrained features, systemic diseases, pharmacological therapies, and functional sinus impairment due to sinus lift augmentation (9). According to the current guidelines, daily clinical practice should consider the most cost-effective treatment equal to clinical efficacy.

Although surgical reliability is well documented, there is still disagreement on clinical and prosthetic primacy techniques. Some suggest it could be a good practice to go beyond these critical issues, using shorter and wider diameter implants to reach a high bone implant surface contact (10, 11). Furthermore, biomechanical considerations such as the intense chewing forces acting in the atrophic posterior maxilla should not be forgotten. Ideally, a prosthetic cantilever should be avoided for this aspect (12): several complications could occur, such as screw and framework fracture, marginal bone loss or implant osteointegration loss.

In the case of severe atrophic patients, the search for native bone can be extended beyond the anatomical limits of the oral cavity. So remote anchorage solutions could involve the pterygomaxillary complex composed of the maxillary tuberosity, the pyramidal process of the palatine bone and the pterygoid pillar. Pterygoid implants are typically placed in this zone to rehabilitate patients affected by severe maxillary atrophy (13).

Bone availability in the maxillary tuberosity is highly variable and is based mainly on the adjacent maxillary sinus pneumatization amount. In 1989, Tulasne (14) introduced implant placement in the pterygoid region to overcome anatomical limitations due to atrophic alveolar bone.

The pterygoid implant entails the fixture penetrating three specific osseous structures: maxillary tuberosity, the pyramidal process of the palatine bone and pterygoid pillar, and if it reaches osteointegration successfully, it offers support and stability to the final cantilever-free prosthesis. It significantly differs from tuberosity implant usually placed in the tuberosity region (mainly composed of 3 or 4 types of cancellous bone at the most distal portion of the maxillary alveolar process) and rarely with an angulation above 10 degrees. The pterygoid implants are usually placed with an angulation of 30 – 60 degrees relative to the horizontal maxillary plane, and they could offer support in partial and full arch prosthetic fixed rehabilitation. This anchorage satisfies surgeons and patients due to the time-consuming surgical strategy and favourable cost-benefit ratio.

The aim of this study consists of the surgical and prosthetic success rate evaluation concerning the pterygoid implants placed (with a minimum torque of 45 Ncm) to support fixed partial or full arch rehabilitation without a cantilever. Its proposal consolidates the literature evidence with our shared experience, whose data were analyzed and interpreted according to a characteristic descriptive statistical analysis.

MATERIAL AND METHODS

Study design

All team members designed and conceived this retrospective multicenter study with an enrolled sample of 92 pterygoid implants to evaluate the reliability and predictability of this anatomically guided surgical technique (Noris Medical PteriFit ™) with a 1-year follow-up. It was performed in three different clinical offices:

1. Dr Tealdo Tiziano Clinical Office, Alba, Italy;
2. Dr Bevilacqua Marco Clinical Office, Boves, Italy;
3. Dr Alberti Christian Clinical Office, Rosà, Italy.

Only one type of pterygoid implant (Noris Medical PteriFit ™) was employed not to introduce further variables. All the patients previously visited after a CBCT 3D scan (Gendex GXDP-700 S) showed clinical and radiological signs of hopeless dentition and severe atrophy. After computer-assisted surgery planning (DTX Studio Clinic software, Nobel Biocare), the implant placement was defined in the pterygoid region. The study was conducted according to the Helsinki Declaration of 1975 principles and revised in 2000 for biomedical research involving human subjects.

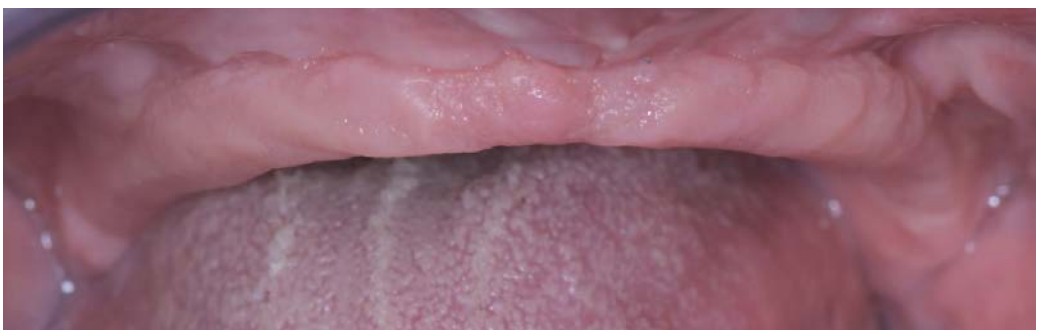

Fig. 1a. *Initial case of the atrophic patient in the maxillary arch.*

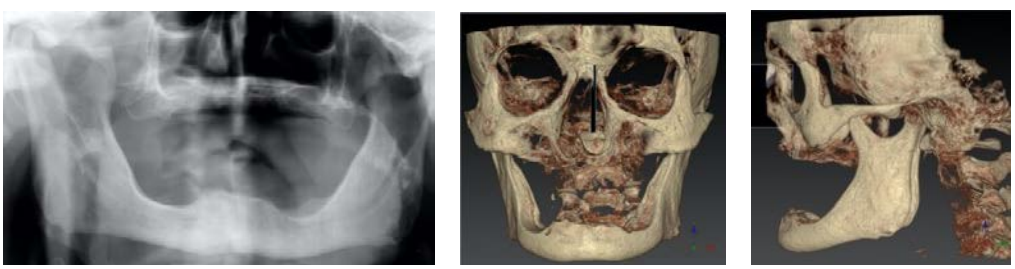

Fig. 1b. *2D radiological images and 3D reconstruction of the same atrophic patient.*

Since the authors analyzed preexisting and no identifiable data of patients, who were all informed about the nature of the data treatment and their written consent was obtained prior to participation.

Pterygoid rehabilitation protocol

All the patients enrolled in this study had to meet the inclusion criteria or good general health, no contraindications to implant placement or insufficient pterygoid bone amount (Fig. 1a, 1b, Fig. 2). All patients had at least 1 year of follow-up after the prosthesis delivery.

The surgical protocol applied to all the enrolled patients (January 2021 to February 2022) consisted of raising a full-thickness flap to expose the pterygomaxillary synostosis and performing the osteotomy for implant placement according to the manufacturer's guidelines. The implant site

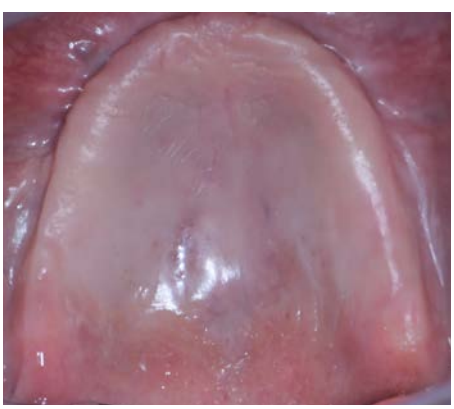

Fig. 2. *Initial case of the patient from the occlusal point of view.*

preparation sequence included a marking drill, the subsequent passage of a manual osteotome with a 2mm tip to define the implant insertion axis, the use of a 2.3mm diameter twist drill at approximately 1000 RPM, a second 2.8 mm diameter twist drill along the entire working length. The implant insertion was manually performed using a dedicated straight screwdriver.

Manual insertion did not allow the implant insertion torque to be objectively quantified; therefore, a torque wrench was fitted to accept the achievement of a torque of 45 Ncm or greater. Unstable pterygoid implants were immediately removed, and the osteotomy was filled with a hemostatic gelatin sponge (Spongostan -Ethicon). Since the Noris Medical PteriFit TM is soft-tissue level fixture, part of the stained neck of the implant was purposely left with extra bone to contract the relationship with the soft tissues in the tuber area.

The axis of the implants was corrected during the surgery by connecting a pre-angled conical abutment at 30Ncm. Before suturing the flap, a healing cup at 10 Ncm was connected above the stump to achieve non-submerged healing. The one-stage solution offers to screw a 5 mm healing cap on the pterygoid implant immediately after the surgery without any risk of interference with the opposite teeth, as interference during mastication with the chewing forces could prejudge the primary stability, and a surgical failure may occur. Thus, it could be recommended to cover the head of the pterygoid implant with the flap after the implant placement (two-stage) (Fig. 3-5).

After a minimum period of 3 months without prosthetic load, the pterygoid implants were registered with the pick-up and open tray technique for the definitive rehabilitation, which envisaged their union with other implants inserted in the same period.

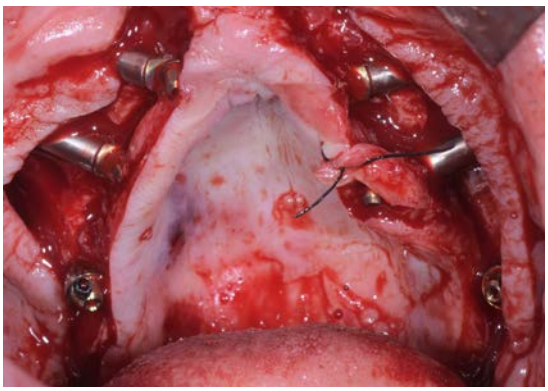

Fig. 3. *Intro-operative picture after implant insertion and Multi Unit Abutment (MUA) connection on different kind of implants.*

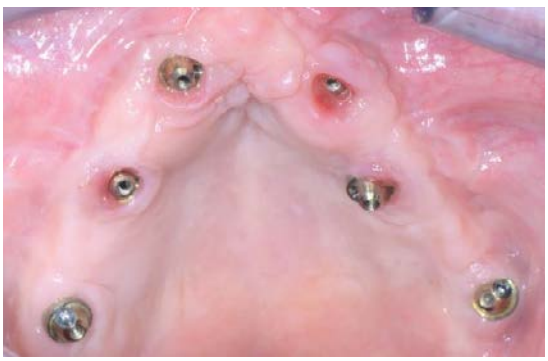

Fig. 4. *Intraoral picture after a healing period of 4 months.*

A specific quick-setting plaster (BF plaster - Dentaltorino, Italy) was used as impression material for fixed full arch rehabilitation. In the case of partial rehabilitation, in addition to the impression plaster to solidify the implants together, silicone was also used for the remaining fixed dental elements. The final prosthetic frameworks were tightened by a

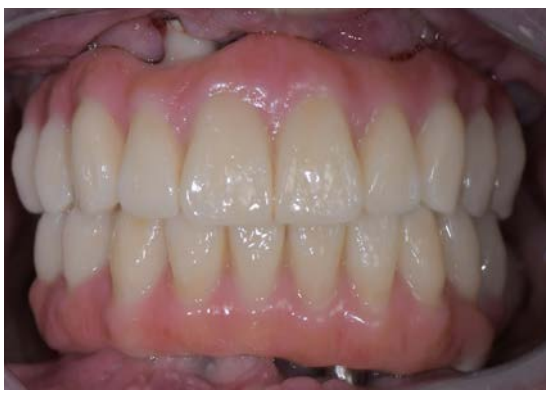

Fig. 5. *Frontal aspect of the provisional prosthesis delivery.*

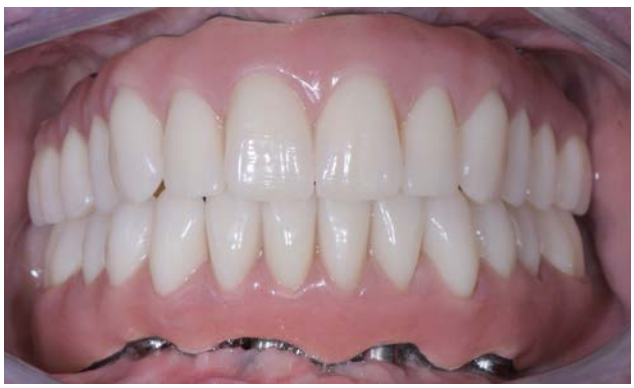

Fig. 6. *Frontal aspect of the final prosthesis delivery supported by the pterygoid implants.*

motor with a torque of 25Ncm on the pterygoid implants Unigrip™ connection (Fig. 6, 7).

Study variables

This kind of implant differs from conventional dental implants according to their extra-oral anchorage. For this reason, all the Authors considered only two outcome variables for this study: surgical and prosthetic success rate. Concerning the surgical success rate, only the pterygoid implants that reached a minimum of 45 Ncm insertion torque were considered and maintained in the pterygoid bone (otherwise, they were immediately removed during the surgical phase). The study was successful with 100 per cent surgical success and all torque values > =45 N/cm. The evaluated criteria to meet the prosthetic success rate were overall stability, comfort, function and patient acceptance. This last concept means that after prosthesis delivery, patients met satisfaction in chewing and phonetics without any excessive encumbrance or symptom. All the patients' feedback was collected and recorded during the follow-up dates planned after the prosthesis delivery.

Predictor variables

The following determinant or predictor variable was addressed in this study:

a) demographic factors (gender, age) (Fig. 8);
b) dental factors (size, length, diameter, MUA angle, torque insertion, surgical date, one or two-stage, number of implants, nasal implants, zygoma implants, partial/full arch rehabilitation, prosthesis delivery) (Fig. 9).

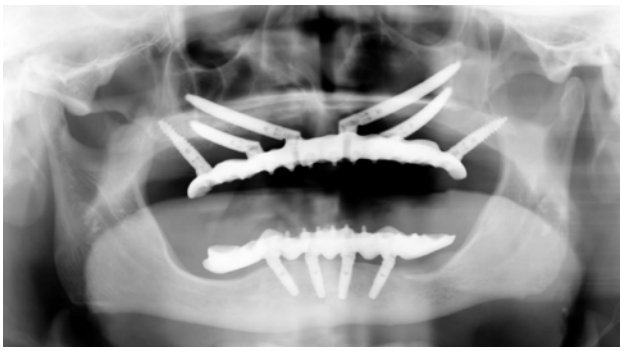

Fig. 7. *A final Ortopantomography exam after the delivery of the final prosthesis.*

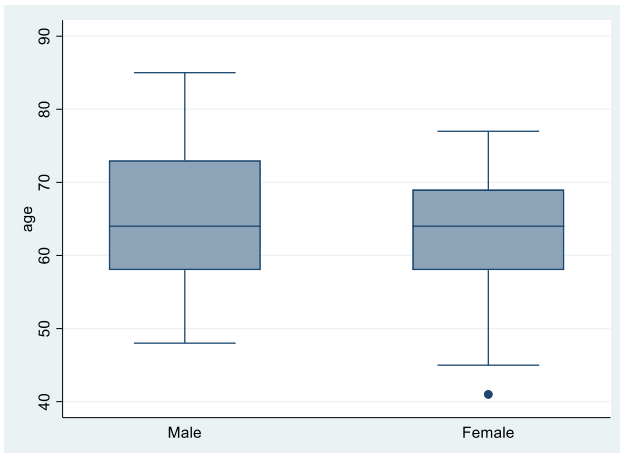

Fig. 8. *Distribution of the age range between the genders.*

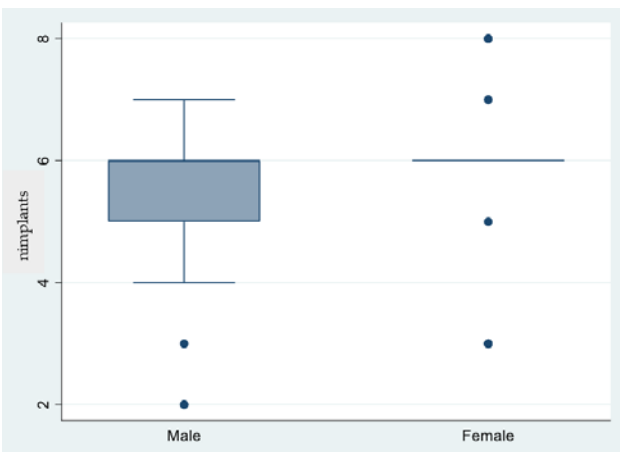

Fig. 9. *Graph describing the distribution of the number of implants over genders (male/female).*

RESULTS

Population under study

The series comprised 56 people who underwent 92 procedures. The male-to-female ratio was close to one (27 men, 29 women). The mean age (± SD) was 64.0±9.3 years (range 41-85 years). The primary endpoint was torque.

Surgical technique

The two-stage approach was used in nearly all patients. The one-stage approach was used in just one patient, a woman aged 74 years receiving a full arch pterygoid implant. Zygomatic implants were done in 15 patients (27%), and nasal implants in 10 (19%). Five patients had both zygomatic and nasal implants.

Variable angulation was never considered. A full arch was used in most subjects (39/56=70%), while a partial arch was used in less than one-third (17/56 = 30%).

Patients in the series received 5.6±1.4 implants overall (mean ± SD) (range 2-8). Patients receiving partial arch had an

average of 4.3±1.9 implants (median 4, range 2-8), while patients receiving full arch had an average of 6.1±0.7 implants (median 6, range 5-8). Notably, two-thirds of the latter group (26/39) received 6 implants. The length of pterygoid implants ranges from 16 to 28 mm (median value 20.78 mm).

Surgical outcomes

The study succeeded with 100% surgical success and all torque values >=45 N/cm. Only one prosthetic failure was recorded in a woman aged 67 years receiving a full arch pterygoid implant.

DISCUSSION

In the case of severe atrophic posterior maxilla, the search for extraoral implant anchorages could represent a reliable strategy to restore and rehabilitate patients and prevent other alternative regenerative treatments (7, 15); in fact, the pterygoid implants play a crucial role in the reaching of extra oral bony pillar (rescue implants).

This retrospective study shows a success with 100 per cent surgical success and with all torque values > =45 N/cm, even if other authors reported lower success rates for pterygoid implants (ranging from 80% to 99%) (10-16, 17). However, the surgical success rate we have observed should not mislead us into thinking it is a simple technique. This surgical approach requires operative skills and learning curves. The surgeon should recur to an accurate previous CBCT scan evaluation.

Clinicians should always consider that numerous vascular structures such as maxillary artery, descending palatine artery and pterygoid venous plexus can be detected in this area. Only with a detailed observation of pre-clinical CBCT can the placement of pterygoid implants be relatively safely planned. Up to now, three surgical techniques exist concerning pterygoid implant placement (18). The first is a free-hand surgical technique: we use this to plan and manage the pterygoid region. After a CBCT examination of the area to determine the correct axe insertion of the pterygoid implant, we expose the pterygoid-maxillary synostosis to access and approach the area. The surgeon can alternatively fold up a guided surgery, particularly a static fully guided implant placement (option #2) or a dynamic guided implant placement (option #3). For the static guide surgery, it is very important to consider the opening of the patient's mouth due to the encumbrance of the template and the dedicated drills (19); either technique requires continuous application and a constant learning curve to reach a well-established surgical skill.

This type of retrospective study requires a descriptive statistical analysis: the primary endpoint was the insertion torque; a value equal to or above 45 Ncm was the initial parameter considered. The authors want to underline the important prognostic value of the insertion torque (> =45 N/cm) on the surgical success rate. The primary stability is not always reachable during surgery. Whenever the insertion torque cannot satisfy the minimum of 45 Ncm, it is reccomended removing the implant to place another in another surgery date. An eventual prosthetic connection with nasal implants (10%) or zygomatic implants (27%) does not seem to play a prognostic decisive role. Even if these pterygoid implants differ from conventional intra-oral dental implants, they show a common feature: the importance of primary stability.

Furthermore, the length of pterygoid implants should be enough to allow these fixtures to engage the pterygoid process of the sphenoid bone. In the present study, implants of length ranging from 16 to 28 mm were used (median value 20.78 mm). The length of these implants is very closely related to primary stability and long-term success, as reported in the literature (16-20). Paying attention to all the surrounding anatomical determinants is mandatory in this situation.

It is possible to perform the one-stage surgery (5 mm height for the healing cap) only in safe conditions: at least 5 mm distance from the antagonist teeth. In case of interference during mastication, the chewing forces could prejudge the primary stability, and a surgical failure may occur. Compared to previous studies (20, 21), all the authors decided to redefine the clinical reliability of some parameters, such as:

- angulation of pterygoid implants: it was initially evaluated on an orthopantomography exam. In our opinion, a Cephalometric evaluation could be more indicated to estimate angulation than an Opt evaluation; it gives only an interpretation of the angulation: but would expose patients to further radiological exposure.
- bone loss: the pterygoid region represents a deep area for anchorage. All the authors consider estimating effective bone loss affecting pterygoid implants very challenging. To the best of our knowledge, the literature does not offer

solid support for scientific evidence on the calculation of bone loss around these implants. These are, unfortunately, empirical evaluations (21);

- bleeding on probing (BoP): in this deep posterior area, the mucosal tunnel is deeper, and a possible BoP is not a necessary sign of inflammation. Therefore, we cannot consider this biological parameter as reliable as dental implants;

If we consider this procedure from a prosthetic and biomechanical point of view, unscrewing and cantilever should be prevented.

The unscrewing may occur if the screw is not tightened with a torque wrench (20 Ncm).

The mobility of the Multi Unit Abutment (MUA) resulting from unscrewing can induce bleeding, suppuration and tenderness and impact the function and satisfaction of the patient. Finally, the cantilever may play an unfavourable role in the overloading and consequent bone loss around the implants (20).

The bone loss was assessed in other studies (22, 23) comparing Opt exams scanned after 1 year of prosthetic loading. We argue that this calculation method is only interpretative but not scientifically reproducible and repeatable.

The postoperative healing phase of each patient did not have any particular signs or events worthy of note: bleeding could occur due to veins of the pterygoid muscles. These events could be stopped with the pterygoid implant placement. Patient acceptance of the distal prosthetic framework was high.

This retrospective study has only one prosthetic failure due to a partial fracture of the framework. As reported in Literature (24), our population under study confirmed high satisfaction with the fixed prostheses. No phonetic problems or speaking problems were referred. Correct and daily hygiene maintenance is mandatory to avoid high levels of plaque index, tissue hyperplasia or mucosal inflammation.

CONCLUSIONS

Fixed maxillary rehabilitations supported by Pterygoid implants represent an alternative reliable treatment solution for atrophic patients in the posterior maxilla; this anchorage allows the time reduction in the surgical procedure and the prosthesis restoration and favourably impacts the quality of the patient's life. This retrospective study met a surgical success of 100% with all torque values > =45 N/cm. Furthermore, these rehabilitation techniques are integrated with the digital flow up from the initial previsualization diagnostic phase, where the patient has real indications of final expectations.

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Conflict of Interest Statement:

All the Authors declare no conflict of interest.

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Case report

UNDIFFERENTIATED CONNECTIVE TISSUE DISEASE WITH HYPERPLASIA OF YELLOW LIGAMENTS IN L4-L5 CAUSING SEGMENTAL SPINAL STENOSIS

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ABSTRACT

Undifferentiated connective tissue disease (UCTD) is a systemic autoimmune disease characterized by clinical and serological manifestations not fulfilling the criteria for defined connective tissue diseases. Up to 90% of the cases are young women. Usually, UCTD has a mild clinical course with a wide variety of signs and symptoms because it can involve any connective tissue in the body. 40% of patients with UCTD develop the stage of a well-defined systemic autoimmune disease during five years of follow-up, while 60% remain in an undifferentiated stage. The most used drugs in treating UCTD are nonsteroidal anti-inflammatory drugs, corticosteroids, calcium channel blockers, and antimalarial drugs. We report a rare case of a woman with UCTD in corticosteroid treatment, suffering from low back pain refractory to therapy, evidence a computed tomography (CT) of abnormal bone hyperplasia of the yellow ligament conditioning spinal stenosis.

KEYWORDS: *undifferentiated connective tissue disease; yellow ligaments; spinal stenosis; systemic autoimmune diseases*

INTRODUCTION

Undifferentiated connective tissue disease (UCTD) is a systemic autoimmune disease characterized by clinical and serological manifestations not fulfilling the criteria for defined connective tissue diseases (CTD) such as systemic lupus erythematosus, mixed connective tissue disease, Sjögren syndrome, systemic sclerosis, polymyositis, dermatomyositis, or rheumatoid arthritis (1, 2). Its diagnosis is considered exclusion (3). UCTD is defined if the following criteria are met:

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signs and symptoms suggestive of a CTD, but not fulfilling criteria for a defined CTD, positive antinuclear antibodies on two separate measurement controls, and disease of duration of at least 3 years (4). The incidence is unknown due to the lack of a proper definition of this pathology, but it has been observed that 20-50% of patients presenting in a rheumatology department have a UCTD diagnosis (5).

From an epidemiological point of view, in more than 90% of cases, this pathology mainly affects women, particularly those between 32 and 44 years old (6, 7). There are two forms of UCTD called stable-UCTD and evolving-UCTD (4). The first case represents the forms that remain undifferentiated and are over 60% of the total, while the evolving forms represent about 40% of the UCTD evolve into defined systemic autoimmune disease during five years follow up (8, 9). Like all autoimmune diseases, the aetiology is unknown; what is known is that genetic factors and environmental triggers induce the triggering of these diseases (10). However, UCTD, like other known connective tissue disorders, is characterized by exaggerated immune system activity (11). The latter produces autoantibodies or activates antigen-specific T-lymphocytes that affect connective tissue at every site of the body (12).

Clinically, UCTD has a generally mild course; in most cases, it is characterized by the absence of severe organ damage or involvement, especially in the renal and neurological systems (3). The main symptoms are arthralgia, which can be present in more than 86% of patients; various skin lesions such as livedo, purpura, acrocyanosis, telangiectasias, urticaria (3, 7); Raynaud phenomenon (33%), sicca symptoms (30%), mucocutaneous symptoms included oral ulcers (23%); arthritis (22%) and thyroid disease (7%) (13-18). Constitutional symptoms, such as fever, malaise, and fatigue, are often the initial presentation of the disease (3). From a diagnostic point of view, serological markers are considered essential in the diagnostic criteria for UCTD (3). In particular, anti-Ro/SSA and anti-U1-RNP are considered markers detected in this disease (3, 5).

Regarding imaging studies, chest radiography and computed tomography (CT) can be helpful in studying cardiac and pulmonary involvement (19, 20). Additionally, ultrasonography of the salivary glands was a good test in differentiating between UCTD and other diseases such as Sjögren syndrome (21, 22). The main treatment of UCTD is pharmacological, and the most used drugs are nonsteroidal anti-inflammatory drugs, corticosteroids, calcium channel blockers and antimalarial drugs such as hydroxychloroquine (3, 23, 24). If the disease is not controlled with these drugs or the symptoms are severe, it is necessary to use immunosuppressive agents such as methotrexate and azathioprine (3, 7).

CASE PRESENTATION

A 75-year-old female patient with a medical history that revealed UCTD was receiving corticosteroid treatment for 15 years.

Since the age of 65, the woman had episodes of neck and low back pain investigated with a rachis x-ray showing diffuse spondyloarthritis manifestations; therefore, she was treated with nonsteroidal anti-inflammatory drugs to reduce the pain symptoms.

For about 60 days, she complained of acute left lumbosciatica with paresthesia and weakness of the left lower limb conditioning intermittent claudication. Furthermore, this symptomatology was not responsive to pain-relieving therapy.

The patient underwent lumbosacral computed tomography (CT) (Fig. 1) that showed marked hyperplasia of yellow ligaments at the fourth lumbar disc and

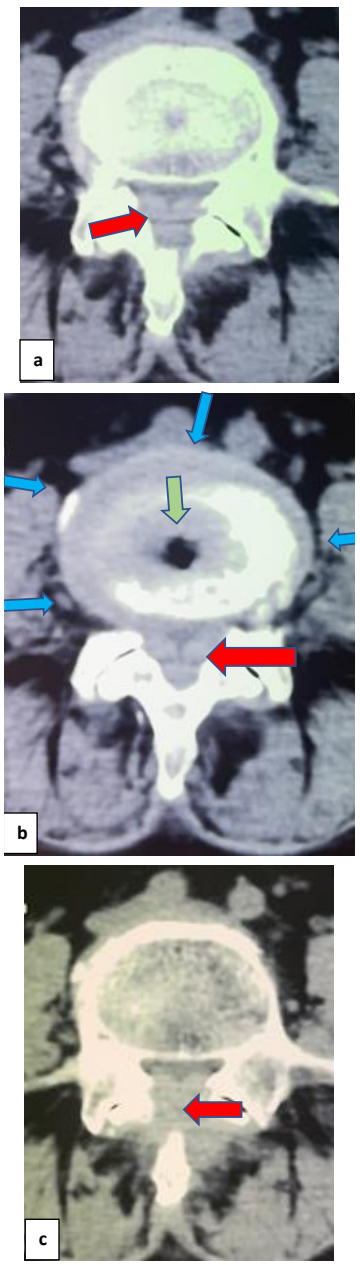

Fig. 1. ***a), b), c):*** *Marked hyperplasia of the yellow ligaments at L4-L5 (**red arrows**), which determines important segmental canal stenosis, where the dural sac appears compressed and displaced anteriorly against the posterior wall of L4 and L5. The disc between L4 and L5 appea rs modestly protruded circumferentially (**blue arrow**) with associated gaseous vacuolar degeneration of the nucleus pulposus (**green arrow**).*

fifth lumbar disc (L4-L5). This hyperplasia determines important segmental canal stenosis, where the dural sac appears compressed and displaced anteriorly against the posterior wall of L4 and L5. Moreover, the intervertebral disc between L4 and L5 appears modestly protruded circumferentially with associated gaseous vacuolar degeneration of the nucleus pulposus. Hyperplasia and subsequent ossification of the yellow ligaments is a rare event that can occur in cases of UCTD.

DISCUSSION

The case report shows a rare hyperplasia of the yellow ligaments that condition root canal stenosis associated with UCTD. As known, the yellow ligament is located inside the spinal canal that connects posterolaterally two laminae of adjacent vertebrae, and it is divided into two portions: capsular portion and interlaminar portion (25, 26). Histologically, connective tissue comprises 80% elastic fibres and 20% collagen fibre (27). It maintains the inherent stability of the spine, controlling intervertebral movement and maintaining a smooth surface of the posterior dural sac (26, 27).

The pathogenesis of the yellow ligament's thickening is unclear (28). Multifactorial agents such as age, mechanical stress, growth factors and systemic disease like connective tissue diseases are known to contribute to hyperplasia development up to ossification of yellow ligaments (28-30). The hypertrophied yellow ligament shows an increase in collagen fibres, calcification, ossification and chondrometaplasia (27); this is due to the production by the cells present in the yellow ligament of a high volume of type II collagen at the expense of elastic fibres (28-30). Subsequently, this collagen is converted to type-1, which can lead to endochondral ossification of the yellow ligament (28-30).

Thickening of the yellow ligaments causes spinal canal narrowing and mechanical compression of the nerve roots, cauda equina and spinal cord (31). This mechanical compression causes low back pain, sciatica, paresthesia, pain and muscle weakness, gait disturbance and bladder-bowel disturbance (26). These symptoms occur even in the absence of bulging *Annulus fibrosus* and herniated nucleus pulposus (26).

Diagnosis is based on the neurological findings, imaging examinations using X-ray, CT and magnetic resonance imaging (MRI) and electrophysiological examinations (32). Generally, the treatment of symptoms brings pain and numbness, and the pain in the lower extremities requires the use of nonsteroidal anti-inflammatory drugs, muscle relaxants and vitamin B12 (26). Physical therapy is recommended at an early stage.

However, dynamic physical therapy, such as massage and stretching of the spine by others, is contraindicated because it increases the risk of hypertrophic yellow ligament injury. Surgical treatment is recommended for patients with ineffective conservative treatment and with severe spastic gait, severe muscle weakness of the lower extremities, and bladder-bowel disturbance. Surgical decompression methods include open-door laminectomy, bulk laminectomy, fenestration, and hemilaminectomy (33-37).

CONCLUSIONS

Hyperplasia of the yellow ligaments and subsequent ossification are rare events of multifactorial aetiology due to advanced age, mechanical stress and systemic disease. Among the pathologies that could cause an alteration of the structural composition and, therefore, the yellow ligaments' functionality are connective tissue diseases, but insufficient data are currently available in the literature. Future studies will be needed to evaluate the relationship between connective tissue diseases such as UCTD and yellow ligament hypertrophy. Studies will then be necessary to make diagnoses with in-depth and targeted imaging techniques to evaluate the spinal column and the subsequent and appropriate medical or surgical therapy.

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Case reports

SUB-CRESTAL IMPLANTS WITH PLATFORM-SWITCHING AND ONE TIME ABUTMENT

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ABSTRACT

The use of dental implants in the rehabilitation of partially or fully edentulous patients is a treatment that has been validated over the last 40 years, with a high success rate. The introduction of platform switching, i.e. the use of abutments with a smaller diameter than the implant neck, has also resulted in an important benefit in terms of biomechanical behaviour, influence on crestal bone and peri-implant soft tissue response. A series of cases using BioPlatform GTB implants in different situations is presented.

KEYWORDS: *short implants, platform switching, one time abutment*

INTRODUCTION

The basis of medium- and long-term rehabilitation success in all implant systems is the integration of the abutment-fixture complex with the surrounding bone tissue. An integration that must be of sufficient quality and quantity and remain stable over time (1).

In particular, the clinical and radiological evaluation of marginal bone loss is considered one of the key factors for the stability and longevity of dental implants, as well as the maintenance of peri-implant soft tissue.

The establishment of a pathogenic microflora at the abutment-fixture interface, with the possible onset of mucositis, the increase in pocket depth and progressive bone resorption, as well as the role of excessive biomechanical stress due to incorrect occlusal loading, are related factors implicated in the loss of marginal bone around dental implants (2-5).

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Over the years, attention has been focused on the role of the position of the neck of the fixture in relation to the marginal ridge, the type, the geometry and the timing of the abutment-fixture connection. Several studies have focused attention on the role of the type of implant-abutment connection that can contribute to the stability of the peri-implant bone level; in fact, the geometry of the connection influences possible bacterial colonisation within the implants (6, 7).

The internal connection seems to show better results in terms of prevention of microbial penetration, resulting in a tight marginal seal and implant stability, thus preventing marginal bone loss (8-10).

Nowadays, the evaluation of those treatments in which abutments with a smaller diameter than the fixture have been used has revealed a better preservation of hard and soft tissues compared to treatments using abutments with similar diameters to the implant (2, 11, 12).

In recent years, developments in the macro-geometries of dental implants and prosthetic components have allowed a considerable increase in the biological performance of dental implants, with a paradigm shift in the surgical approach and implant-prosthetic rehabilitation (1).

The use of 'short' implants, < or = 6 mm in length, has thus become a predictable therapeutic alternative, capable at times of avoiding bone regeneration procedures that are certainly more complex, of longer duration and with a more uncertain or operator-dependent prognosis.

Research interest is therefore focusing on the comparison of marginal, heavily loaded bone with unfavourable levers and crown-radicular ratios (2:1 or more) (10-12).

Case 1

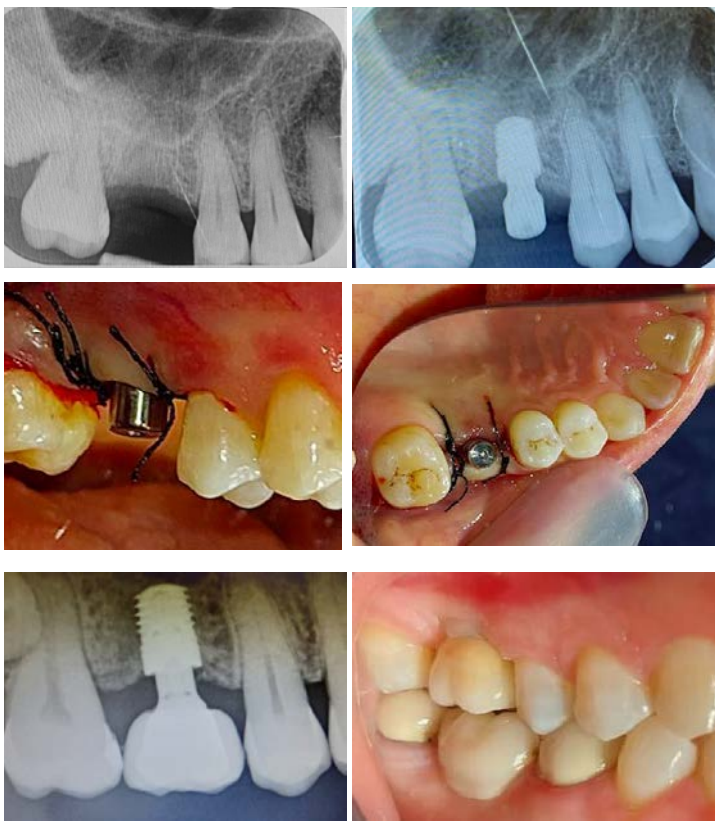
A female patient, 55 years old, non-smoker, with good oral hygiene control was admitted to our department. She had monoedentulous first upper right molar for more than 6 months. On radiological evaluation with TCCB, she had 7 mm of bone thickness in the buccal vestibular direction and a distance of 6 mm from the lower sinus floor. The proposed treatment plan was the insertion of a 4.3 mm diameter and 6 mm long GTB implant fixture, after transcrestal sinus elevation.

The surgical planning was carried out according to the surgical protocol for GTB implants, which provides for the eventual reduction of the 'knife-edge' ridge, the placement of fixtures according to the prosthetic axis, and the placement of the implant at a subcrestal level of at least 1.5 to 2 mm.

This planning was then performed surgically according to protocol, achieving a screwing stability of 25 Ncm. At the same time, the healing abutment GFA, with a height of 4.5 mm, was placed over the fixture.

After 60 days, and radiographic control, the impression was obtained was taken by unscrewing the healing abutment of the GFA according to the "one time abutment" protocol, screwed with a torque of 25 Ncm according to the GTB prosthetic protocol. The definitive polyether impression by using a transfer screwed directly onto the GFA abutment; a metal ceramic crown was then delivered.

At check-up 6 months after definitive loading, the bone closure on the neck of the abutment is complete, visible both radiologically and by the absence of probing.



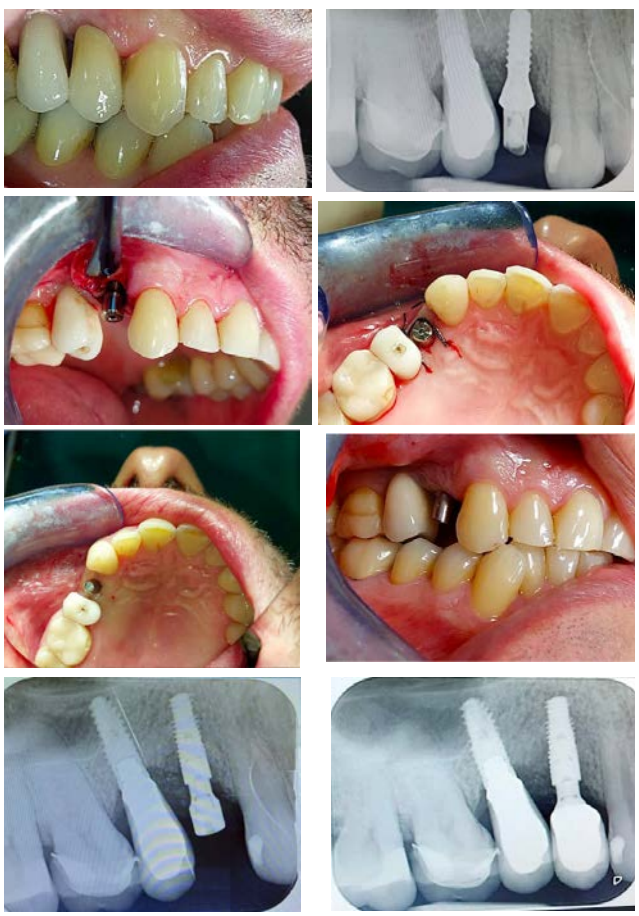
Case 1.

Case 2

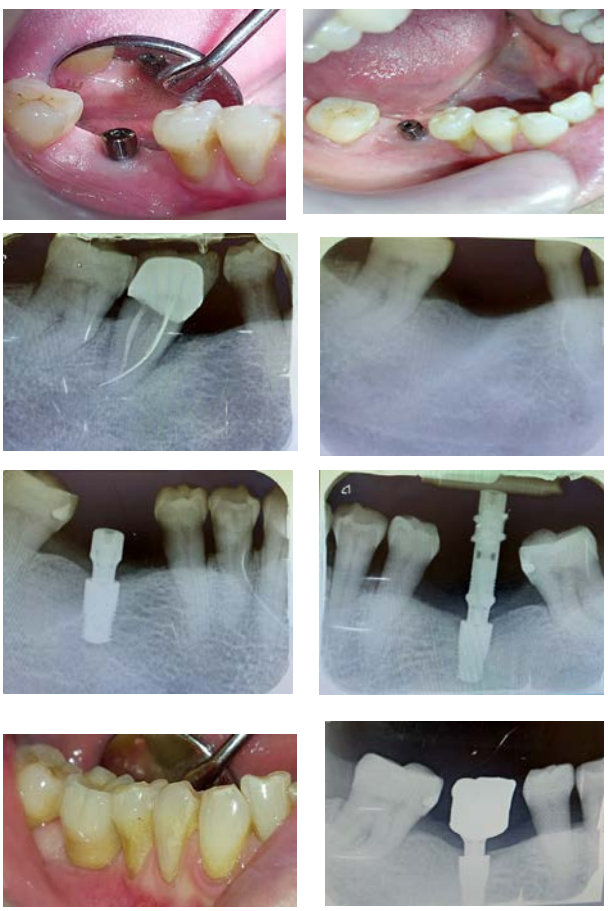
A 54-year-old male patient presented with mono-edentulous zone 2.4, an endosseous implant was inserted with a diameter of 3.3 and a length of 10 mm, but when the prosthetic abutment was tightened to about 25 N the implant fixture rotated. It was decided to carry out a new osseointegration but after 3 weeks a mucositis and peri-implant resorption process appeared. It was decided to remove the implant and proceed with a new contextual insertion. We chose the insertion of a GTB 3.3 10 mm implant with subcrestal placement, to achieve primary stability and optimal healing of the peri-implant mucosal tissue thanks to the use of the GFA component and the one-time abutment. A good healing of the hard tissues and the peri-implant marginal mucosal tissues with satisfactory pink aesthetics and bone stability was obtained at the time of the final radiographic check (70 days).

Case 3

A 60-year-old female patient presented with periodontal compromised tooth 4.7 such that extraction was necessary. After three months a GTB 4.3 x 7.5 mm length implant fixture was inserted and a 3.5 mm GFA placed. Two months after the surgical phase an impression was taken and a definite crown was inserted, following the indications for a pontic crown that maintains the stability and quality of the keratinized gingiva. There is excellent integration both with the surrounding teeth (white aesthetics) and in the stability of the peri-implant soft tissue (pink aesthetics).



Case 2.

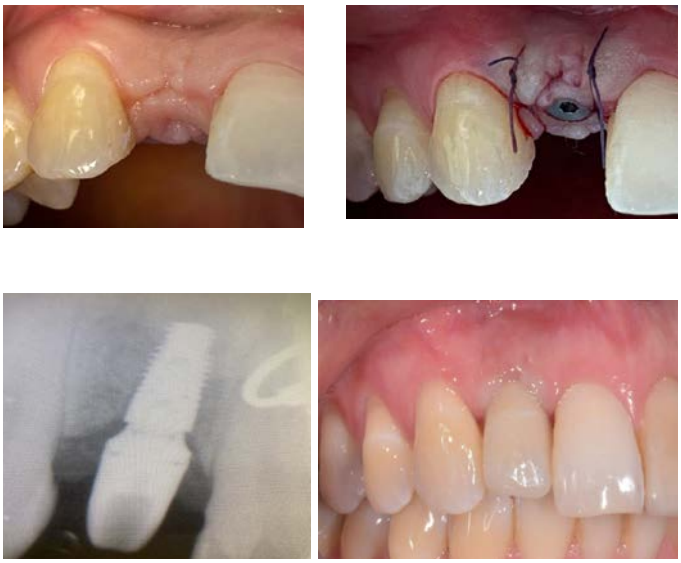


Case 3.

Case 4

A 30-year-old patient with mono-edentulous zone 1.2 due to a previous root crown fracture presented to us for prosthetic rehabilitation. He had a thin biotype and the smile-gum which makes both implant insertion and the aesthetic result very difficult. It is decided to insert a 3.3-diameter and 9-mm-high implant with 3.5-mm GFA. At the end of the surgical phase, a corrected positioning of the GFA level with the gingival margin but after waiting for the osseointegration phenomenon and at the moment of taking the impression the gingival margin seemed to have migrated apically requiring a substitution of a 2 mm GFA abutment.

After the correct selection of the GFA the temporary crown has integrated correctly with the peri-implant soft tissue with an aesthetic result satisfactory.



Case 4.

DISCUSSION

Marginal bone loss around dental implants has been attributed to several factors. It may be the result of the establishment of a pathogenic microflora, which promotes the onset of peri-implant disease with mucosal inflammation, increased pocket depth and progressive bone resorption. Other studies have suggested that changes in marginal bone level may be the result of biomechanical stress due to incorrect occlusal design (6, 9, 13, 14).

Crestal bone loss may be the physiological result of incorrect three-dimensional positioning of the fixture. The coronal portion of the bone may tend to resorb if the fixture is placed too close to adjacent teeth/implants or a thin residual buccal wall (10, 15).

Subcrestal placement of the implant platform may negatively influence the stability of the peri-implant marginal bone. Crestal bone resorption is also related to the presence of a microgap between implant and abutment and the position of this microgap in relation to the crestal bone level.

The microgap, the micromovement between the fixture and the abutment, and the presence or absence of the switching platform are therefore considered the main factors in marginal bone resorption (2, 5, 9, 12).

Respect of the surgical protocol with a subcrestal positioning and a screwing torque of the implants that is not excessive and the control of the implant insertion axis, which must be as coincident as possible with the prosthetic axis, are key factors in the long-term success of implant rehabilitation (1, 10).

CONCLUSIONS

A conical or cono-morse implant-abutment connection allows subcrestal placement of the fixture, with a substantial reduction in the risk of microbial colonisation and/or micromovement, both negative prognostic factors for marginal bone maintenance.

It is even more evident how the use of abutments with a smaller diameter than the fixture (platform switching) and their early and single insertion (one-time abutment) both contribute to preserving the mucosal bone tissue complex around the implant, positively influencing the prognosis and success of therapy (1, 16, 17).

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Case report

SURGICAL APPROACH OF AN ECTOPIC THIRD MOLAR IN THE MAXILLARY SINUS

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ABSTRACT

Ectopia of third molars within the maxillary sinus is uncommon. Few cases have been reported in the literature. Generally, the diagnosis of upper third molar ectopia at the level of the maxillary sinus can be made following a routine diagnostic examination such as panoramic X-ray, or CBCT in which any lesions created by the element itself can additionally be detected. Our case presents a third molar included in the left upper maxilla of a 60-year-old male patient. The element was removed under general anesthesia, and after twelve months of follow-up, new panoramic X-ray and CBCT were requested to assess the healing of the compromised area.

KEYWORDS: *ectopia, molar, maxillary sinus*

INTRODUCTION

Dental eruption is a physiological process by which the tooth element in formation achieves its functional position within the oral cavity. Development of the element and proper intraoral positioning depend on complex cellular interactions and molecular processes that may be subject to variation determining the development of an ectopic tooth.

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Ectopic eruption of a tooth element is frequently encountered in clinical practice and the etiology is multifactorial: cleft palate, trauma, odontogenic or rhinogenic infections, genetic factors, cysts, and dental crowding can all contribute to the onset of the phenomenon (1).

This altered process is frequently seen in dental areas, but less common in non-toothed areas such as the mandibular condyle, coronary process, orbit, palate, and nasal cavity. Occasionally, a tooth may erupt within the maxillary sinus.

In the English literature, patients were observed with higher prevalence of ectopic teeth in third molars, 21 cases, followed by unspecified molars. The lowest prevalence of ectopic teeth was found in the first molar, second premolar, and first incisor (2-6).

Generally these elements remain asymptomatic for years and their diagnosis is made only after routine diagnostic exams are performed; sometimes they may cause recurrent sinusitis.

Case report

A male patient aged 60 years came to our observation, reporting pain in the left upper maxillary area, retronasal purulent discharge and halitosis for about three months.

On intraoral clinical examination, there was mild swelling in the left upper vestibule at the level of the molar apices. The area was painful on palpation with discharge of purulent material at the intrasulcular level of elements 26 and 27 and from the left nasal choana.

A panoramic X-ray was done and it showed a radiotransparent area involving the region of the left upper maxilla and the upper third molar within the maxillary sinus (Fig. 1).

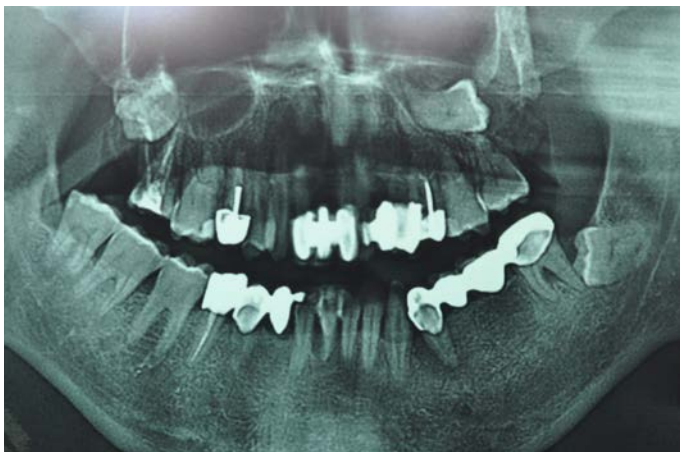

Fig. 1. *Panoramic X-ray showing the presence of ectopic tooth element 2.8 at the level of the left maxillary sinus.*

A chronic purulent sinusitis associated with a maxillary odontogenic cyst from 28 in ectopic position was suspected. Then a CBCT scan has been prescribed, showing a hypodense and well-circumscribed lesion measuring 20 mm x 30 mm in the posterior region of the maxilla, surrounding the crown of the left third molar in an ectopic position. The right maxillary sinus showed mucosal thickening and filling of the alveolar recess, indicative of chronic maxillary sinusitis (Fig. 2).

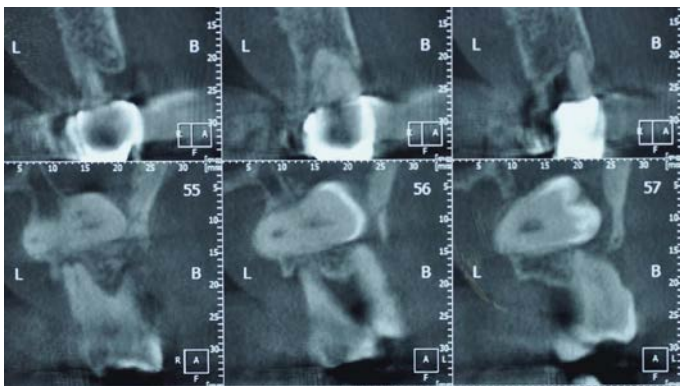

Fig. 2. *From the CBCT, a hypodense and well-circumscribed lesion surrounds the crown of the third molar.*

The patient was admitted to the hospital for surgery under general anesthesia. Before surgery, informed consent was signed by the patient. Under general anesthesia, we proceeded to do Caldwell-Luc surgery with removal of the cyst and removal of the associated tooth and extracted the severely compromised elements 26 and 27. A thick purulent creamy material, due to the infectious process, was found within the cavity. The surgery was accompanied by a counter-opening performed in the medial sinus wall, introduction of PVC canula for drainage and endosinus lavage with physiologic saline. The canula was removed on day 5. Periodic nasal sinus lavages with physiologic were performed every 10 days for a period of 2 months.

The specimen was sent for histological examination, which confirmed the diagnosis of odontogenic cyst. In the postoperative course there were no severe complications. The final diagnosis of maxillary sinusitis caused by dentigerous cyst with ectopic third molar was confirmed. Severe and disabling symptomatology disappeared after surgery.

After 14 days, sutures have been removed. The healing was found to be good, and the mucosa appeared healthy and pink. On an objective examination performed 30 days after surgery, the patient was asymptomatic and optimal tissue healing was evident. Approximately 12 months after surgery, a panoramic X-ray and a CBCT were prescribed to the patient to assess the healing and bone regeneration of the cavity (Fig 3, 4).

DISCUSSION

Dental tissue development begins in the intrauterine phase, during the sixth week, through interaction between oral epithelium and mesenchymal tissue. Abnormal tissue interactions, embryological pathologies, such as fusion defects or cyst formations, during this stage, can generate dental ectopias. In addition, the same phenomenon could be caused by displacement of the dental gems, by expanding dentigerous cysts or displacement during eruption of the third molar, malpositioning related to trauma and supernumerary teeth (2).

Certainly, the ectopic condition in an area that physiologically does not involve the presence of dental elements, such as the maxillary sinus, is not frequently encountered in clinical practice. The elements most susceptible to ectopia seem to be the third molars and canines, which generally take a longer time to erupt.

The discovery of a tooth element in ectopic position may or may not be accompanied by the presence of symptoms such as sinusitis and purulent rhinorrhoea, that cannot be treated with antibiotic prophylaxis. In addition, patients often report swelling, pain, headache, and nasal obstruction. In some cases, symptoms like infraorbital nerve hypoesthesia, epiphora and hemoptysis have been described. Regarding possible infections, cases of oroantral fistulas and purulent discharge have been reported (6-9). Our patient reported pain in the left upper maxillary area , retronasal purulent discharge and halitosis for about three months.

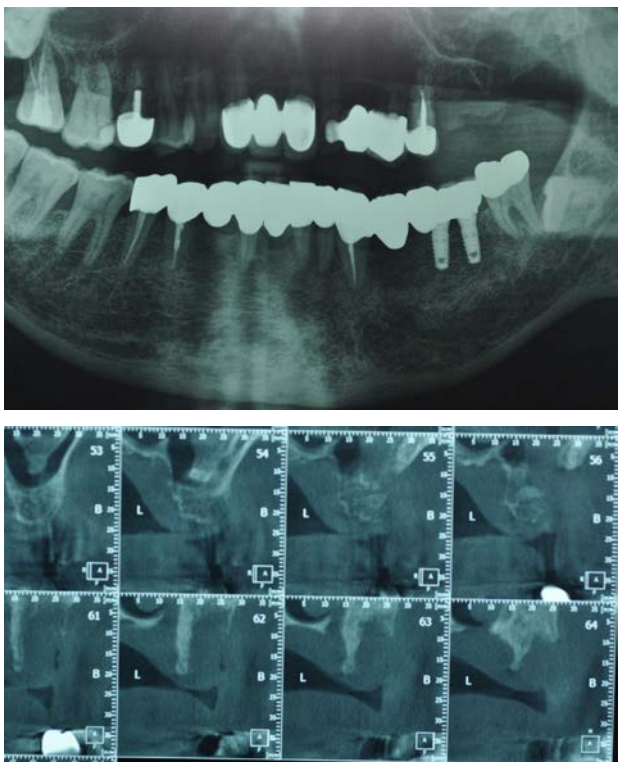

Fig. 3, 4. *X-rays demonstrating successful bone healing.*

The diagnosis of the lesion associated with ectopic element was made following a panoramic X-ray. Subsequently, the patient underwent a CBCT to better highlight the location of the tooth and the margins of the hypodense lesion identified in the previous X-ray. The CBCT gives a better representation of the sinuses; it also allows us to have more details regarding the position, in this case, of the ectopic element and the size and extension of the associated lesion (10). After viewing the CBCT we opted for enucleation of the cyst removing the associated element with Cadwell-Luc surgery, by which the operators ensured a direct view of the element during the surgical procedure.

CONCLUSIONS

In conclusion, dentigerous cysts associated with ectopic maxillary third molars are rare and poorly documented. They can involve the maxillary sinus and cause chronic maxillary sinusitis (11, 12). Treatment involves surgical removal of the tooth and of the associated lesion using the Cadwell-Luc procedure. If there is unilateral maxillary pain, or hemifacial headache, odontogenic sinusitis should be suspected. A careful oral and radiographic examination is essential as evidenced by the case reported in this article, in which a dentigerous cyst associated with an ectopic third molar caused a maxillary odontogenic sinusitis.

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Case report

TREATMENT MANAGEMENT IN A YOUNG PATIENT WITH TEMPOROMANDIBULAR DISORDER AND MALOCCLUSION: A CASE REPORT

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ABSTRACT

Signs and symptoms of temporomandibular disorders (TMD) are observed in a percentage ranging from 7.3 to 30.4% of children and adolescents. The purpose of this work is to report a clinical case of a young patient suffering from TMD and malocclusion and who was treated with a gnathological occlusal splint and fixed orthodontic appliance. The patient, a girl aged 10 years and 10 months, had a slight tendency to skeletal Class III malocclusion, 6 mm overbite, 1.4-1.5 crossbite, multiple rotations and lower crowding. A gnathological occlusal splint was made to alleviate the acute symptoms and a gnathological retention splint at the finishing stage of fixed appliance was applied to achieve the functional occlusion. Observation after 2 years out of orthodontic treatment revealed a stable occlusion and improved of TMD symptoms.

KEYWORDS: *temporomandibular disorder, malocclusion, treatment, management, adolescent patients*

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INTRODUCTION

In everyday clinical practice, it is common to find patients reporting orofacial pain. Thus, a routine temporomandibular disorder (TMD) examination prior to the beginning of the orthodontic therapy is essential (1). For orthodontists and general dentists, it is mandatory to carry out a complete medical history and a comprehensive temporomandibular joint (TMJ) exam to evaluate the presence of any TMD. This allows to recognize patients suffering from orofacial pain conditions and thus to exclude them from the orthodontic treatment until the pain sensation is managed (2).

TMD is a collective term, including several clinical problems involving muscles, TMJ or both. Even if TMD more frequently affects adults, signs and symptoms are observed in a percentage ranging from 7.3 to 30.4% of children and adolescents. The prevalence is higher in females than males and increased with pubertal development (3–5).

The TMD etiopathogenesis of growing patients includes systemic, pathological, psychosocial traumatic, hormonal, genetical, skeletal and occlusal factors (3, 6). The diagnosis of TMD is based on anamnestic collection, clinical examination and instrumental diagnosis.

Clinical and physical assessment of the patient may include the history and determination of joint sounds, evaluation of the mandibular range of motion, appraisal of pain, evaluation for signs of inflammation and a correct clinical and radiographic examination (7, 8). For clinical diagnosis, the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) use, by Schiffman et al (2014), are strongly recommended (9).

TMD treatment goals include restoration of function, pain decrease, control of any aggravating or contributing factors and improvement of life quality.

Treatment of TMD can be divided into reversible and irreversible. It has been suggested that simple, conservative and reversible types of therapy are effective in reducing most TMD symptoms in children (10–13), including patient education, physical therapy [e.g., jaw exercises or transcutaneous electrical nerve stimulation [TENS)], behavioral therapy, prescription medication (e.g., non-steroidal anti-inflammatory drugs and muscle relaxers) and occlusal splints (3).

The goal of an occlusal appliance is to provide orthopedic stability to the TMJ. These may be used to decrease parafunctional activity and pain (14–16). Occlusal splints are made of hard acrylic. The stabilization type of splint covers all teeth on either the maxillary or mandibular arch and is balanced to allow the occlusion of all teeth when the jaw is in a musculoskeletal stable position.

The aim of an occlusal appliance is to provide orthopedic stability to the TMJ before starting an orthodontic treatment in permanent dentition. These alter the patient's occlusion temporarily and may be used to decrease the parafunctional activity and pain.

Every comprehensive dental history and examination should include a TMJ history and assessment (17). The history should include questions concerning the presence of head and neck pain and mandibular dysfunction, previous orofacial trauma and current illness with an account of the symptoms. In the presence of a positive history and/or signs and symptoms of TMD, a more comprehensive examination (e.g., palpation of masticatory and associated muscles and the TMJ's, documentation of joint sounds, occlusal analysis, and assessment of range of mandibular movements including maximum opening, protrusion, and lateral excursions) (18), together with general dental and medical assessments (19, 20) should be performed.

Thus, the purpose of this work is to report a clinical case of a young patient accompanied with temporomandibular, treated with gnathological occlusal splint, fixed orthodontic appliance and transcutaneous electrical nerve stimulation (TENS).

CLINICAL CASE

Diagnosis and etiology

The patient came with their parents to the Orthodontic Program of the Multidisciplinary Department of Medical-Surgical and Dental Specialties of the University of Campania Luigi Vanvitelli in Naples. They were worried about her orofacial pain and temporal headache and were unsatisfied with her smile.

The patient was a 10 years and 10 months old Caucasian girl who was particularly anxious. A full visit with occlusal and functional examinations was performed by an orthodontist. The clinical evaluation revealed mouth opening reduced

(36 mm), normal lateral mandibular movements (9 mm), joint pain during functions and no clicking sounds in the TMJ. About the symptoms, she referred daily temporal headache, weakness upon weaking, myofascial pain, difficulty in mouth opening, parafunctional activities and anxiety.

Moreover, the patient presented a slight tendency to class III skeletal malocclusion, increased lower third of the face, irregular smile arch, crossbite of 1.4-1.5, increased overbite (6 mm), moderate lower crowding and multiple rotations. She did not receive any previous gnathological or orthodontic treatment.

In frontal view, the patient presented a symmetric face while in lateral view, the profile was retruded with incompetent lips at rest. There was no history of trauma of craniofacial complex. The panoramic radiograph showed the presence of all permanent teeth and the symmetric condyles without any pathological alterations (Fig. 1).

The cephalometric morphological assessment of the lateral skull radiograph showed a slight tendency of skeletal Class III (ANB = 1°; AoBo = -1 mm) with hyperdivergency (S-N / Go-Gn = 39°; FMA = 30°) and the lower incisors presented lingual inclination (IMPA = 82°).

Treatment objectives

Based on the patient's age and diagnosis, the best treatment option was an initial gnathological phase followed by orthodontic treatment.

The treatment of choice seemed to be the most rational option considering the patient and her parents' anxiety and expectations, the TMD and the occlusal features showing unilateral crossbite and lower crowding. The main treatment objectives are described below.

First phase: gnathological treatment to reduce muscle contraction, parafunctional activity and pain. The appliances used were gnathological occlusal splint, TENS and physical therapy.

Second phase: orthodontic treatment with crossbite correction, vertical growth pattern control, lower crowding correction, alignment, leveling and arch form coordination and overbite correction. The appliances used were a 7-7 multibracket fixed appliance in the upper and lower arch (0.022x0.028 MBT prescription) and cusp seating elastics.
Thus, a two-phase gnathological-orthodontic treatment was proposed and accepted by the patient and her parents.

Treatment progress

The first phase of treatment started one month later the initial check-up, in October 2016. The first gnathological phase

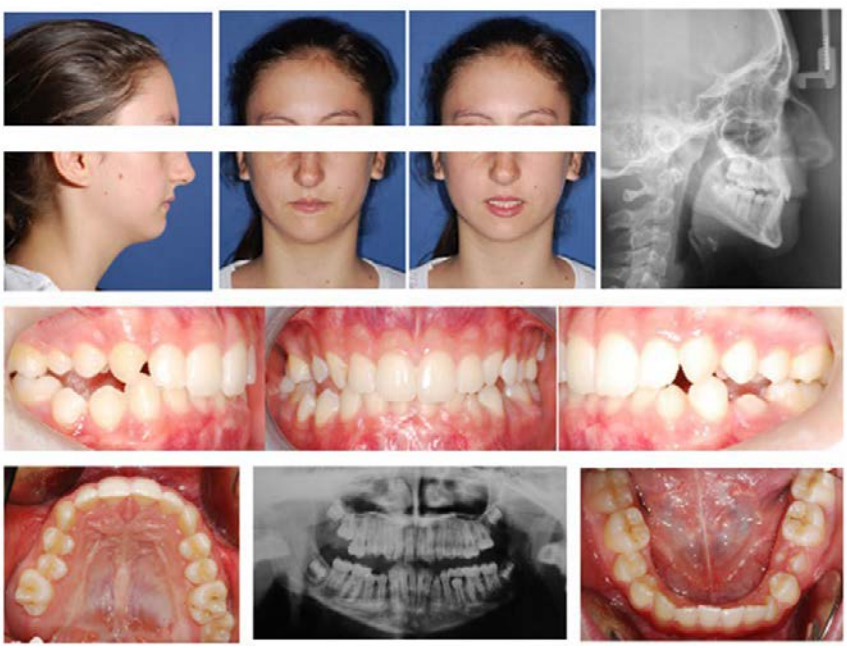

Fig. 1. *Pre-treatment records*

consisted of a treatment with occlusal splint in the upper arch (functionalized one a month), TENS (two a month) and physical therapy (two a month) for 8 months (Fig. 2).

After this period of time, the patient underwent a re-evaluation with interim records (both photographic and radiographic) in July 2017. During the re-evaluation was found an improvement of temporal headache, weakness upon weaking, myofascial pain, difficulty in mouth opening, parafunctional activities and anxiety. Then the patient was ready to proceed towards the second phase, controlling constantly any recurrence of temporo-mandibular symptoms.

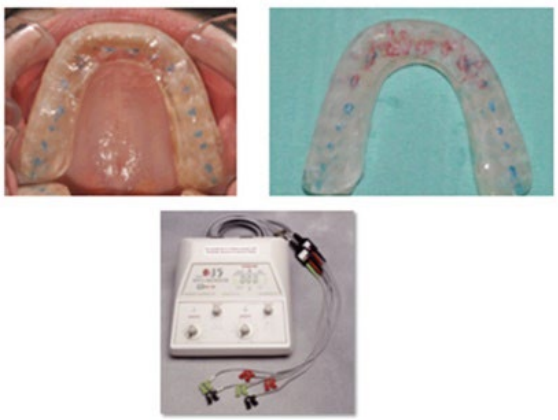

Fig. 2. *Gnathological occlusal splint and TENS*

The second phase of treatment started in September 2017. The upper and lower arches were fully bonded with 0.022x0.025" MBT multibracket fixed appliances.

The following archwire sequencing was used: .016 nickel-titanium for alignment, .019x.025 nickel-titanium for leveling, .019x.025 stainless- steel for arch coordination and .018 AJ Wilcock Australian wire with refinement bends and cusp seating elastics for the finishing stage. This phase of treatment lasted 1 years and 6 months.

The retention phase included a Hawley retainer appliance in the upper arch and a cuspid-to- cuspid fixed retainer in the lower arch. The patient was repeatedly advised to report any case of recurrence of orofacial pain during the orthodontic phase.

Treatment results

The treatment goals were achieved (Fig. 3). The occlusal, functional and esthetic results were satisfactory, the patient and her parents were happy of her smile. TMD symptoms were improved, the smile arch was good with no buccal corridors, however the profile appears still biretruded.

Oral hygiene during orthodontic treatment was quite good, periodontal tissues were healthy. There were no decayed elements or signs of enamel decalcification and the panoramic radiograph did not show any sign of bone loss or root resorption.

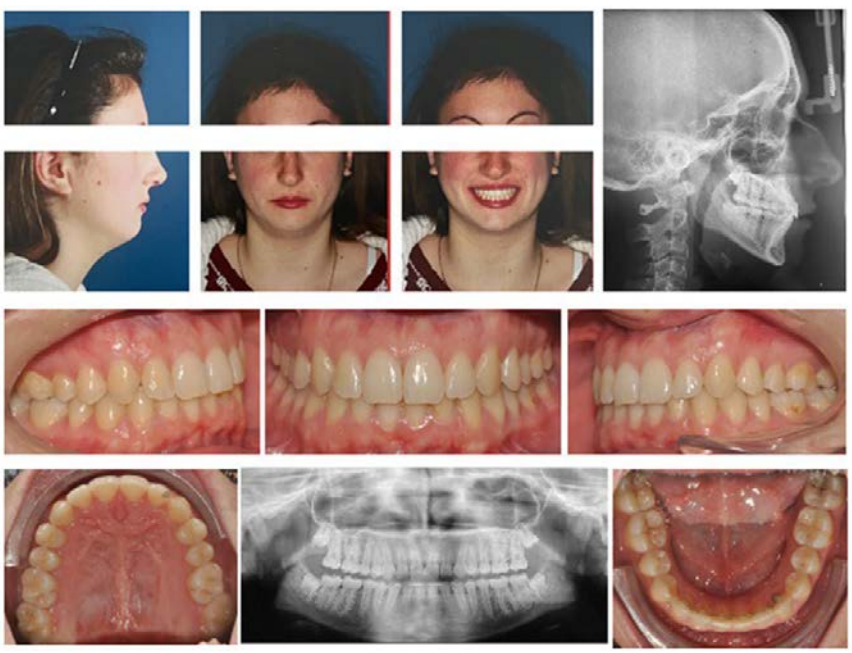

Fig. 3. *Final records*

Intra-oral photographs and dental casts showed a good alignment of marginal ridges, while leveling and arch coordination were achieved: the crossbite and the lower crowding were corrected. The overjet was maintained and the overbite was corrected.

The final static occlusion was satisfactory also on the lingual side and no prematurity was present during protrusive and lateral mandibular movements. Panoramic radiograph revealed that good roots angulation was achieved.

The lateral skull radiograph showed the control of vertical skeletal relations between pre-treatment and post-treatment cephalograms and the incisor inclination.

The panoramic radiograph showed no signs of condylar resorption or periodontal disease. The third molars were present and impacted within the jaw bones.

No clear signs of root resorption can be noted. Root angulations were parallel.

In the final lateral cephalogram assessment the hyperdivergent pattern was controlled (S-N/Go-Gn from 39° to 38°).

The upper and lower incisors inclinations were improved (I/SN from 98° to 102°; IMPA from 82° to 92°). Overjet has remained relatively unchanged while the overbite was corrected.

DISCUSSION

The reported case of a child with TMD pain shows how treatment goals were achieved. The symptomatic, functional, occlusal, esthetic and psychological results were satisfactory. The outcome was rewarding for the clinicians and appreciated by the patient and her parents The key points determining the success of the treatment were good interdisciplinary cooperation (orthodontist, physiotherapist and mental health specialist) and the parent's and patient's collaboration, as reported previously in the international literature (21, 22). Further possible medical correlations should be always checked and monitored in these patients. It is important to prioritize the patient's symptoms, evaluating not only the occlusion but the entire orofacial area, trying not to minimize any signs of TMD. In the field of clinical dentistry, TMD are one of the major diseases. TMD pain in adolescents' patients is frequent and has a clear impact on daily living. In the present study we have used a splint in the upper arch (functionalized one a month), and TENS. Splint therapy has been used to help a majority of young patient with TMD pain and was also a treatment approach in this study (23). TENS is a non-invasive treatment modality for acute and chronic pain. TENS has a positive effect in treatment of TMD patient.

CONCLUSIONS

Treatment of adolescent patients with combined TMD and severe dento-skeletal malocclusions is among the most difficult challenges for orthodontists. In fact, the orthodontists cannot simply aim an occlusal correction but also have to treat all the orofacial complex trying to keep TMD under control, trying to prioritize TMJ signs and symptoms improvement.

Therefore, the treatment in a patient with TMD and malocclusion should be an interdisciplinary treatment that aimed to improve the function, the occlusion and consequently the patient's quality of life. The present study shows also the immediate effects of TENS treatment on TMD-related muscle pain.

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Letter to the Editor

INTERVENTIONAL TREATMENT OF SACROILIAC JOINT DISEASE

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ABSTRACT

Sacroiliac joint (SIJ) disease is a common cause of lower back and buttock pain. It poses a significant diagnostic and therapeutic challenge due to its complex anatomy and varied clinical presentation. Interventional treatments have emerged as effective options for managing SIJ disease, offering potential pain relief and improved quality of life for patients. This comprehensive review explores the interventional treatment modalities available for sacroiliac joint disease, including diagnostic techniques, minimally invasive procedures, and emerging therapies. We delve into the evidence-based literature, discuss the efficacy and safety profiles of these interventions, and highlight key considerations for their implementation. By examining the interventional armamentarium for SIJ disease, this review aims to provide clinicians and patients with a thorough understanding of the available options and inform decision-making in the management of this challenging condition.

KEYWORDS: *sacroiliac joint, fixation, injection*

INTRODUCTION

The sacroiliac joint (SIJ) plays a crucial role in load transfer and stability of the pelvis, linking the spine to the lower

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extremities; while the SIJ disease refers to a range of pathologies including inflammation, degeneration, and instability the SI pain refers to discomfort or pain in the sacroiliac joint (1). SI pain can manifest as pain, tenderness, or discomfort in the lower back, buttocks, hips, or groin area that may be exacerbated by sitting, standing, walking, or climbing stairs (2).

The pain may be localized to one side or can radiate down the leg, resembling sciatica leading to difficulties in differential diagnosis (1-2). The exact prevalence of SI joint-related LBP is challenging to determine due to diagnostic difficulties and varying definitions of SI joint dysfunction. However, studies suggest that the SI joint is a potential source of LBP in approximately 15% to 30% of individuals with chronic low back pain without significant gender difference (3-4).

Despite its prevalence, diagnosis and treatment of SIJ disease remain challenging due to its complex anatomy and the lack of specific clinical and radiographic findings. The advent of interventional techniques has revolutionized the management of SIJ disease, providing targeted therapies and enhancing patient outcomes.

Diagnosis of sacroiliac pain

Diagnosing sacroiliac (SI) pain can be challenging because the symptoms may overlap with other conditions affecting the lower back and hips. The diagnosis of sacroiliac (SI) pain typically involves a comprehensive evaluation that includes a combination of medical history, physical examination including and diagnostic tests; once the diagnosis is confirmed, long-term solutions may be considered.

1. Medical History: several factors can increase the risk of developing SI pain, including:

- pregnancy and childbirth: The hormonal changes and increased stress on the SI joints during pregnancy can contribute to SI pain. It is estimated that up to 60% of pregnant women may experience SI joint pain (5);
- trauma or injury: accidents, falls, or repetitive activities that strain the SI joint can lead to SI pain (2). SIJ disease is present in 45%-75% patients undergone posterior fixation treatments (fig. 1a, b);

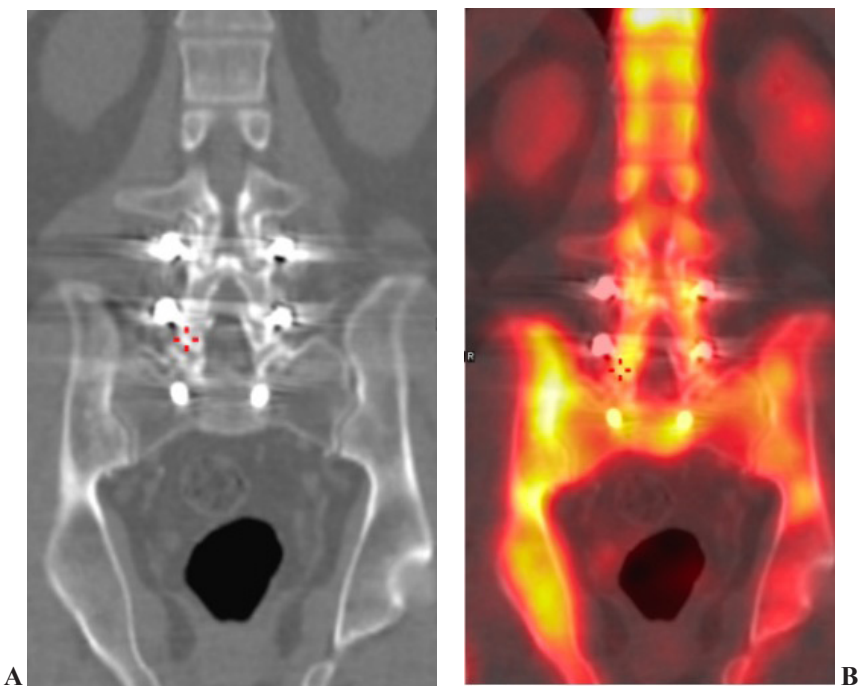
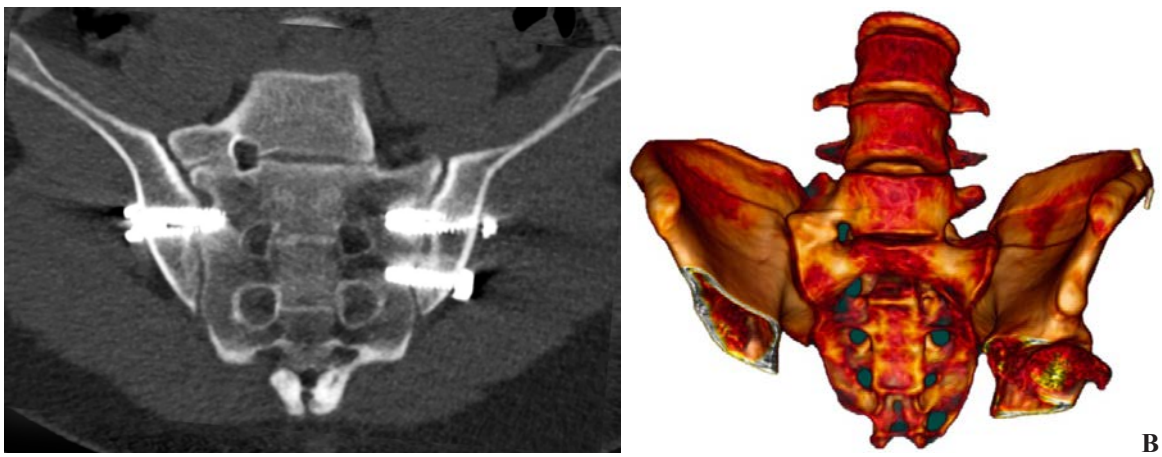


Fig. 1. *Chronic right-side pain and sacro-ileitis in a patient undergone posterior fixation. Coronal CT 2D recon demonstrates transpeduncolare screws at the level of L4, L5 and S1, in a patient treated 5 years before with surgical posterior fixation. No significant bone abnormality can be detected on CT scan (**1a**). On SPECT-CT scan, evident Tc99 uptake can be detected at the level of right SIJ area as well as right iliac bone, secondary to posterior fixation (**1b**).*

- inflammatory conditions: certain inflammatory diseases, such as ankylosing spondylitis and psoriatic arthritis, can affect the SI joints and lead to pain (6);
- degenerative conditions: conditions like osteoarthritis or degenerative joint disease can affect the SI joints and cause pain (7). Transitional lumbar vertebra is another condition commonly associated to the SIJ disease (Fig. 2a, b).

2. Physical examination: clinical evaluation involves (2):
- posture assessment;
- range of motion in order to assess the mobility and stability of the SI joint using maneuvers such as the FABER (flexion, abduction, external rotation) test, Gaenslen's test, and the thigh thrust test aid in identifying SIJ pathology;
- provocative tests able to reproduce SI joint pain stressing the SI joint in various positions to determine if it is the source of pain.

3. Imaging tests: no specific radiological findings for the diagnosis of sacroiliac joint-related pain however diagnostic imaging tests are often used to help confirm the diagnosis and rule out other possible causes of pain.
These may include:
- plain films: X-rays can provide a basic view of the SI joint and can help identify fractures, degenerative changes, or abnormalities in the joint structure;
- It is important to remember that the SI joint has a complex three-dimensional structure, and plain film X-rays provide a two-dimensional representation. This limitation can make it challenging to accurately assess the joint's full extent, especially regarding subtle changes or early-stage pathology. Neverless, radiographic features such as erosions, sclerosis, and ankylosis are typically seen in advanced inflammatory sacroiliitis and are graded from 0 (normal) to 4 (ankylosis) according to the modified New York criteria (8).
- Magnetic Resonance Imaging (MRI): an MRI scan can provide more detailed images of the SI joint, soft tissues, and surrounding structures. It can help detect inflammation, joint abnormalities, or other potential causes of pain and it has been introduced for the evaluation of axial spondylarthritis due to contrast resolution and 3D according to sacrum plane (9).
- Computed Tomography (CT) scan: a CT scan may be ordered to provide a detailed, cross-sectional view of the SI joint and surrounding structures, particularly if there is a suspected bony abnormality.



A **B**

Fig. 2. *Right L5 emisacralization in a patient with transitional vertebra and bilateral sacroiliac pain. On 3D CT recons there's evident fusion between the right L5 hemivertebra and the ipsilateral sacral wing, concurring to the asymmetrical loadstress and SIJ disease development (**2a**). Bilateral SIJ fixation putting 2 screws on regular left side, one at the S1 level and the second at S2, and a third contralateral screw at S1 level were introduced, resolving the clinical symptoms related to the disease (**2b**).*

- CT Sensitivity, accuracy and detailed information compared to plain radiography. However, due to higher radiation exposure, it is not advisable to use CT for diagnosis or follow-up purposes.
- nuclear medicine is not typically used as a first-line imaging modality for evaluating SI pain, it can be considered in certain cases to assess specific underlying conditions.

No comprehensive guidelines for SI pain have been provided yet. Routinely, conventional radiography represents the first-line modality in most instances and serves as a useful baseline for future comparison; however, the absence of radiographic changes does not exclude an underlying process and many patients with suspected inflammatory back pain usually proceed to further imaging, in particular MRI (9-10). In patients with suspected infection, contrast-enhanced MRI (CE-MRI) or planar or SPECT-CT isotope bone scintigraphy are the modalities of choice, with MRI offering better assessment of anatomical changes and periarticular soft tissue structures over SPECT-CT without ionizing radiation exposure (9-10).

MRI, CT, and isotope bone scintigraphy are all useful in the detection of stress fractures of the sacrum and pelvis. CT is helpful in situations in which there is a contraindication to MRI and provides excellent delineation of periarticular erosions, sclerosis, or osseous metastasis (9-10).

4. Diagnostic Injections: diagnostic injections, such as intra-articular anesthetic blocks or provocative SIJ injections, are considered the gold standard for confirming the diagnosis of SIJ-related pain; in fact, controlled injections into the SIJ can provide temporary pain relief, aiding in the accurate identification of the pain source.

These injections involve injecting an anesthetic (eg lidocaine) or a combination of anesthetic and anti-inflammatory medication into the SI joint in order to temporarily numb the joint and assess its involvement in the patient's pain symptoms: if the injection provides temporary relief of pain, it suggests that the SI joint is the source of the pain (11).

The diagnostic injections are performed under imaging (fluoroscopy and/or CT rarely under US or MRI) guidance in order to drive accurately the needle at the level of SI joint with patient in prone position; usually a local anesthesia is performed before needle insertion at the level of SI joints (11).

No more than 2.5 mL of injectate are recommended during an intra-articular diagnostic injection; in fact, extravasation of local anesthetic onto nearby neural structures theoretically compromises the specificity of the diagnostic injection (12-13).

Minimally invasive procedures

There are various nonsurgical treatment options available for sacroiliac joint SI pain, including pain medications such as nonsteroidal anti-inflammatory drugs (NSAIDs), physical therapy (PT), steroid injections into the SIJ, and radiofrequency ablation (RFA) targeting the sacral nerves.

For acute or subacute SI pain, a combination of NSAIDs, icing, and activity modification can be helpful in reducing pain (11). However, it's important to note that NSAIDs do not address the underlying disease process. Moreover, opioids have not been proven to be safe and effective for treating chronic SIJ pain, and their potential for addiction remains a significant public health concern.

The effectiveness of PT for treating chronic SIJ dysfunction and pain has not been demonstrated probably because of a paucity of high-level literature secondary to the great variability in the functional biomechanical deficit in patients with SI pain.

In this scenario, minimally invasive techniques can play a pivot role in SI pain management. Minimally invasive treatments aim to alleviate discomfort and improve functionality in the sacroiliac joint and enhance the overall quality of life for affected individuals. These techniques offer a targeted and minimally invasive alternative to surgical interventions, reducing morbidity, and optimizing resource utilization.

Sacroiliac joint injections

Sacroiliac joint injections involve the injection of local anesthetics, corticosteroids, or a combination of both into the SIJ. These injections aim to provide pain relief, reduce inflammation, and facilitate functional improvement. Various approaches, such as fluoroscopy-guided, CT-guided or ultrasound-guided injections, can be employed to ensure accurate

needle placement. There is no high-level evidence supporting the short- or long-term effectiveness of this treatment option.

Since there is no conclusive evidence supporting corticosteroid injections as superior to a placebo, the usefulness of trials using corticosteroid injections as an active control group is uncertain. No improvement in pain or function beyond 1 month with injections in 3 randomized control trials (RCT) evaluating SIJ injection versus radiofrequency (14-16). The cost-effectiveness of sacroiliac joint steroid injections has not been established.

There is a lack of evidence demonstrating long-term pain relief from this procedure, and the benefits of repeated injections have not been confirmed through studies.

Radiofrequency ablation

Radiofrequency ablation (RFA) involves the use of thermal energy to create lesions on the nerves supplying the SIJ, thereby interrupting pain signals. This minimally invasive procedure offers prolonged pain relief and has shown promising outcomes in patients with SIJ pain refractory to conservative management.

The analysis of RF ablation literature is constrained by the inconsistencies in patient selection criteria, the specific nerves chosen for ablation, and the diversity of RF ablation technologies and techniques employed. Four randomized trials, aiming to explain the effectiveness of radiofrequency (RF) ablation compared to sham procedures, have been published. Two studies indicate that RF ablation of the lateral branches of sacral nerve roots can provide temporary relief from SI pain (17-18). A one-year follow-up from one of the cooled RF ablation trials showed a moderate reduction in pain (19). In a smaller trial conducted by Mehta et al. (with a sample size of 30), RF ablation strip lesioning was compared to a sham procedure, resulting in significant improvement in Visual Analog Scale (VAS) and EuroQOL-5D scores at 3 months (20). A more recent study comparing heated RF ablation to a sham procedure demonstrated no significant difference in pain level or patient satisfaction at 1 or 3 months (21).

Additionally, there are three pragmatic RCTs comparing RF ablation to SIJ steroid injection demonstrating better clinical results in RFG groups (14-16). Moreover, SIJ RF ablation randomized against PT, the authors demonstrated no significant differences in pain level or patient satisfaction at 3, 6, 9, or 12 months (22). In the context of the Dutch healthcare system, RF ablation was determined to lack cost-effectiveness from a societal standpoint for patients experiencing chronic pain originating from the sacroiliac joint (23).

Prolotherapy and PRP injection

Prolotherapy involves the injection of biological substances, such as dextrose, into ligamentous tissue is believed to trigger a series of activities, from the influx of granulocytes, macrophages, and fibroblasts to the release of growth factors, finally leading to collagen deposition.

PRP injections utilize the patient's own concentrated platelets to promote tissue regeneration, reduce inflammation, and alleviate pain. PRP therapy has gained popularity as an adjunctive treatment for SIJ disease, particularly in cases of ligamentous laxity and degeneration. There are not RCT nor cost analysis related to those techniques.

A recent case series demonstrated that concentrated dextrose prolotherapy combined with platelet-rich plasma (PRP) injections has been successfully employed to treat lumbo-sacral spine osteoarthritis (OA) in elderly patients who had previously experienced ineffective results with conventional treatment approaches (24).

Minimally invasive fusion techniques

Minimally invasive fusion techniques, such as SIJ fusion using implants or bone grafts, provide long-term stabilization and pain relief for patients with severe SIJ dysfunction. These procedures aim to restore joint stability while minimizing tissue trauma and accelerating recovery:

- SI Joint Fusion with Implants: this technique involves the use of implants or devices designed to stabilize the SIJ. It typically requires a small incision and the insertion of screws, rods, or plates to fuse the joint. The implants help provide stability while the joint heals.
- SI Joint Fusion with Bone Grafting: in this approach, bone graft material is used to promote fusion between the sacrum and ilium. The graft material may be obtained from the patient's own body (autograft) or from a donor (allograft).

Minimally invasive techniques involve small incisions and the use of specialized instruments to prepare the joint and place the bone graft.

- SI Joint Fusion with Percutaneous Screws: percutaneous or minimally invasive screw fixation involves the placement of screws across the SIJ to provide stability and promote fusion. This technique requires small incisions and the use of image guidance to accurately position the screws (Fig. 3).

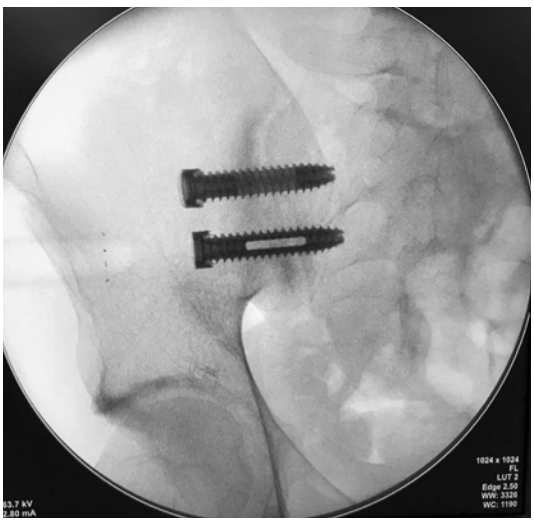


Fig. 3. Right side SIJ fixation, AP radiographic view: the lower screw inserted at the level of S2 shows fenestration, to facilitate bone integration.

The lateral approach has been demonstrated that minimally invasive lateral sacroiliac joint fusion (MIS SIJF) generally causes minimal changes in motion or stress at the opposite sacroiliac joint (contralateral SIJ), minimal increase in motion at the L4-L5 or L5-S1 motion segment, and a limited (5%) increase in stress at the hip joint (25-28).

In 2008, SI-BONE, Inc., obtained FDA clearance to market a porous-surfaced transiliac transfixing implant (TTI) for sacroiliac joint fusion (SIJF). Since then, different lateral transiliac transfixing devices have also received FDA clearance for minimally invasive lateral SIJF. The clinical evidence supporting the use of these devices has significantly expanded over the past decade. However, the majority of high-level clinical evidence regarding the safety, effectiveness, durability, and economic benefits of lateral minimally invasive SIJF is primarily derived from the use of the iFuse implant system (29-31).

These studies present compelling evidence supporting the safety and effectiveness of lateral transiliac minimally invasive sacroiliac joint fusion (MIS SIJF) using lateral transfixing devices. The findings consistently show significant improvements in pain levels, functional abilities, and quality of life (QOL). In both randomized trials, patients who underwent SIJF experienced considerably higher levels of pain relief, reduced disability, and improved QOL compared to those who received non-surgical treatment (32-40).

According to the International Society for the Advancement of Spine Surgery, Policy 2020 Update the MIS SIJF is not indicated in the case of (11):

- Less than 6 months of SIJ pain and/or functional impairment.
- Failure to pursue conservative treatment of the SIJ (unless contraindicated).
- Pain not confirmed with a diagnostic SIJ block.
- Presence of other pathology that would substantially prevent the patient from deriving benefit from SIJF.

EMERGING THERAPIES

Peripheral nerve stimulation

Peripheral nerve stimulation (PNS) involves the placement of electrodes near the nerves supplying the SIJ to modulate pain signals.

PNS is believed to provide pain relief by engaging the gate-control theory of pain, as originally described by Melzack and Wall (41). According to this theory, the excitation of inhibitory dorsal horn interneurons occurs through the stimulation of large-diameter, low-threshold, non-nociceptive Aβ fibers (42). These interneurons play a role in processing and transmitting nociceptive information from Aδ and C nerve fibers, effectively inhibiting the transmission of pain signals from the spinal cord to higher centers in the central nervous system (CNS). PNS also acts to reduce central sensitization and hyperalgesia by diminishing excessive peripheral nociceptive activity within the spinal cord. It achieves this by inhibiting wide dynamic range neurons in the dorsal horn and reducing Aβ fiber-induced activity within the medial lemniscal pathway in the brain. Additionally, animal studies have indicated that the analgesic effects of PNS may involve various pathways, including the serotonergic (5HT2, 5HT3), GABAergic, and glycinergic systems (43).

In a study involving patients with sacroiliac joint pain that did not respond to conservative measures and injection therapy, PNS was implemented, and the patients were followed for up to four years. The study observed significant reductions in average pain scores at one year (measured on the Visual Analog Scale) from 8.8 to 1.6, at two years from 8.8 to 1.9, and at three years from 8.8 to 2.0. By the fourth year, two out of three patients reported satisfaction with the placement of PNS (44). This emerging therapy offers a reversible and adjustable option for pain management, particularly for patients who have failed conventional treatments (40).

Biologic agents and stem cell therapy

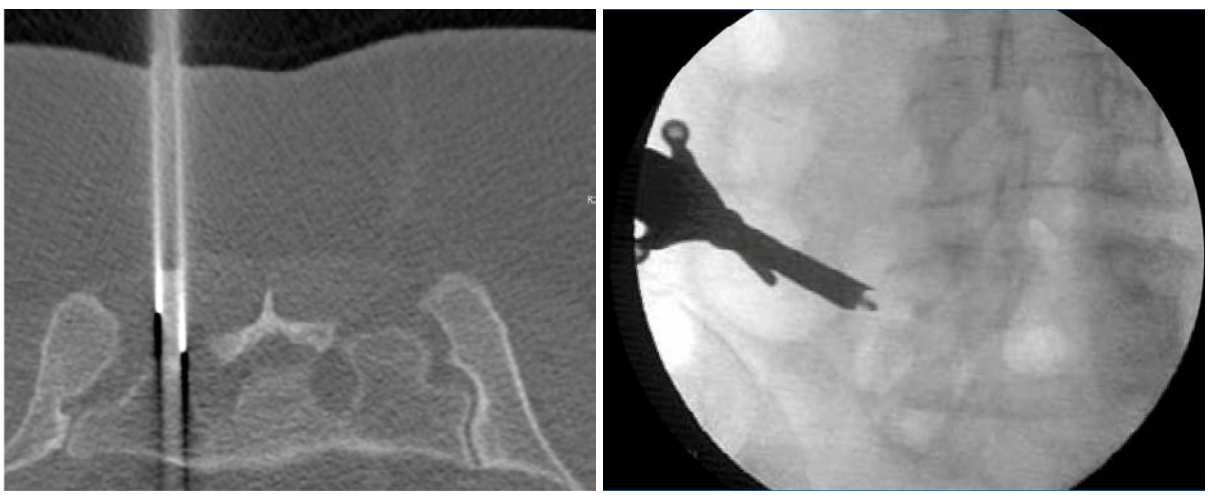
Biologic agents, such as anti-inflammatory cytokines, growth factors, or inhibitors of pain mediators, hold promise for the treatment of SIJ disease. These agents target specific pathways involved in inflammation and pain, providing a potential disease-modifying approach.

Among the different biologic agents, adult stem cells, often known as 'medical signaling cells' or 'mesenchymal stem cells' (MSCs), have been extensively studied. MSCs do not express major histocompatibility complex Class II (MHC class II) proteins, which makes them adaptable to various cell types and reduces the risk of treatment rejection. Their remarkable capacity to differentiate into specific cell types plays a crucial role in the healing process by providing the cells necessary for regeneration (45).

Stem cell therapy explores the regenerative potential of stem cells to repair damaged tissues and promote joint healing. Early preclinical and clinical studies have shown encouraging results, suggesting that stem cell therapy may have a role in the future treatment of SIJ disease. While there are a limited number of studies on the utilization of prolotherapy and biologics for treating axial spine pain, further research with stronger evidence is needed to determine the effectiveness of these therapies (45).

Endoscopic radioablation

Recently invented, Endoscopic radioablation seems to demonstrate more effectiveness in comparison to conventional single-needle RF ablation. The procedure consists in introducing two small working cannulas at the level of the lateral border of both S1 and S1 posterior sacral foramina (Fig. 4a), introducing through the cannula an extremely powerful electroknife together with optic fiber, scratching the lateral margin of the sacral foramina from where the SIJ nerve networks projects to the iliac bone (Fig. 4b), disconnecting the SIJ innervation (46-47).



A **B**

Fig. 4. *Endoscopic radioablation of the SIJ. Under CT-guidance, a working cannula is placed at the lateral margin of the posterior first sacral foramen (**4a**) and a RF probe is then inserted into, emerging at the level of the sacral bone (**4b**), performing strong ablation of the SIJ nerve network at the emerging area.*

CONCLUSIONS

Interventional treatments for SIJ disease aim to alleviate pain, improve functional capacity, and enhance the overall quality of life for affected individuals. These techniques offer a minimally invasive alternative to surgical interventions, reducing morbidity, and optimizing resource utilization. By precisely targeting the source of pain and providing therapeutic interventions, interventional treatments have become integral to the comprehensive management of SIJ disease.

Ongoing research into innovative therapies and technologies, such as targeted drug delivery systems, nanomedicine, and regenerative medicine, holds promise for the future management of SIJ disease. These advancements may offer novel approaches to pain relief, tissue regeneration, and joint stabilization.

Interventional treatments have revolutionized the management of sacroiliac joint disease, providing targeted approaches to pain relief, functional improvement, and joint stabilization. A comprehensive understanding of diagnostic techniques, minimally invasive procedures, emerging therapies, and their efficacy and safety profiles is crucial for informed decision-making and optimizing patient outcomes.

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Letter to the Editor

OZONIZED ORAL GEL AS AN ADJUVANT IN THE TREATMENT OF PERIODONTAL DISEASE: A PRELIMINARY REPORT

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ABSTRACT

Ozonized oils have been demonstrated to induce the reduction of many oral microorganisms. The aim of this study was to evaluate the efficacy of a new ozonized oil formulation for the treatment of periodontal disease. A total of 10 patients with a diagnosis of chronic periodontitis were randomly selected, and a split-mouth scheme was used. All patients underwent to support periodontal therapy at the baseline measurement. Microbial sampling and analysis were performed in each selected site before supporting periodontal therapy. The selected site corresponded to the deepest periodontal pocket of the oral cavity. *Aggregatibacter actinomycetemcomitans, Porphyromonas gingivalis, Tannerella forsythia, Treponema denticola, Fusobacterium nucleatum, Campylobacter rectus*, and Total Bacterial Loading were evaluated through the quantification of total bacterial genome copies by PCR. Then, support periodontal therapy was done using an ultrasonic scaler. After support periodontal therapy, each patient was given ozonized sunflower seed oil [Ozoral gel, Innovares SRL, Sant'Ilario d'Enza (RE), Italy]. The patients were instructed to apply the gel daily after evening oral hygiene at home. After 2 weeks, microbiological samples were collected again in each patient and analyzed. A statistically significant difference was detected between Total Bacterial Loading ($p<0.014$) and *Tannerella Forsythia* ($p<0.012$) pre and post-ozonized sunflower seed oil treatment. Ozoral has demonstrated antiseptic properties. Additional studies with larger sample sizes are needed to confirm this preliminary result.

KEYWORDS: *ozonized oil, ozone therapy, periodontal disease, periodontal pathogens*

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INTRODUCTION

Ozonized oils, like ozonized sunflower oil, have been demonstrated to induce the reduction of many oral microorganisms (1). Ozonation of edible oil is performed by bubbling the gas mixture (O2/O3) into the oil under a controller reaction environment. This preparation is ideal for topical use in treating chronically infected cutaneous and mucosal areas of the body (2). Ozonized oils are widely recognized as one of the best bactericidal, antiviral and antifungal agents, and, therefore, it is profitably and practically employed in medicine and odontology. In this sense, studies have been carried out in peri-implant mucositis (3), caries prevention (4), periodontal diseases (5), regeneration and wound healing of the extraction socket and surgical site (6, 7).

Plaque biofilm is the main cause of both caries and periodontal disease. Ozonized oils have been proven useful in controlling oral infectious microorganisms in dental plaque (3). The antimicrobial property of ozonized oils effectively reduces the number of various periodontal bacteria (8). Ozonized oil seems to exert its antimicrobial action through different mechanisms, including: 1) Direct oxidation (germicide) (2, 9, 10); 2) Cytotoxicity (11); 3) Grow factors Release (12) and 4) Oxidative pre-conditioning (13).

Various etiological factors cause oral lesions, and microorganisms play a major role (14). Elimination of these microbial pathogens is the aim of most dental treatments. It has been demonstrated that ozonated sunflower oil effectively kills the biofilms formed by Candida species and the bacterium *Streptococcus mutans* (15).

The efficacy and safety of ozonized oil is closely linked to its quality control. The peroxide value is one of the basic parameters to define the dosage and its clinical application (16). This indicator is critical to define the proper indication. Lack of standardization and quality control of ozonized oils may cause variability when the germicide capacity is assayed. A new ozonized sunflower seed oil [Ozoral gel, Innovares SRL, Sant'Ilario d'Enza (RE), Italy] has recently been introduced in the market for periodontal treatments (3, 5). Ozoral® is a mucoadhesive hydrogel containing 15% of Ozonia3000® Sunflower, an ozonized sunflower seed oil registered to ECHA (European Chemical Agency https://echa.europa.eu) in compliance with the Reach Regulation https://echa.europa.eu/it/regulations/reach/legislation and classified as non-toxic, non-irritating and non-hazardous by ingestion. The muco-adhesiveness of Ozoral® is due to a polysaccharide of vegetable origin, which favours adhesion and permanence of the product on the oral mucosa despite the humidity.

In the present study, the antimicrobial properties of this new ozonized sunflower seed oil against oral and periodontal pathogens have been evaluated using the quantification method of total bacterial genome copies by PCR. The study's null hypothesis was that the ozonized sunflower seed oil did not demonstrate antibacterial effects; it does not affect antibacterial capabilities in addition to supporting periodontal therapy (SPT).

MATERIALS AND METHODS

The study was a single-centre clinical trial. A total of 10 patients with a diagnosis of chronic periodontitis were randomly selected. Patients enrolled in this study were 35-55 years old. Subjects had not previously received any surgical or non-surgical periodontal therapy. The patients were excluded from the study if they met the following criteria: pregnancy; a history of taking antibiotics or using antibacterial mouth rinses for the past 6 months; teeth with furcation involvement; smoking, and drug or alcohol abuse. Subjects participating in the study volunteered to follow a detailed verbal description of the procedure and signed consent forms. This trial was approved by the Albanian University Ethical Committee n 232.

A total of 10 patients were selected, and a split-mouth scheme was used. The patients were treated with SPT. Before SPT, microbial sampling and analysis were performed in each selected site. The selected site corresponded to the deepest periodontal pocket of the oral cavity. Microbiological samples were collected from each patient. For bacteria analysis, sites were isolated using cotton rolls. Sterile absorbable paper points (size 60) were used to collect subgingival samples and were immediately transferred to the microbiological laboratory for processing. *Aggregatibacter actinomycetemcomitans, Porphyromonas gingivalis, Tannerella forsythia, Treponema denticola, Fusobacterium nucleatum, Campylobacter rectus*, and Total Bacterial Loading were evaluated. Then SPT was done using an ultrasonic scaler. After SPT, ozonized oil (Ozoral®) was given to each patient for use on the left side of the oral cavity. The patient was instructed to apply the gel once a day after evening oral hygiene. After 2 weeks, microbiological samples were collected again in each patient.

Ozoral gel was supplied by Innovares SRL, Sant'Ilario d'Enza (RE), Italy. The manufacturer did a quality control report of the batch. The method to assay the peroxide values was ISCO3 (2016) (17). Peroxide Values in Ozonized Oils - www.isco3.org.

Probes oligonucleotides were designed based on 16S rRNA gene sequences of the Human Oral Microbiome Database (HOMD 16S rRNA RefSeq Version 10.1), counting 845 entries. All the sequences were aligned to find either a consensus sequence or less conservated spots. Two real-time polymerase chain reaction (PCR) runs were performed for each sample. The first reaction quantified the total amount of bacteria using two degenerate primers and a single probe matching a highly conservated 16S ribosomal RNA gene sequence. The second reaction detected and quantified the following bacteria: *Aggregatibacter actinomycetemcomitans, Porphyromonas gingivalis, Tannerella forsythia, Treponema denticola, Fusobacterium nucleatum, Campylobacter rectus*. Oligonucleotide concentrations and PCR conditions were optimized to ensure sensitivity, specificity, and no inhibitions in case of unbalanced target amounts. Absolute quantification assays were performed using the Applied Biosystems 7500 Sequence Detection System. The amplification profile was initiated by a 10 min incubation period at 95°C to activate polymerase, followed by a two-step amplification of 15 s at 95°C and 60 s at 57°C for 40 cycles. All these experiments, including non-template controls, were performed to exclude reagent contamination.

Plasmids containing synthetic DNA target sequences (Eurofin MWG Operon, Ebersberg Germany) were standard for the quantitative analysis. Standard curves for each target were constructed in a triplex reaction using a mix of the same plasmids in serial dilutions ranging from 101 to 107 copies. There was a linear relationship between the threshold cycle values plotted against the copy number log over the entire range of dilutions. The copy numbers for individual plasmid preparations were estimated using the Thermo NanoDrop spectrophotometer; the absolute quantification of total bacterial genome copies in samples allowed for calculating a relative number of bacterial species. Plasmid purification and handling was performed in a separate laboratory with dedicated pipettes to prevent samples and polymerase chain reaction contamination.

Descriptive statistics (mean, standard deviation, minimum, median, and maximum) were calculated for each group and variable. The data normality of the distributions was calculated with the Kolmogorov–Smirnov test. The Friedman non-parametric test was then performed, followed by Dunn's post hoc test. Significance was predetermined as $p < 0.05$ for all the tests performed. SPSS program and paired simple statistic T-test were used to detect significant differences.

RESULTS

A statistically significant difference was detected between Total Bacterial Loading ($p<0.014$) and *Tannerella forsythia* ($p<0.012$) pre and post-ozonized oil treatment (Table I). When the p-value is less than 0.05, the difference between the two compared bacterial loadings is statistically significant.

Table I. *paired sample test.*

	Pairwise differences					t	Degree of freedom	*p value*
Couple	Media	Standard deviation	Standard error	Confidence interval for the 95% difference				
				inferior	superior			
AA1 - AA2	130450	334141	105664	-108579	369481	1.235	9	.248
PG1 - PG2	-136	2700	854	-2068	1795	-.160	9	.877
TF1 - TF2	18552	18768	5934	5126	31978	3.126	9	.012
TD1 - TD2	19213	32478	10270	-4020	42446	1.871	9	.094
FN1 - FN2	1107097	1682268	531979	-96324	2310519	2.081	9	.067
CR1 - CR2	68025	187066	59155	-65793	201844	1.150	9	.280
TBL1 - TBL2	1365269	1429368	452005	342761	2387778	3.020	9	.014

AA: *Aggregatibacter actinomycetemcomitans;* ***PG:*** *Porphyromonas gingivalis;* ***TF:*** *Tannerella forsythia;* ***TD:*** *Treponema denticola;* ***FN:*** *Fusobacterium nucleatum;* ***CR:*** *Campylobacter rectus;* ***TBL:*** *Total Bacterial Loading 1 pre-treatment, 2 post-treatment. The table reports data on the treated side only, pre-and post-treatment.*

DISCUSSION

Ozonized oil seems to strongly inhibit the formation of dental plaque and reduce the number of pathogens, both Gram-positive and Gram-negative organisms, including: *Staphylococci*, *Streptococci*, *Enterococci*, *Pseudomonas*, *Escherichia coli* and, above all, against Mycobacteria (18, 19) This effect of oxidation gives to its bactericidal, virucidal, and fungicidal activity. After contact with ozonized oil - microorganism, severe alteration of the cytoplasm was observed (20). In addition, applying ozonized oil reduces amylase, lipase, keratinase and urease enzyme activities in the microorganism significantly, in line with a reduction in nucleic acid content (11). This action seems not to damage human body cells; the reason attributed to this is the antioxidant ability of mammalian cells (21).

Even when the exact action mechanism of the ozonized oil is not described, there is much pre-clinical and clinical evidence of its antimicrobial and wound healing beneficial efficacy. As an antimicrobial, the most sensible bacterium is *Staphylococcus aureus,* and the primary resistant is *Pseudomonas aeruginosa* (22). A recent *in vitro* study confirms the microorganism sensibility to ozonized oil in that way (from more to less sensibility): *Staphylococcus aureus* > *Candida albicans* > *Escherichia coli* > *Pseudomonas aeruginosa* > *Enterococcus faecalis* (23).

In general, a lethal effect of ozonized oil is evident when it is applied to a multi-resistant strain of *Staphylococcus epidermis*, *Staphylococcus aureus*, also when it is applied to fungi from the genus *Trichophyton*, *Epidermophyton* and *Microsporum*, yeast as *Candida albicans* and protozoan as *Giardia lamblia* (24, 25).

A comparison regarded the antimicrobial effectiveness of ozonized extra virgin olive oil (peroxide value of 560/590 mEq/kg) with 0.2% chlorhexidine digluconate and 10% povidone-iodine through a disk diffusion test was done recently (8). Ozonized oil showed a significantly better behaviour than the references. This effect on one of the main pathogens suggests its potential applicability for periodontal treatment (8).

However, the word *ozonized* is without scientific meaning if it is not associated with *how much* peroxides are present in the oil. Probably the leading cause of variability regarding the microbiological efficacy of these active components is closely connected with the lack of standardization. The few studies on the therapeutic effects of ozonized oils on acute cutaneous wound healing in animal models did not investigate the dose/effect response, expressed as the number of peroxides in the ozonized derivative used (26).

Our study evaluated the antibacterial properties of a standardized ozonized sunflower seed oil in a group of patients who used it as a home-care praesidium. Ozoral gel has been statistically significant ($p<0.05$) in reducing Total Bacterial Loading and *Tannerella forsythia* bacterial loading. This last bacterium belongs to Socransky's red complex, a periodontal pathogen (27-32). Thus, Ozoral gel demonstrated antibacterial effects. In contrast with previous studies, based on the only analysis of traditional microbiology, these results demonstrate for the first time the reduction of the total bacterial load by ozonized oils, using quantification of total bacterial genome copies by PCR; this should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

CONCLUSIONS

It is our knowledge, however, that additional studies with a larger sample size and a higher number of home-care applications are needed to firmly demonstrate the effectiveness of ozonized oil as a viable antimicrobial agent in routine dental therapies.

Author Contributions: Conceptualization, Writing, original draft preparation D.L.; Validation, E.Q.; Investigation, D.BM; Supervision, F.C. All authors have read and agreed to the published version of the manuscript.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest: The authors declare no conflict of interest.

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Letter to the Editor

OSTEONECROSIS OF THE MANDIBLE ASSOCIATED WITH ZOLEDRONATE THERAPY

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INTRODUCTION

Bisphosphonates are synthetic compounds that mimic the structure of a naturally occurring substance called inorganic pyrophosphate (1). They have a high affinity for hydroxyapatite, the mineral component of bone tissue, and bind to regions of bone with high turnover (2); this allows them to effectively inhibit the activity of osteoclasts, which are the cells responsible for breaking down and resorbing bone tissue (3). As a result, bisphosphonates can be used to treat various bone disorders by preventing bone resorption at the molecular, cellular, and tissue level (4). The standard of care for treating osteopenia and osteoporosis, as well as Paget's disease and Osteogenesis imperfecta, still involves oral bisphosphonates (5). Additionally, intravenous bisphosphonates such as pamidronate (Aredia) and zoledronic acid (Zometa) are also used for these conditions (6).

Multiple myeloma and metastatic bone lesions are commonly treated with pamidronate and zoledronic acid, effectively preventing skeletal complications like pathologic fractures and hypercalcemia of malignancy (7). The action of bisphosphonates involves several mechanisms, such as inhibiting the differentiation of osteoclast precursors, promoting apoptosis of osteoclasts, and stimulating the release of osteoclastic inhibitory factors to osteoblasts (8). Additionally, these compounds can interfere with cellular metabolism by resembling adenosine triphosphate (ATP), disrupting cellular processes and further reducing osteoclast activity (9).

While bisphosphonates offer various therapeutic benefits, a notable complication that can arise in some patients receiving these drugs is bisphosphonate-related osteoradionecrosis of the jaws (BRONJ) (10). This condition, first identified and reported by Marx in 2003 (11), can have significant consequences for affected individuals. The onset of symptoms in BRONJ can be unpredictable, making it difficult for clinicians to diagnose and manage the condition promptly (12). This

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variability in presentation often means that the disease is only identified once it has become symptomatic, posing a challenge for effective diagnosis and management (13). The following report describes a case of BRONJ involving the lower maxilla in a patient suffering from multiple myeloma.

CASE REPORT

A 74-year-old female patient reported pain and swelling in the left lower jaw that has been present for several weeks.

The patient's medical history reveals that she has a history of diabetes, hypertension, and kidney failure, in addition to the previous history of multiple myeloma and treatment with intravenous zoledronate for two years. Upon local examination, it was observed that the patient had partial edentulism and alveolar mucosal dehiscence in the left body of the mandible. In addition, there was evidence of an exposed bone section that appeared yellowish-white in colour close to the posterior mandibular region, next to the roots of the first left lower molar (Fig. 1).

The orthopantomogram revealed the presence of diffuse osteolytic lesions and erosion on the left side of the mandible, affecting both the buccal and lingual cortical plates (Fig. 2). The size of the exposed bone gradually expanded, and the area became increasingly more sensitive to pain. The first-line conservative measures, comprising administration of chlorhexidine 0.2% mouthwash and oral antibiotics, resulted in a reduction of pain but failed to bring about resolution of the denuded bone.

Considering the progressive nature of the BRONJ, surgical intervention of sequestrectomy was subsequently planned. Using a large round burr and saline irrigation, the necrotic maxillary alveolus was excised until healthy, actively bleeding bone was achieved. Subsequently, a biopsy was performed to affirm the bone's vitality and exclude any malignancy. One year later, the patient reported discomfort, swelling, and pain, prompting the need for further clinical evaluation. Cone beam computed tomography revealed loss of integrity and diffused erosion of the lingual cortical bone. (Fig. 3).

The therapeutic approach was based on administering amoxicillin + clavulanic ac 1gr x 2 /day, metronidazole 1000 mg/day for 15 days, and oral chlorhexidine (0.12%) rinses three times a day. Intravenous Zoledronate was stopped. Spontaneous bone sequestration eventually occurred a few months later, followed by the mandibular bone's stable and painless mucosal coverage. At follow-up after one year, the patient was disease-free (Fig. 4).

DISCUSSION

There are several possible causes of swelling in the jaws.

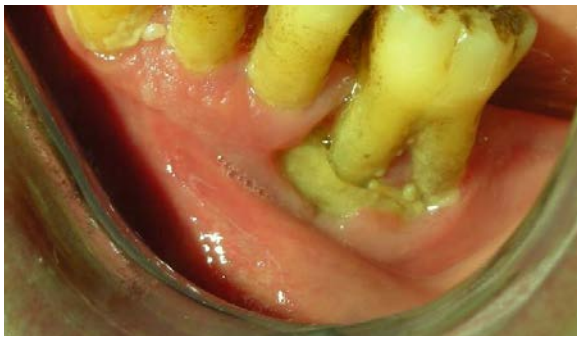

Fig. 1. *Exposed bone section that appeared yellowish-white in color close to the posterior mandibular region, next to the roots of the first left lower molar.*

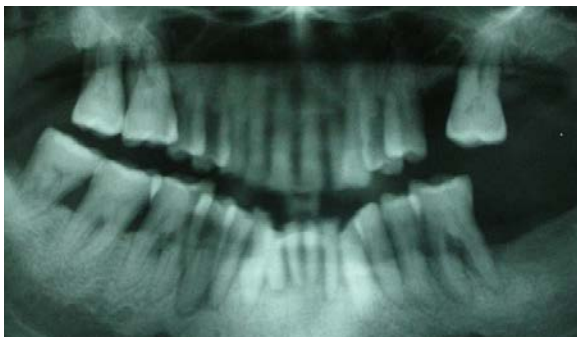

Fig. 2. *The orthopantomogram revealed the presence of diffuse osteolytic lesions on the left side of the mandible.*

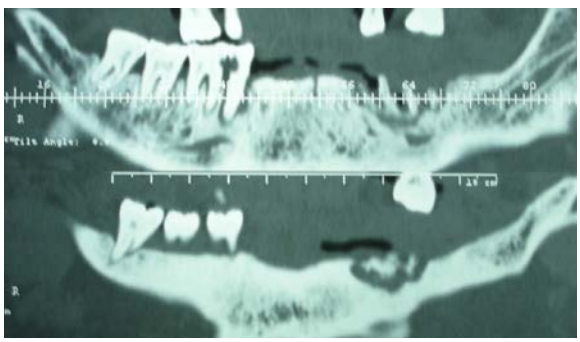

Fig. 3. *Cone beam computed tomography after one year.*

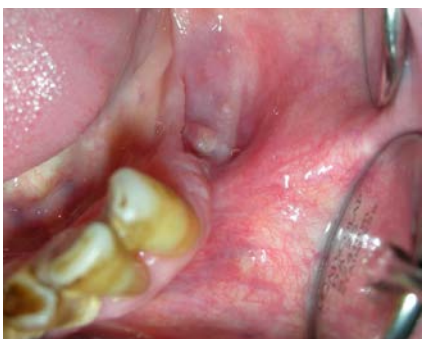

Fig. 4. *Follow-up after one year.*

An infection in the jaw can cause swelling, pain, and tenderness due to poor oral hygiene, dental caries, or a periodontal abscess (14). Furthermore, disorders of the salivary glands, such as sialadenitis or sialolithiasis, can cause swelling in the jaw (15). Benign or malignant tumors and cysts can develop in the jaw and lead to swelling (16). Also, swelling and tenderness may occur in patients with temporomandibular joint (TMJ) disorders (17). Lastly, a fracture, an injury, or other trauma to the jaw can cause swelling (18).

In the abovementioned case, the patient's medical history reveals a 2-year treatment course of intravenously administered bisphosphonates, specifically zoledronic acid, after diagnosing multiple myeloma. The patient presented with clinical symptoms of swelling and exposed non-vital bone in the left alveolar region. This presentation is consistent with the possibility of jaw osteonecrosis, a rare but known complication associated with the long-term use of bisphosphonates.

An oral-maxillofacial surgeon first reported osteonecrosis of the maxilla and mandible as a complication of intravenous bisphosphonate treatment in 2003 (11). Following this, osteonecrosis of the jaw was also reported in patients taking oral bisphosphonates for osteoporosis (19). Since then, the number of reported cases of BRONJ has increased, but the estimated incidence varies considerably from less than 1% to 18.6% (20). The drug's potency, administration route, and therapy duration are determining factors, with zoledronate (Zometa) having the highest reported incidence and the oral forms having a relatively low incidence (21). Both dental and oncological practitioners must possess a thorough awareness of the significant risk of developing osteonecrosis of the jaw (ONJ) in patients who are receiving bisphosphonate therapy (22).

Hence, the reported case re-affirms that dental and oncological professionals must exercise caution when treating patients receiving BPs and provide appropriate education and monitoring to minimize the risk of ONJ development.

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