Retrospective Observational Study

TEN-YEAR IMPLANT SURVIVAL AFTER MAXILLARY SINUS LIFT WITH PIEZOELECTRIC SURGERY AND ILIAC CREST AUTOGRAFT

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ABSTRACT

The introduction of surgical techniques based on the exploitation of ultrasonic vibrations has made it possible to obtain important innovations in all dental fields. The present study aims to evaluate implant survival ten years after definitive prosthetic rehabilitation on implants inserted in a second surgical stage compared to the maxillary sinus lift performed using piezosurgery technology and the application of a graft taken from the iliac crest. A total of 8 patients were selected, aged between 25-70 years, awaiting implant-prosthetic rehabilitation of the postero-superior sectors, but with anatomical conditions initially not favorable to implant insertion. The total number of implants inserted is 42, of which 20 support a screw-retained prosthesis and 22 support a cemented prosthesis. They underwent a 10-year evaluation, positioned in two surgical stages in the posterior sectors of the maxilla. Of the 42 implants inserted, 2 were lost during the osseointegration phase. Once removed and reinserted, they showed no sign of failure at the second 5-year follow-up. In the remaining 40 implants inserted, after 1 and 5 years, stable implant osseointegration occurred. At 10 years, only 2 more implants were lost. The ten-year implant survival percentage of implants inserted six months after maxillary sinus lift, performed using piezoelectric technology and insertion of autologous bone from the iliac crest, appears very valid and in line with that obtained from numerous reviews of the literature on large sinus lift.

KEYWORDS: *implantology, implant survival, iliac crest graft, maxillary sinus lift, piezoelectric surgery*

INTRODUCTION

Background

A sufficient alveolar bone volume must be present to obtain a good functional and aesthetic outcome of implant therapy (1). In the 1980s, the type of implant was chosen based on the quantity of residual bone (2).

Over the years, different methods of increasing bone volume in deficient sites have been described: osteo-induction, through the use of appropriate growth factors (3, 4); osteoconduction, through the use of a graft that functions as a scaffold for bone regrowth, distractive osteogenesis, i.e., the execution of a fracture through a surgical technique with newly formed bone in the gap (5), guided bone regeneration, in which spaces preserved by the application of membrane-

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barriers let new bone formation (6-8), and revascularized bone grafts, i.e., the transfer of vital bone, equipped with its vascular pedicle, from a donor site to a recipient site (9).

Over the decades, new bone formation through the maxillary sinus lift technique for implant insertion has seen numerous improvements that have helped medicine achieve today's results. Molinetti can be considered a pioneer of paranasal sinus surgery who, in the second half of the 1600s, performed access to the malar region of the maxilla through an incision in the soft and hard tissues (10). Mikulicz conceived the approach to the maxillary sinus via the inferior nasal meatus in 1887. George William Caldwell 1893 proposed a combined surgical approach to the maxillary sinus by creating access to the sinus at the level of the canine fossa, capable of allowing extensive exploration and cleansing of the site. In 1900, sinus surgical techniques continuously evolved, resulting in a greater conservative attitude. Boyne and Kruger introduced the basis for the current vertical bone augmentation procedures of the lateral-posterior sectors of the maxilla: they demonstrated the ability of the sinus walls to induce new bone formation following the lifting of the sinus membrane alone (11).

Thanks to the discovery of the potential new bone formation starting from the maxillary sinus floor and osteo-inductive and osteo-conductive properties of graft materials, the foundations of all surgical techniques for maxillary sinus lift began to be laid.

In the early 1970s, Hilt Tatum used autogenous bone harvested from the ribs to produce adequate vertical height in the posterior region of the maxilla for implant placement. The following year, he developed a technique for lateral access to the maxillary sinus to lift the sinus membrane and simultaneously position the implants. At the same time, he introduced the use of osteotomes to create the implant site (12).

In 1980, Boyne was responsible for developing the first scientific work on the use of autologous bone grafts at the level of the maxillary sinus aimed at increasing bone thickness for implant purposes (13). Mish modified this technique by designing a bone window in the wall lateral of the maxillary sinus, which, once tipped upwards, created a new floor of the maxillary sinus.

In the 1990s, Summers developed a technique to elevate Schneider's membrane crestally, using specific osteotomes capable of compacting the bone of the implant site both laterally and apically (14-16).

Thanks to progress in biomaterials, these methods have increasingly predominated over time, leading to the establishment of two main surgical techniques. The first surgical technique, called "small maxillary sinus lift, " involves the elevation of Schneider's membrane via transalveolar access. The second technique, defined as "large maxillary sinus lift, " consists of lifting the sinus mucosa through access from the anterolateral wall of the maxillary sinus and inserting graft material.

Over the years, dental bone surgery has mainly used manual and mechanical instruments. Manual instruments offer good control when used to remove limited amounts of bone in poorly mineralized areas, while mechanical instruments are useful where bone density is greater. Introducing surgical techniques based on the exploitation of ultrasonic vibrations has made it possible to obtain important innovations in all dental fields.

The phenomenon of piezoelectricity, or the ability of a material to generate a potential difference when subjected to mechanical stimuli, was discovered in 1880 by the brothers Pierre and Jacques Curie. From this moment on, the therapeutic applications of piezoelectric technology began to have an important diffusion until, in 1953, Catuna experimented with its application on extracted teeth, starting numerous studies on the use of this method on mineralized tissues (17). Among these, Mararowe McFall analyzed the advantages and disadvantages of ultrasonic technology compared to traditional rotary technology (18, 19).

In 1975, Horton et al., carrying out experiments on dogs, described how the bone surface was smoother with rotary instruments compared to ultrasound, although bone regeneration was superior (20).

Twenty years later, in 1998, Torrella performed a maxillary sinus lift using ultrasound equipment, but Vercellotti was responsible for introducing ultrasonic instrumentation, also called "piezoelectric", into the dental field. In a clinical study, Vercellotti describes the execution of a ridge expansion, which cannot be performed except with piezoelectric instrumentation, given the extremely thin thickness of the edentulous ridge (21-24).

Rationale and objectives

The present study aims to evaluate implant survival ten years after definitive prosthetic rehabilitation on implants inserted in a second surgical stage compared to the large maxillary sinus lift performed using piezosurgery technology and the application of a graft taken from the iliac crest (25-27). The checks were performed via radiological examination and objective evaluation. Therefore, the absence of postoperative complications, the effective increase in the vertical dimension of the alveolar ridge, and the successful implant osseointegration are considered.

MATERIALS AND METHODS

Patient selection

Patients were selected to ensure maximum similarity of intervention. The inclusion criteria were:

- partial or total edentulism of the diatoric sectors;
- residual bone height of 5-8 mm (SA3) or < 5 mm;
- acceptance of an implant-prosthetic treatment;
- informed consent of the patient;
- age greater than 18 years.

The exclusion criteria were:

- insufficient oral hygiene: the presence of plaque and bleeding index greater than 25%;
- serious systemic pathologies that interfere with surgery;
- presence of periapical lesions or other anomalies affecting dental elements adjacent to the maxillary sinus;
- current acute sinusitis;
- benign or malignant lesions, as well as foreign bodies within the maxillary sinus;
- habit of smoking;
- alcohol or drug abuse;
- acute odontostomatological infections;
- SA 4 or 5;
- remote or recent radiotherapy at the level of the oro-maxillofacial area;
- recent chemotherapy;
- recent bisphosphonate therapy;
- state of pregnancy;
- uncontrolled diabetes.

Study design

For the development of the study, a total of 8 patients were selected, aged between 25 and 70 years, awaiting implant-prosthetic rehabilitation of the postero-superior sectors but with anatomical conditions initially not favorable to implant insertion. The total number of implants inserted is 42, of which 20 support a screw-retained prosthesis and 22 support a cemented prosthesis. They underwent a 10-year evaluation, positioned in two surgical stages in the posterior sectors of the maxilla. The maxillary sinus lift operations with lateral access and autologous graft harvesting from the iliac crest were performed at the San Gerardo Hospital in Monza. The study was performed retrospectively, subjecting patients to radiographic checks and physical examination 10 years after surgery. For the radiographic evaluation, digital ortho-panoramic radiographs at three post-operative moments were considered: radiographic control one, five, and ten years after applying the definitive prosthesis on the implants.

Different parameters were taken into consideration through orthopantomogram examinations:

- peri-implant bone height, including the autologous bone graft inserted into the subantral space and the alveolar bone itself. Therefore, a possible loss of bone height mesial and distal to the implant surface was evaluated. A peri-implant bone reduction of less than 1-1.5 mm in the first year after implant insertion and less than 0.2 mm in the following years is considered physiological (28). The implant height was taken as a reference to overcome the limits given to the distortion of orthopantomography, thus making the quantification of the lost bone more likely. Each implant is independently monitored for any bone loss for a more precise assessment of implant success or failure;
- peri-implant radiolucency, an indication of peri-implantitis (29);
- quantification of new bone formation following the insertion of autologous bone in the context of a major sinus lift. It is carried out by taking the implant-abutment junction and the most apical bone-implant contact inside the maxillary sinus as reference points. An absence of bone gain indicates therapeutic failure and can occur following extensive resorption by the autologous graft;
- The presence of a diffuse radiopacity within the sinus is indicative of ongoing sinusitis.

The manifestation of an infectious process affecting the maxillary sinuses, in the context of a sinus lift performed using an autologous graft, is indicative of a possible loss of continuity of the sinus membrane, with consequent penetration

of the autologous material contaminated by intraoral bacteria, into the space antral. Another possible cause is the dislocation of the implant in the sinus antrum (30).

For objective evaluation in the immediate post-operative period and during subsequent follow-ups, attention is paid to several aspects:

- absence of spontaneous pain or under horizontal and vertical mechanical forces: pain is the first parameter considered to exclude a possible peri-implant infectious or incorrect distribution of prosthetic loads. Persistent pain may occur in conjunction with increased implant mobility, even before radiographic abnormalities are detectable. This symptom is indicative of implant failure. Clinically, the presence of pain is verified by the percussion of the implant;
- The absence of implant mobility is objectively verified by exercising horizontal and vertical forces on the fixture. An implant movement of less than 75 microns is considered physiological (31);
- signs of inflammation affecting the soft tissues around the implants: redness, swelling, on probing or spontaneous, pain on probing. These clinical manifestations lead to a diagnosis of mucositis. At the same time, the detection of ongoing peri-implantitis presupposes the involvement of the peri-implant hard tissues in the inflammatory process, with consequent loss of bone support. This last parameter is confirmed by radiological investigation and indicates implant failure. As a diagnostic aid for the detection of peri-implant inflammation, a periodontal probe is used, passed circumferentially around the implant. Thus, bleeding on probing, absent in healthy peri-implant conditions, the probing depth, considered pathological if greater than 5 mm, and the presence of suppuration around the implant are recorded (32);
- signs and symptoms of acute sinusitis with late onset in the postoperative period can lead to graft failure if not resolved with simple antibiotic therapy. The symptoms to which attention is paid are nasal congestion, pain, a sense of tension in the face, hyposmia, and purulent discharge from the nose. The patient may also report migraines, bad breath, dental pain, and fever (33).

On radiographic analysis, the presence of partial or total opacification of the sinus is visible. Once the pathology has been detected, the cause can be traced back to a perforation of the sinus membrane with displacement of graft material in the antral space, obstruction of the ostium following edema of the mucosa lining the sinus, bacterial contamination of the grafted bone inserted into the subantral space.

The surgical operations reported in the study were carried out using the piezosurgery system. This technology allows osteoplasty and osteotomy cuts limited to mineralized tissues, thanks to the action of ultrasonic micro-vibrations capable of preserving the integrity of soft tissues, vessels, and nerves.

Patient assessment

In the preoperative phase, the patient's medical history was investigated to exclude pathologies or pharmacological therapies that represent a contraindication to surgery for major sinus lift and implant insertion. Once the listed inclusion and exclusion criteria had been evaluated, we proceeded with the oral clinical examination. Then, orthopantomography and Dentalscan CT scan were performed to define the morphology of the sinus and the edentulous ridges, as well as the intermaxillary space and the degree of atrophy.

A therapeutic plan was developed after obtaining informed consent from the patient, which envisages the removal of autologous bone from the anterior iliac crest and simultaneous elevation of the maxillary sinus in the first phase, while in the second phase, the insertion of the implant.

Surgical protocol

These procedures are performed on a supine patient, subjected to total anesthesia and nasotracheal intubation to obtain free access to the oropharynx. An incision is parallel to the iliac prominence and placed approximately 1.5 cm internally to avoid injury to the lateral femoral cutaneous nerve.

Remaining on a supra-periosteal plane, the iliac muscle is pulled medially and the gluteal muscle on the external side, after which four osteotomies are carried out, and the bone block between the anterior superior iliac spine and the iliac tubercle is removed (Fig. 1). The bone block is then fragmented and temporarily preserved in a liquid composed of a sterile physiological solution and the patient's blood, taken during the surgical operation (Fig. 2).

After completing the suturing of the muscular and the intra-dermal layers, we proceeded with the maxillary sinus lift. Once the vestibular and palatal plexus anesthesia has been carried out, the access flap is incised and detached, keeping the instrument well adhered to the bone plane to preserve the integrity of the periosteum.

Using piezoelectric instrumentation equipped with a diamond ball insert, we proceed with an osteotomy and the removal of the lateral access trapdoor to the sinus (Fig. 3). The Schneiderian membrane is then separated from the bone

planes, using a non-cutting insert, first cranially, then mesially and distally, and only finally caudally. Once the sinus membrane has been elevated, the bone graft is inserted into the subantral space (Fig. 4, 5).

Closing the access window is carried out only in some cases by applying a portion of cortical bone taken from the iliac crest, modeled, and fixed with osteosynthesis plates. Given the invasive nature of the plaque removal operation, in some patients, it was decided to close the window by applying an absorbable membrane, while in others, simple fibrin glue was applied.

Implant insertion was performed once the graft had been integrated, six months after the maxillary sinus lift operation, after detaching a full-thickness flap on the lateral wall of the sinus (Fig. 6-9). Once inserted, the implants were submerged beneath the soft tissue for 6 months.

Once the period of implant osseointegration has passed, we proceed with the uncovering of the implant and the replacement of the cap screw with the healing screw, which, emerging from the gum, allows it to be modeled as an emergence profile. After waiting about a month for the peri-implant soft tissues to heal, healing screws were substituted with transfert, and an impression was taken.

In three patients, rehabilitation took place using the Toronto Bridge, a prosthesis fixed with screws on mesostructures, which were in turn connected to the body of the implants with screws. Prosthetically, the screw access holes are positioned on the occlusal surfaces of the posterior teeth and the palatal surfaces of the anterior teeth and then closed with composite resin.

In the present study, this type of prosthesis was screwed onto a variable number of 6-7 implants for each upper jaw. During the physical examination, the evaluation of the peri-implant soft tissues took place directly, thanks to the possibility of removing the prosthesis with the aid of a specific screwdriver. Thus, using instruments, such as the periodontal probe, to check probing depth and bleeding was possible.

On five patients, a cemented prosthesis was instead applied, in which the prosthesis is cemented onto the abutments, while the connection screws are used for fixing the abutment to the implant. For each upper jaw, this type of prosthesis was mounted on a number of implants ranging from 2 to 5.

Since cemented prostheses were not removed from implants, the post-operative implant evaluation was carried out exclusively through instrumental radiographic examinations, intra-oral examination of the visible peri-implant tissues, and the detection of painful symptoms.

In the period following implant placement and prosthetic restorations, each patient was recalled for check-ups, starting with the removal of the stitches one week after the operation. During each recall, the state of health of the soft tissues was checked, and the patient was motivated to maintain oral hygiene at home to prevent the accumulation of plaque and tartar, as well as implant failure. In both types of prosthetic rehabilitation, the space between the base of the prosthesis and the keratinized gum allowed adequate peri-implant hygiene.

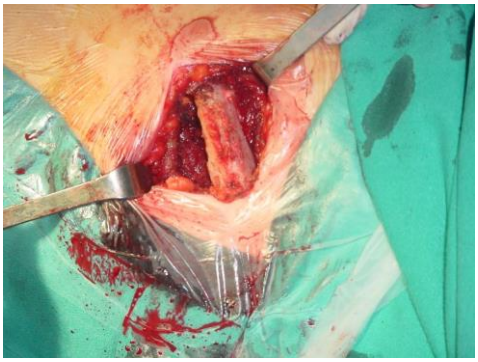

Fig. 1. *Autologous bone harvesting from the iliac crest: donor site.*

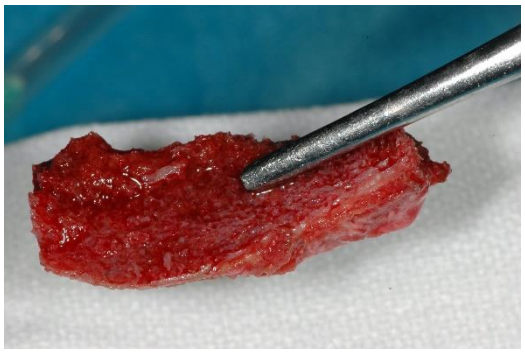

Fig. 2. *Piece of bone taken to be grafted.*

Fig. 3. *Maxillary sinus lift: bony trapdoor.*

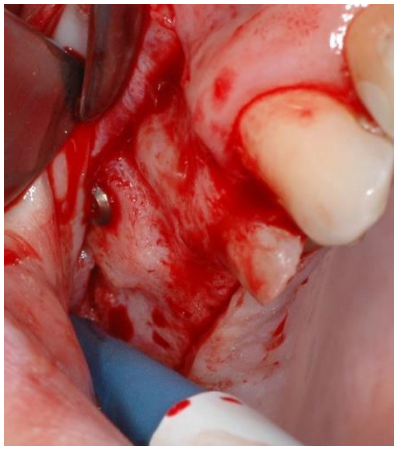

Fig. 4. *Onlay graft with fixation screws.*

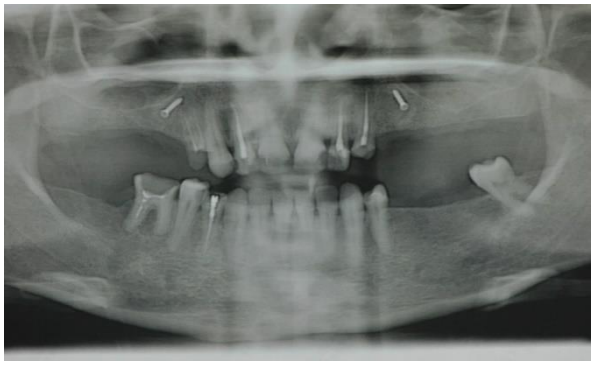

Fig. 5. *OPT was performed immediately after the iliac crest graft in the upper jaw.*

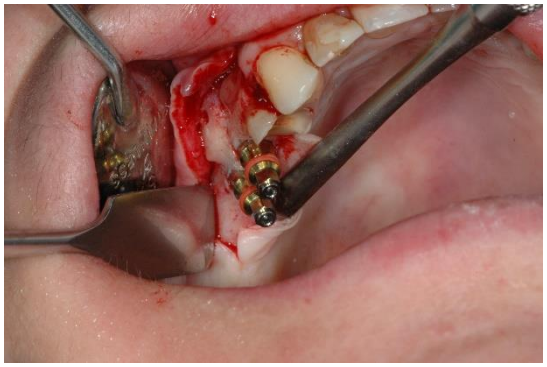

Fig. 6. *Insertion of 2 implants in the first quadrant.*

Fig. 7. *Insertion of 3 implants in the second quadrant.*

Fig. 8. *OPT was performed 6 months after the graft, at which time 2 implants were placed in the first quadrant and 3 implants in the second quadrant.*

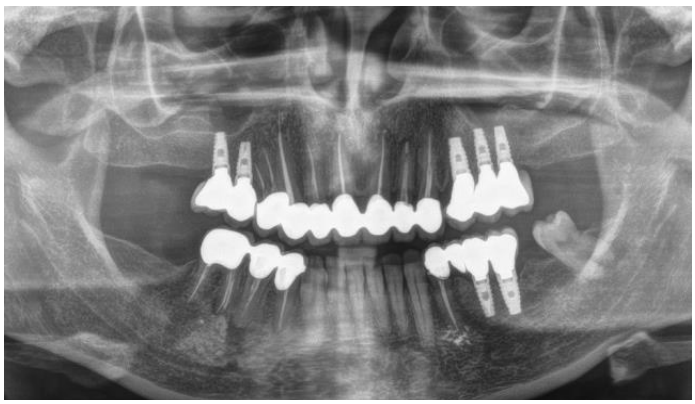

Fig. 9. *OPT performed at follow-up at 10 years, after checking the patient annually. The implants are still perfectly osseointegrated and loaded.*

RESULTS

Of the 42 implants inserted, 2 were lost during the osseointegration phase. Once removed and reinserted, they showed no sign of failure at the second 5-year follow-up. In the remaining 40 implants inserted, after 1 and 5 years, stable implant osseointegration occurred in the absence of early postoperative complications such as wound dehiscence, acute infection, perforation of the membrane due to the insertion of an excessive quantity of graft material, as well as late complications such as failure to integrate the graft, peri-implantitis, oro-sinus communication of chronic maxillary sinus infection. At 10 years, only 2 additional implants were lost. The surgical procedure of large maxillary sinus lift has made it possible to obtain prosthetic surgical success in patients with insufficient bone volume for implant insertion. The success obtained in this retrospective study was 95.2% at 1 and 10 years and 100% at 5 years (Table I).

Table I. *Prosthetic surgical success at 1, 5, and 10 years.*

Case	Age	Number of implants	Types of prosthesis	Implants lost 1 week after insertion	Implants lost 1 year after application of the definitive prosthesis	Implants lost 5 years after application of the definitive prosthesis	Implants lost 10 years after application of the definitive prosthesis
1	41	7	Screwed	0	0	0	0
2	45	7	Screwed	0	0	0	1
3	40	6	Screwed	0	0	0	0
4	42	5	Cemented	0	0	0	0
5	25	2	Cemented	0	0	0	0
6	55	5	Cemented	0	0	0	0
7	70	5	Cemented	0	2	0	1
8	53	5	Cemented	0	0	0	0

DISCUSSION

Implant rehabilitation of the posterior region of the maxilla often requires particular attention from the clinician, given the frequent reduction in the height of residual bone as a consequence of the pneumatization of the maxillary sinus following dental extractions. To overcome these anatomical limitations, the maxillary sinus lift technique is the main surgical procedure capable of obtaining a vertical bone gain in the posterior maxilla to insert fixtures.

In the literature, the percentage of implant success corresponds to an equal percentage of success of the maxillary sinus lift and osseointegration of the grafted material (34).

Radiological and clinical criteria are therefore taken into consideration to establish the success or failure of implant therapy. According to the scheme drawn up during "The International Congress of Oral Implantologists Pisa, Italy Consensus Conference", implant success (i.e., understood as the optimal condition for the permanence of the implant in the oral cavity) and failure (i.e., the loss of implant or the need to remove it), are evaluated based on:

- presence of pain on palpation, percussion, or function;
- clinical mobility;
- peri-implant bone loss visible radiographically;
- presence of exudate around the implant.

The introduction of regenerative techniques in odontostomatological surgery has allowed the rehabilitation of edentulous areas that would otherwise be impossible to rehabilitate with fixed solutions.

The maxillary sinus lift has been developed over time with different techniques, which involved the insertion of autologous or non-autologous bone in the subantral space, as well as the non-use of graft material. The use of autologous bone as a graft material for maxillary sinus lift has the advantage of supporting the sinus membrane and acting as an osteo-conductive support during bone formation by osteoblasts. This property, and the presence of osteogenic progenitor cells within the graft material, has led to this material being preferred for sinus membrane elevation. In the present study, the anterior iliac crest was chosen as the sampling site, given the need to re-establish large quantities of bone volume.

The insufficient quantity of residual bone crest at the level of the posterior maxilla has also led to the need to carry out implant rehabilitation at a later stage compared to the application of the bone graft in the subantral space. Implant insertion was done once the graft material matured and guaranteed adequate primary stability.

In the study by Yamamichi et al. on 625 implants, 53% were inserted at the same time as the sinus lift, while the remaining 47% were inserted after healing, on average 6.5 months after the sinus lift. An average survival rate of 96.4% is detected, while 3.6% present mobility before prosthetic loading, indicating therapeutic failure. All cases of failure corresponded to implant insertion at the same time as maxillary sinus lift, regardless of the implant surface and the graft applied. The authors attribute this result to the possibility that two-stage implant insertion can increase the probability of implant success and overcome limitations due to particularly advanced bone atrophy present in the pre-surgical period (35).

The use of piezoelectric instrumentation for the creation of the lateral sinus access window and the lifting of the sinus membrane has allowed a clear reduction in the risk of perforation of the sinus membrane, one of the main factors of implant failures.

The absence of perforation of the sinus membrane during major sinus lift is also a strictly operator-dependent variable, as it is closely linked to the surgeon's manual ability during the surgical operation. In the present study, the lack of onset of the complication of perforation of the sinus membrane is, in fact, to be attributed, in addition to the action of the piezoelectric instrumentation, to the presence of a single operator.

The main advantage of ultrasound technology is attributable to the selective cutting of mineralized tissues and the immediate cessation of operation of the piezoelectric device in case of accidental contact with the sinus membrane (23).

Wallace et al. report a reduction in perforation of the sinus membrane following sinus lift, from 30% with the use of rotary instruments to only 7% with the aid of piezoelectric instrumentation (36).

Comparing rotary and piezoelectric instrumentation in the execution of maxillary sinus lift, Barone et al. found a reduced percentage of membrane perforations compared to rotary instrumentation (23% vs 30%) but a greater time requirement in the execution of osteotomy cuts via piezosurgery (37).

In several studies, the survival of implants inserted in the context of large sinus lifts performed using piezosurgery has been investigated. In a study conducted on 53 maxillary sinuses raised through the use of piezoelectric technology and the insertion of autologous bone or Bio-oss, Blus et al. found a survival rate of 96.6%, six months after the operation upward. In subsequent checks 3, 6 and 12 months after prosthetic loading, none of the 117 implants inserted failed (38).

In addition to a clear reduction in the percentage of perforations of the sinus membrane during sinus augmentation, piezoelectric instrumentation also made it possible to reduce post-operative pain and edema, causing less discomfort in the treated patients (39). It also favors the primary and secondary stability of the inserted implants, thanks to the ability to create bone-cutting surfaces without signs of cellular necrosis. For the implant to undergo complete osteointegration, it is, in fact, necessary for the graft positioned beneath the Schneiderian membrane to present a good percentage of viable bone and osteogenic cells, that is between 25 and 35% (40).

Numerous studies have been carried out to evaluate the survival of implants inserted into raised maxillary sinuses through the insertion of different types of grafting materials. In a literature review, Al-Nawa et al. analyze implant survival in implant augmentations performed through the insertion of autologous bone or bone substitutes as graft materials, for a total of 4687 implants. Implant success is estimated at 98.6% ± 2.6 for augmentations performed through the insertion of bone substitutes, 88.6% ± 4.1 in cases in which autologous bone and bone substitutes are mixed and 97.4% ± 2.2 for augmentations performed by insertion of autologous bone alone. No statistically significant difference in implant success is therefore detected between the two surgical techniques (41).

The success of maxillary sinus lifts, regardless of the type of graft material inserted into the subantral space, has been confirmed by numerous literature reviews. Among these, Chiapasco et al. analyze 59 studies in which 13889 implants are inserted into raised maxillary sinuses by inserting autologous bone or bone substitutes, alone or mixed. An implant survival rate between 60-100% was detected, with a pitch of 98%. It is also confirmed that the insertion of different graft materials beneath the sinus membrane does not influence the average implant survival in a statistically significant manner. The application of graft materials in the context of the sinus lift, therefore, appears to be an operation that leads to a low percentage of complications, mainly linked to a possible perforation of the sinus membrane, which, according to the same study, occurs in 10% of patients cases. The loss of the graft material occurs in less than 1% of cases, while post-operative sinusitis is detected in a range between 0-27% of cases, generally in maxillary sinuses already previously affected (42).

Regardless of the graft material used, the persistence of sinus graft height stability was confirmed by Jensen et al. (43), which, during a 3.2-year follow-up of 349 implants inserted into raised maxillary sinuses, revealed a minimal reduction in the height of the graft ranging from 0.8 mm in the case of insertion of autologous bone mixed with alloplastic material, to 2.1 mm in the case of autologous material only. Similar findings arose from further studies aimed at analyzing the long-term stability of sinus grafts (44, 45).

In a 5-year longitudinal study, Wiltfang et al. analyze the difference, in terms of bone resorption and implant survival, of the insertion procedure of onlay bone graft and maxillary sinus lift using autologous bone graft to rehabilitate the posterior maxilla.. Out of 349 implants inserted in 61 patients, the survival obtained following maxillary sinus lift was 94.6%, while when an onlay graft was applied, the survival of the 235 implants was 91.5%. Sinus lift also allowed a lower percentage of bone resorption to be obtained (46).

CONCLUSIONS

Implant rehabilitation of the posterior areas of the atrophic jaws requires a carefully designed treatment plan. The major problem arises when the pneumatization of the maxillary sinus does not allow direct fixture insertion. The maxillary sinus lift technique is a pre-prosthetic surgical procedure that can be used effectively to achieve adequate bone height for implant-prosthetic rehabilitation.

In the present study, lateral maxillary sinus lift was used, a safe and predictable surgical procedure that guarantees high rates of success and implant survival. The ten-year implant survival percentage of implants inserted six months after maxillary sinus lift, performed using piezoelectric technology and insertion of autologous bone from the iliac crest, appears to be comparable with that obtained from international literature.

Given the low percentage of resorption, excellent long-term stability and high integration, it was decided to proceed with the insertion of autologous bone into the subantral space. The harvest from the iliac crest was dictated by the need to rehabilitate large, edentulous areas. Despite the extensive resorption, the bone chips inserted in the context of maxillary sinus lift demonstrated optimal integration in all cases presented, without any associated complications.

In the literature, similar implant survival rates are associated with different graft materials placed in the subantral space. The absence of a statistically significant difference between the success of large maxillary sinus lifts performed through the insertion of autologous bone or bone substitutes indicates the effectiveness of this surgical technique regardless of the graft material used. Although conventional surgical techniques, such as the use of rotary instruments which reduce operating times, ultrasonic bone surgery is currently a method with high predictability and good short and long-term results.

In line with what has been stated in international literature, the use of piezoelectric technology to perform maxillary sinus lift has made it possible to significantly reduce the probability of perforation of the sinus membrane, a complication that did not occur in any case during this study.

Conflicts of interest

The authors certify no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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Investigative Study

TENSILE STRENGTH AND OTHER MECHANICAL PROPERTIES OF DENTAL FLOSS: AN EXPERIMENTAL STUDY

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ABSTRACT

This in vitro study aimed to investigate the tensile strength and other parameters of various interdental floss types to provide insights into their mechanical properties. A selection of representative dental flosses, encompassing different structures and coatings, was subjected to a controlled experiment. Tensile strength measurements were conducted using a testing apparatus, assessing each floss's ability to withstand forces during simulated use. Results indicated significant variability in tensile strength among the tested interdental flosses. The study also explored passage force and displacement of the force using a universal dental holder. Further research is warranted to explore the long-term implications of these mechanical properties on interproximal plaque removal and overall oral health.

KEYWORDS: *dental floss, interproximal devices, tensile strength, proximal contact*

INTRODUCTION

Oral hygiene is the cornerstone of any dental treatment plan and removing plaque using a toothbrush is recommended for most tooth surfaces as the most effective means of cleaning (1). Several studies have demonstrated that relying solely on a toothbrush for at-home oral hygiene procedures yields suboptimal outcomes when compared to incorporating any interproximal cleaning method, such as dental floss, interdental brushes, or toothpicks, in combination with regular toothbrushing (2). Dental floss is often considered a challenging instrument to wield, demanding proficient manual dexterity to navigate the proximal contact points in a gentle manner and achieve the appropriate tension, which is crucial for its effectiveness (3); additionally, patients reported pain due to wrapping the floss around their fingers, and difficulties in reaching the second/third molars and carrying out the correct movement in these very posterior areas (4).

Although patients usually prefer toothpicks and interproximal brushes over dental floss, due to their ease of use (5, 6), these types of devices can not be prescribed for every patient: only those patients with sufficient embrasure space for their positioning can use these instruments. Patients with their intact gingival papillae filling the interproximal spaces are usually instructed to use dental floss for plaque removal on the proximal surfaces. Dental floss is the most recommended device for interproximal plaque control, useful to plaque removing and effective in decreasing marginal inflammation (7, 8).

Some papers addressed the plaque-removing ability or the plaque removal at different sites of different types of floss; even if flosses diverge enormously in structure, size, materials, and adjuvants, no significant clinical differences were found between several flosses (9).

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Although some illustrious scholars have tried over the years to propose the perfect physical characteristics of a dental floss, more research should be done to investigate the relationship between physical characteristics and clinical effectiveness of dental floss; furthermore, the control of physical properties in the production of dental floss should be more studied in deep (10). Dental floss has been described as the best and most recommended device for cleaning anterior teeth interproximal surfaces, while their effectiveness on the posterior ones is not so certain (11). They have been found to cleanse coronal portions better than apical ones, buccal portions of the interproximal areas better than lingual ones, and distal surfaces better than mesial ones (12). These differences in the effectiveness of interdental cleaning may indicate a difficulty in using floss or account for self-injuries due to improper use of the floss (injuries stemming from an uncontrollable force required to navigate the proximal contact point), which is frequently noted (13).

According to Hanes et al., a patient's acceptance of floss and consistency in its use may be related to the capacity of dental floss to pass the proximal contact point (10). In accordance with Torkzaban et al. flossing may improve gum health through periodontal indices enhancement. Flossing before brushing could potentially be more effective for plaque control, as brushing afterwards might remove loosened plaque deposits (14).

In young individuals without interproximal bone resorption, precise oral hygiene regimens incorporating either a manual toothbrush alone or supplemented with interdental cleaning aids, such as dental floss, interdental brushes, or interdental rubber picks, can demonstrably attenuate both dental plaque accumulation and gingival inflammation. However, the utilization of interdental brushes or rubber picks exhibits a statistically significant superiority in the reduction of interproximal plaque compared to the sole implementation of manual toothbrushing (15).

Adjunctive interdental cleansing implements assume a paramount role in the preservation of optimal gingival health and the promotion of comprehensive oral hygiene, particularly in individuals undergoing orthodontic therapy. Compelling research data suggests that the utilization of dental floss or interdental brushes in conjunction with a careful toothbrushing regimen confers a multitude of advantages in comparison to the singular implementation of a manual toothbrush. It is crucial to highlight the significance of proper utilization techniques and the need for individualized treatment plans when recommending oral hygiene tools and practices for patients undergoing orthodontic treatment (16).

The accurate control of dental plaque accumulation is demonstrably essential in maintaining peri-implant health. Several mechanical plaque removal modalities, including dental floss, interdental brushes, and irrigating oral hygiene devices, may prove efficacious in achieving plaque control and reducing the incidence of gingival inflammation near implant-supported single crowns, as evidenced by research documented by Almoharib et al. (17).

Despite being widely recommended as an integral part of oral hygiene, the use of floss presents certain limitations that warrant consideration to optimize its effectiveness and minimize potential risks. The primary limitation lies in the manual dexterity required by the patient, particularly in the posterior regions of the mouth. The angulation and curvature of posterior teeth make it challenging to correctly position the floss and effectively reach interdental spaces (18). The shape of floss has proven effective in removing food debris lodged between teeth. However, its ability to cleanse and remove plaque beneath the contact point between teeth remains a subject of debate. Some research suggests that floss cannot adequately reach and clean these areas, leaving bacterial plaque undisturbed (15, 17).

The scientific literature on the efficacy of flossing in preventing gum disease is controversial. Some studies demonstrate that its use, in addition to regular brushing, improves gingival health (14, 16, 18). Others, however, maintain that flossing is ineffective in removing plaque, and that improper use can even damage the gums, causing gingival recession due to bone loss (19, 20).

Experimental research about physical properties of dental floss, such as tensile strength and percentage of elongation, is still unexplored; most of the data is provided by manufacturer, used for commercially claim purpose, which make them controversial and really hard to interpret. The aim of this study was to compare several types of waxed and unwaxed dental flosses and test them with a universal testing machine to evaluate some mechanical properties.

MATERIALS AND METHODS

This study involved the use of 17 dental flosses of different brands and types. Nine of them were waxed, and eight were unwaxed. The mechanical properties were tested via three parameters, using the universal testing device Lloyd Instruments LR 30K Stress Test Machine (AMETEK® Test and Calibration Instruments) supported by the Nexyen Plus Software: tensile strength, passage force, and displacement of the floss in a holder.

To evaluate two of these parameters (passage force and displacement), we employed an experimental design previously used in 2010 (6), with some variations due to the diversity of wires used (the original study utilized dental floss holders of different shapes and usage modalities - disposable or reusable - whereas this study aims to analyze simple interdental flosses, with no holders). The model involved the use of a simulator constructed with two extracted human

molar elements, devoid of restorations or caries, positioned adjacent to each other respecting the existing physiological contact point between these elements; to adhere as closely as possible to reality, the two elements were constantly moistened with artificial saliva, just as it occurs inside the oral cavity.

Tensile strength

Segments of thread 20 cm long were obtained tied with the same type of knot (surgical knot). The wire loops were subjected to unidirectional tensile stress through the Lloyd Instruments LR 30K Stress Test Machine (AMETEK® Test and Calibration Instruments) supported by the Nexyen Plus Software. The machine was set up with the following settings (Fig. 1):

preload = not applicable;
speed = 50.0 mm/min;
useful trait = not applicable;
area = not applicable;
breaking point = the load gives way quickly;
initial load = - 0.00 N; elongation = 0.01%.

Fig. 1. *Universal testing device Lloyd Instruments LR 30K Stress Test Machine (AMETEK® Test and Calibration Instruments).*

For each wire, the experiment was conducted as follows: a segment of wire of the established length was passed through the movable hook located at the bottom of the machine and secured with a vise, then it was tied to the fixed hook positioned at the top. At that point, each wire was stretched and brought to zero tension; the machine was then activated. Individual tests were carried out by a single operator to make the results comparable. The stages, such as cutting the wire, placing it inside the machine, and especially the technique and type of knot used, were performed by a first operator, while a second operator analyzed the data displayed on the apparatus screen and recorded them. The calibration of the machine was performed using a wire that was not included in the experiment.

Passage force and displacement

The experimental design was carefully formulated to align with both user requisites and the specifications delineated by the manufacturer. Thirty interdental passages were systematically conducted for each dental floss variant, diligently inserted into a multi-use holder (Healifty®, floss holder). The secure fastening of the dental floss within the holder was accomplished using a standardized apparatus, ensuring uniformity in revelation for the subsequent assessment of mechanical properties.

This experimental setup precisely corresponds to the number of proximal contacts inherent to a fully dentate individual, accounting for 15 contacts in the upper jaw and an equivalent number in the lower jaw. In adherence to stringent protocols, synthetic saliva (BIOXTRA®, Biopharm srl) was consistently applied to the proximal contacts throughout the entirety of the measurement process. This accurate procedural approach was employed to simulate physiological conditions and maintain an environment reflective of realistic usage scenarios, enhancing the validity of the mechanical property assessments conducted. This investigation adhered to stringent criteria established in accordance with anatomical and clinical considerations, ensuring a detailed evaluation reflective of realistic conditions.

Specifically, the predefined parameters were defined to encompass a displacement of less than 4 mm after 30 passages, coupled with a requisite passage force exceeding or equaling 10.0 N. The application of such stringent benchmarks enhances the study's scientific rigor and the validity of its findings in delineating the performance attributes of the tested dental floss.

The force exerted during the passage of dental floss is influenced by proximal contact strength, the friction between the dental floss and the dental surface (whether enamel or restoration materials), and the inherent properties of the dental floss. As the force is applied, it causes displacement of the dental floss within the floss holder, resulting in alterations to its length and a reduction in diameter. This displacement continues until the force, perpendicular to the stretching direction, reaches a level adequate to traverse the proximal contact point. The passage force is contingent upon the material properties of the dental floss, including variations such as nylon, Teflon, or PTFE.

To facilitate a standardized performance test of the dental floss holder, it is imperative to devise a procedure that mimics the mechanical stability of the dental floss holders, regardless of the specific parameters of the dental floss. Additionally, this procedure should replicate a physiologically oriented force to ensure comprehensive and reliable testing.

The evaluation of passage force, for each model, occurred after completing each cycle (30th passage) through the utilization of the LR 30K Lloyd Instruments universal testing device. The dental floss holder was positioned in a way that ensured a consistent vertical deflection of the floss during the application of reproducible mechanical force. The set maximum force applied to the holder was 10 N, with a precision of force measurement maintained at 0.1 N. Each measurement concluded either upon reaching a force of 10 N or after traversing a path of 10 mm. Measurements 2-29 were emulated using a physiological proximal contact, established with two extracted human lower jaw molars devoid of cavities or fillings. These molars were securely affixed to each other with an interdental force of 8 N, achieved through a spring balance (9). The force recorded at the conclusion of each cycle was then subject to evaluation.

Displacement, denoting the extent of floss movement when subjected to the passage force, is quantified as a measurable length in millimeters (mm). This measurement is precisely taken at the pivotal moment of traversing the proximal contact. Employing the testing device, the 30th passage of each dental floss was meticulously assessed. To account for anatomical considerations, the material testing device's measurement head was limited to a maximum travel of 10 mm. Substantial floss displacement during the application of passage force presents an escalated risk of potential harm to both the papilla and gingiva. The maintained positioning accuracy for these measurements was upheld at an impressive 0.01 mm.

RESULTS

The data recorded for tensile strength, passage force, and displacement are shown in Tables I, II and III.

Table I. *Tested flosses, maximum load at breaking in N, waxed/unwaxed floss.*

Dental Floss Code	Maximum Load in N	Waxed/Not waxed
DF 1	102.655N	Waxed
DF 2	89.502N	Waxed
DF 3	82.682N	Waxed
DF 4	82.297N	Waxed
DF 5	78.623N	Waxed
DF 6	78.001N	Not Waxed
DF 7	75.449N	Not Waxed
DF 8	72.557N	Waxed
DF 9	69.839N	Waxed
DF 10	65.783N	Not Waxed
DF 11	61.553N	Not Waxed
DF 12	61.467N	Waxed
DF 13	52.623N	Not Waxed
DF 14	45.358N	Waxed
DF 15	41.662N	Waxed
DF 16	39.340N	Waxed
DF 17	36.513N	Waxed

[1]*From maximum to minimum load in N.*

Table II. *Dental flosses ranked from maximum to minimum passage force value after thirty passages.*

Dental Floss Code	Minimum (N)	Maximum (N)	Median (N)[1]
DF 4	10.0	10.0	10.0
DF 2	10.0	10.0	10.0
DF 14	9.8	10.0	10.0
DF 10	10.0	10.0	10.0
DF 5	10.0	10.0	10.0
DF 6	10.0	10.0	10.0
DF 16	10.0	10.0	10.0
DF 7	10.0	10.0	10.0
DF 13	10.0	10.0	10.0
DF 17	9.9	10.0	10.0
DF 15	9.7	10.0	10.0
DF 12	10.0	10.0	10.0
DF 1	9.8	10.0	10.0
DF 3	10.0	10.0	10.0
DF 9	9.7	9.9	9.9
DF 8	9.6	9.9	9.8
DF 11	9.2	9.8	9.7

[1]*Median is shown from maximum to minimum.*

Table III. Dental flosses ranked from maximum to minimum displacement of the floss in the holder value after thirty passages.

Dental Floss Code	Minimum (mm)	Maximum (mm)	Median (mm)[1]
DF 2	3.7	4.0	3.8
DF 14	3.6	4.0	3.8
DF 4	3.7	3.9	3.9
DF 16	3.7	4.1	3.9
DF 5	3.7	4.2	3.9
DF 10	3.9	4.1	4.1
DF 7	3.9	4.2	4.1
DF 1	3.8	4.3	4.1
DF 6	3.9	4.1	4.1
DF 12	3.8	4.3	4.1
DF 13	3.7	4.2	4.2
DF 17	3.7	4.1	4.1
DF 15	3.8	4.1	4.2
DF 8	4.0	4.4	4.2
DF 3	3.9	4.5	4.2
DF 9	4.0	4.4	4.2
DF 11	4.1	4.5	4.3

[1]*Median shown from minimum to maximum.*

The passage force values ranged from a maximum of 10 N to a minimum of 9.2 N (Table II). Only three flosses had not reached the cut off of 10 N but were very close to this value (values could not exceed 10 N because this was set at the beginning of the test).

The software connected to the Stress Machine was able to process a graph during each test that showed the trend of the floss tension and the breaking point, just as seen in Fig. 2.

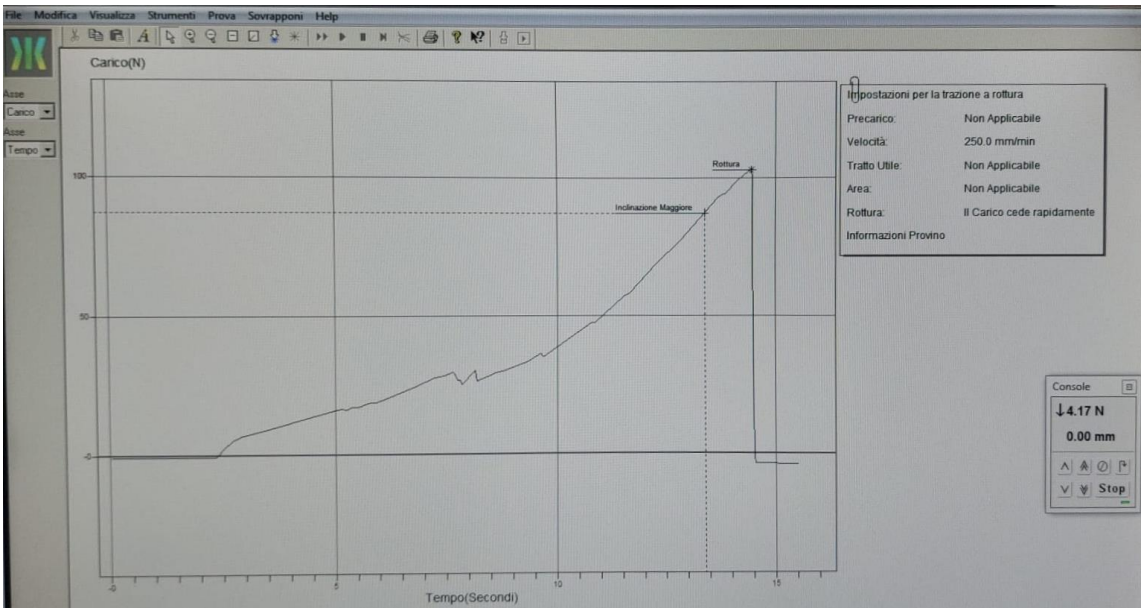

Fig. 2. *Graph developed by Nexyen Plus Software, which supports the universal testing device. The line rises, more or less linearly, up to a peak: here, the floss breaks, followed by a steep fall in the straight line. The small peaks present during the ascending phase signal the fraying of the floss but not its complete breakage, indicated by the highest point. The tensile strength expressed as maximum load in N differed between 102.655 N (DF 1) and 36.513 N (DF 17). There was a big gap between the best performance of 102.655 N (DF 1) and the second position of 89.502 N (DF 2); from the third position, there was a progressive decrease until the last performance of 36.513 N.*

The minimal median displacement for the 30th proximal contact passage was 3.8 mm (DF 2), while the maximal median displacement was 4.3 mm (DF 11).

DISCUSSION

The regular removal of dental plaque from interproximal tooth surfaces is an important component of any oral hygiene regimen that is designed to prevent or control dental caries and periodontal disease (1). Due to the relative ineffectiveness of toothbrushes in interproximal sites, other devices such as floss, toothpicks and interproximal brushes are recommended as adjuncts to toothbrushing.

According to ISO 28158:2010, dental floss is defined as “the multiple filaments gathered into thread, spun yarn, single filament or tape, commonly synthetic fiber, with or without coating material(s), designed for the removal of plaque or debris, or both, from the proximal surfaces of natural or artificial teeth and the gingival surfaces of pontics of fixed prostheses”. This document goes into more details and establishes what material dental floss should be made of (“…free from extraneous matter when examined according to visual inspection by normal acuity without magnification”... “Materials intentionally added to dental floss, such as wax, pigments or flavoring agents, shall be considered as part of the device”), the shape it should have (“the integrated dental floss shall not have any sharp surface or parts…”), and its strength (“…shall withstand the static load of 10 N for 10 s without a breakage of the floss”) (21).

Other very important parameters that may influence the mechanical properties of dental floss are tensile strength and percentage of elongation: the first one has an impact on the maximum load supported by the floss to pass the interdental contact point, while the percentage of elongation sets the maximum length of the floss before tearing apart. (22). There are several types of dental floss available: silk, nylon, or PTFE (polytetrafluoroethylene floss), with or without wax. Nylon is used for multifilament dental floss, while monofilament floss is usually made of PTFE. Other investigations have previously assessed the clinical efficacy of waxed and unwaxed dental floss, and they have consistently reported no significant variations concerning their capability to eliminate interproximal plaque (23).

This research sought to scrutinize specific mechanical attributes of dental floss, driven by the existing literature's limitation in providing a comprehensive overview of this subject. A portion of the experimentation necessitated the utilization of dental floss holders to facilitate and standardize the measurement procedures. The flosses analyzed in this study are of various manufacturing types (waxed and unwaxed), different structures (expanding, ribbon, standard), and various brands, ranging from well-known dental brands to less common household names. In accordance with findings

from previous in vivo investigations (13), wherein the average passage force required to traverse interproximal contact points was established at 9.4 ± 0.5 N (representative of the force a patient employs to navigate proximal contacts without causing harm to gums and soft tissues), the universal testing machine was configured to operate at 10 N. Simultaneously, the maximum displacement of the floss was confined to 10 mm. This setup ensures alignment with established physiological benchmarks while maintaining a margin of safety within the experimental parameters. The dental floss holder underwent a recurrent force application of 11.0 N, considering prior in vivo studies that ascertained mean passage force values at 9.9±0.5 N. These findings indicated the force anticipated to be exerted by patients (24) during the traversal of proximal contacts.

Due to inherent anatomical characteristics and construction-related attributes of the holders, we imposed constraints on the maximal displacement of the floss, restricting it to 10 mm. Additionally, we established a limitation on the maximum force applied, capping it at 11.0 N. These measures were implemented to ensure that the experimental conditions remained within physiological bounds and adhered to the designed parameters of the study. The integration of two experimental configurations, namely the LR 30K Lloyd Instruments universal testing device and the proximal contact strength simulator, enabled the simulation of proximal contact passage and accurate determination of the floss displacement within the holder. This combined approach facilitated a comprehensive evaluation of the mechanical aspects associated with proximal contact interactions.

Tensile strength

The performance of the different tested flosses was not influenced by whether they were waxed or not (excluding the wire that showed significantly better performance than others, where subsequent positions included both waxed and unwaxed wires). Furthermore, two reactions were observed in the tested wires during the trial: either breaking sharply once the tolerated tensile limit was reached or fraying before ultimately breaking.

Displacement

A minimal floss displacement, specifically below 4 mm, is deemed favorable as it signifies the ability of the holder to navigate the proximal contact without inducing excessive elastic or plastic deformation in either the floss or the holder. This criterion is established based on anatomically relevant considerations of the proximal space. Numerous studies (25-27) indicate that the average length of the clinical crown measures 10.19 mm in men and 9.39 mm in women.

Proximal contact strength is situated approximately 1-2 mm below the tooth's shoulder, exhibiting dimensions dependent on the tooth type, typically ranging from 1-2 mm. In individuals with periodontal health, the proximal space is occupied by the papilla, extending cervically as an epithelial attachment into the proximal region. This delineation adheres to anatomical norms and contributes to a comprehensive understanding of desirable floss displacement parameters within the proximal space (28).

The results of this part of the experiment reveal a maximum difference between the means of 0.5 mm, with all values very close to the 4 mm cutoff; this suggests that the value is not particularly influenced by the wire type, but rather by the type of flosser used. In the reference study, indeed, the values were much more heterogeneous, due to the utilization of many flossers of different shapes and uses.

Passage force

The findings reveal substantial similarity among the flosses concerning their response to passage force. The majority of the sample exhibited adequate strength, attaining the requisite 10 N; only three flosses exhibit slightly lower, yet still acceptable, values compared to the established cutoff value. Consequently, by comparing the obtained values to those of the reference study, we infer that this parameter is also influenced by the flosser rather than the wire itself.

CONCLUSIONS

While this study examines numerous interdental flosses with different characteristics and specificities, being an in vitro study provides a precise snapshot related solely to the parameter of tensile strength. In vivo, within the oral cavity, interdental floss is subjected to the action of a greater number of multidirectional forces (not replicable in an experimental model of this kind) that stress the floss at multiple points. Furthermore, friction with various restorative materials (amalgam, composite, gold) or orthodontic materials (steel), as well as friction at contact points and the presence of saliva that saturates the floss, can influence its resistance.

Moreover, the utilization of a single type of universal dental floss holder standardized the values, preventing the observation of significant differences among the various flosses. It would be intriguing to assess each floss with different types of holders and analyze the obtained results.

Following the results found in literature, dental flosses with greater tensile strength should also be the best in clinical removal of dental plaque. However, in vivo, dental floss is subjected to a combination of multiple types of forces: friction at contact points, rubbing on restorations of different materials, bidirectional tensile forces. In light of these considerations, there is a need for further in vivo studies to be able to associate greater tensile strength with advantageous clinical characteristics.

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Review

DENTAL CARE AND INFECTIVE ENDOCARDITIS. A REVIEW

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ABSTRACT

Infective endocarditis is a relatively rare infection of the inner layer of the heart's valves and chambers. Most cases of endocarditis are caused by streptococci, which is a normal oral flora and is associated with plaque, dental caries, gingivitis, and periodontitis. Guidelines for preventing infective endocarditis recommend good oral hygiene for people at higher risk because of a pre-disposing cardiac condition, and prophylactic oral antibiotics when undergoing specific dental procedures. The objective of this article was therefore to review the currently available literature regarding oral health and infective endocarditis and to unfold the latest recommendations. A multidisciplinary approach including the patient's cardiologist is fundamental and can potentially reduce complications and improve dental treatment results.

KEYWORDS: *bacteremia, oral health, heart*, *endocarditis*

INTRODUCTION

The medical history of the patient is the first step of any dental treatment. A compromised medical status can alter the dental treatment plan and lead to severe consequences. Cardiovascular diseases are the leading global cause of death (1-3). With extensive improvement in healthcare facilities and an increase in life expectancy, dentists are encountering more and more elderly and medically compromised patients. In dental practice, though syncope is the most common medical emergency reported (4), cardiovascular events are not very infrequent (5, 6). So, it is very critical for dental practitioners to possess adequate knowledge, skills, and resources to address the problem. The spread of microorganisms from the oral cavity to other sites has been associated with the occurrence of systemic diseases such as infective endocarditis (7, 8).

Infective endocarditis is a severe disease that affects the surface of the endocardium (9-11), occurring more frequently in the vicinity of acquired or congenital heart defects (12, 13). The pathogenesis has been associated with the occurrence of bacteremia, the source of which can include periodontal infection sites (14, 15), dental and oral tissues manipulation (16, 17) and even daily lifestyle habits (brushing and flossing) (18). In the presence of infection, tooth-supporting tissues became highly vascularized and enter an intimate relationship with microbial biofilm, increasing the risk of bacteremia (19). Mounting evidence has indicated that dental treatment in patients at risk of developing infective endocarditis could be beneficial.

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DISCUSSION

Infective endocarditis

Infective endocarditis is an infective disease affecting a native or prosthetic heart valve, the endocardial surface, or an indwelling cardiac device that affects approximately 1 to 11 per 100,000 people every year (20), with typical age shifting from 40 years old in the 1980s to 70 years old in the new century (21). Several risk factors have been described like poor oral hygiene, alcoholism, and disorders causing immunological changes (cancer, systemic lupus erythematosus, renal insufficiency, diabetes mellitus, or chronic inflammatory intestinal disease) (22). Despite its low incidence, infective endocarditis is an issue of concern representing a life-threatening disease with a reported mortality rate of 19% during hospitalization, increasing to 41% after five years. However, it substantially varies depending on microbiology and clinical circumstances (23). Unfortunately, the complication rate is high (24). Congestive heart failure has a relevant impact on prognosis, while peri-annular abscesses, systemic embolization, and neurological complications are very common (24). Based on these assumptions, it seems clear that proper prevention and an early and accurate diagnosis are key factors when facing infective endocarditis (25).

Several microorganisms have been identified as being responsible for infective endocarditis development. While up to 90% of infective endocarditis are caused by gram-positive Staphylococcus sp. (species), Streptococcus sp. and Enterococcus sp. (26, 27), Staphylococcus aureus is considered the most common in high-income countries (28). However, 90% of them are transient or stable components of oral microbiota (Staphylococcus aureus, Streptococcus viridians, Streptococcus bovis, and Enterococcus faecalis) (26, 27).

Additionally, the detection of low-pathogenic gram-negative bacteria that reside in the oral-pharyngeal regions (haemophilus sp., aggregatibacter sp., cardiobacterium hominis, eikenella corrodens, kingella sp.) and fungi (candida sp. being predominant in this group) in blood culture of patients with infective endocarditis strongly support the role of oral microbiota in development and progression of this disorder (28). Indeed, infective endocarditis is usually correlated to bacteremia, and as suggested by some authors, tooth brushing, chewing, and dental procedures allow the dissemination of these microorganisms into the bloodstream (29). Therefore, understanding the pathophysiology and participation of both the host and the bacteria is a major challenge to improve the methods used to prevent infective endocarditis.

Infective endocarditis and dental procedures

There is controversial data about the differences in oral health in normal patients and patients with congenital heart diseases. Some research findings have shown that oral streptococci, the main cariogenic and causative organisms of infective endocarditis, grow more in the oral cavity of cardiac patients (30). Viridans streptococci are responsible for dental caries, pericoronitis, and subacute infective endocarditis.

The most frequently isolated viridans streptococcus from infective endocarditis patients is S. sanguinis, followed by S. oralis (31). In dental infections, the risk increases, and it has been estimated that 10% of infective endocarditis is related to oral infections with no oral bleeding treatment. This is due to the permeability of the epithelium surrounding the tooth-gingival tissue interface and the prostaglandins in blood that increase the number of leukocytes and fibrinogen. Blood circulation is reduced, and bacteria may enter (16).

The prevalence of caries and gingivitis among children with congenital heart diseases is much higher than in healthy children (30). Periodontal disease is another risk of endocarditis in patients suffering from congenital heart diseases (32). Oral hygiene habits such as brushing, toothpicks, flossing, or chewing can result in bacteremia during non-exposure periods. The microtrauma caused by these daily activities induces bacteremia in similar proportions to those of invasive oral procedures. The fact that the cumulative non-exposure periods are much longer than the exposure periods strongly suggests that most cases of infective endocarditis are due to everyday life bacteremia (33).

The incidence of bacteremia for tooth extraction ranges from 18% to 85%, periodontal surgery from 60% to 90% and toothbrushing or irrigation from 7% to 50%. Routine daily activities unrelated to a dental procedure are associated with a similar risk of bacteremia (34). These activities are shorter and more frequent than dental procedures. Moreover, most people only visit a dentist once or twice per year, and therefore, only exposed to a bacteremia related to dentist or dental hygienist manipulations on rare occasions. In contrast, daily activities expose them to transient bacteremia very frequently. Even though this daily transient bacteremia is of low grade and short duration, it is of high incidence.

There is only a small percentage of infective endocarditis related to dental procedures; most infective endocarditis is associated with oral hygiene habits. According to the American Heart Association, the biggest causes of infective endocarditis include poor oral hygiene, minor gum injury caused by tooth brushing, and dental procedures.

The incidence of bacteremia ranges from 20% to 68% for toothbrushing and flossing, from 20% to 40% for the use of wooden toothpicks, from 7% to 50% for the use of water irrigation devices, and from 7% to 51% for chewing food (34). It is not realistic to administer prophylaxis against this random daily physiological bacteremia. Therefore, if prophylaxis is administered before a once yearly or twice-yearly dental procedure, even if it is effective, only an exceedingly small proportion of cases of infective endocarditis would be prevented (34).

It is estimated that only a small percentage of cases would have been potentially prevented if antibiotic therapy were given to all patients at risk in dental treatment (16). Furthermore, it has been observed that in many cases the onset of endocarditis occurred many months after the procedure or that the causative agent was not a bacterial species that lives in the oral cavity (34). The prevalence and intensity of bacteremia vary among different surgical procedures.

The oral cavity is a reservoir of hundreds of different species of bacteria. Therefore, any procedure capable of causing a breach in the oral mucosal barrier places the internal body environment in contact with the highly contaminated oral cavity, resulting in potentially harmful microorganisms penetrating the systemic circulation. All surgical dental procedures are characterized by a significantly higher prevalence of bacteremia compared to non-surgical procedures (35). Bacteremia peaks during the first minutes following tooth extraction or an invasive dental procedure and falls over time (36). However, blood culture reveals that antibiotic therapy reduces viable cultivable bacteria in the bloodstream after tooth extraction (37).

Some research has studied the effect of the duration of surgery on bacteremia and found that the prevalence is higher in longer surgery than when the duration of surgery is shorter (38).

Prevention of infective endocarditis

Antibiotic prophylaxis to prevent infective endocarditis before dental and other non-cardiac interventions is not warranted. The recent guidelines for the prevention of infective endocarditis emphasize that all people who are at risk of developing this infection need to take particular care to remain free of dental disease (39). People with high-risk cardiac conditions are considered those who have a prosthetic heart valve, previous endocarditis, unrepaired cyanotic congenital heart disease or a repair procedure within the last six months and cardiac shunts or conduits for palliation. For an unknown reason, infective endocarditis occurs twice as often in males as females, although females are more likely to have a worse prognosis.

Prophylactic antibiotics are recommended for people at high risk of developing infective endocarditis who undergo dental procedures involving manipulation of either gingival tissue or tooth root region or perforation of the oral mucosa (39). People at high-risk who are undergoing the following routine dental procedures do not require prophylactic antibiotics: routine dental anesthetic injections through non-infected tissue, dental x-rays, placement of removable prosthodontic or orthodontic appliances, adjustment of orthodontic appliances, placement of orthodontic brackets, losing deciduous teeth and treatment of bleeding due to trauma to the lips or oral mucosa (39).

Amoxicillin is the first-line prophylactic antibiotic for people undergoing invasive dental procedures at high risk of developing endocarditis. Clindamycin or clarithromycin are possible alternatives for people in whom amoxicillin treatment is inappropriate or potentially ineffective. To ensure that levels in the blood are maximal at the time of procedure, the antibiotic should be given in the following timeframes: orally, one hour before the procedure; intramuscularly, 30 minutes before the procedure; intravenously, immediately before the procedure. If the patient carelessly does not receive an antibiotic before the dental procedure, it may be administered up to two hours later, although the effectiveness of the prophylaxis may be reduced (39).

The routine use of prophylactic antibiotics for infective endocarditis prevention began in the 1950s. There was a change in thinking when the American Heart Association produced guidance (2007) recommending that antibiotics should be limited to patients who had the highest lifetime risk of infective endocarditis and specifically only before invasive dental procedures. The European Society of Cardiology also produced similar guidelines (39). The principal reason for the reduction in antibiotic use was that the risk of a person developing infective endocarditis following a dental procedure is very low, even for those with a high lifetime risk (40). Based on these, it was argued that the use of prophylactic antibiotics for people other than those at the highest lifetime risk of infective endocarditis would prevent very few cases of infective endocarditis (41). Also, widespread use of antibiotics would result in an increased number of adverse reactions and contribute to the growing problem of antimicrobial resistance (42).

The UK National Institute for Health went one step further. It recommended that antibiotics should no longer be prescribed solely to prevent infective endocarditis, regardless of the patient's risk (43). Subsequently, in 2008 antibiotic prophylaxis was completely abolished for all patients in the UK, posing the basis for a revision of the guidelines in other countries including Europe with a reduction of types of cardiac conditions requiring prophylaxis.

The recommendation was based on clinical evidence and strongly influenced by the possibility that the use of antibiotics for infective endocarditis prevention may result in a net loss of life due to adverse effects associated with antibiotic use (43). One study after the introduction of the guidelines failed to detect a significant increase in the incidence of infective endocarditis compared with before the guidelines (44, 45). The study from England was not the first to examine the relationship between antibiotic prescribing and rates of infective endocarditis. Studies conducted in the USA following the introduction of the modified guidelines from the American Heart Association, also did not detect an increase in the incidence of infective endocarditis (46-57).

Decades of published data still do not provide evidence on which to make strong recommendations for antibiotic prophylaxis against endocarditis at the time of dental procedures (49). The association between origin of the IE causing bacteria and findings during oral infection screening might be uncertain and may suggest that the benefit of screening and elimination of oral infections in patients admitted with IE might be overestimated.

Since a change in this confusing and contradictory recommendation situation is not foreseeable, clinicians faced with the decision to prescribe antibiotic prophylaxis in patients with an increased risk should consider national guidelines and international recommendations (58, 59). To ensure responsible therapy, practitioners should regularly observe scientific discussion and review the latest updates (60-62).

CONCLUSIONS

Dental treatment, although considered safe, can be life-threatening if medical problems of the patient, especially cardiac disorders, are ignored. A detailed medical and drug history from each patient at every appointment and vast knowledge of the risk factors and clinical manifestations of various cardiac diseases can prevent many medical consequences in the dental clinic. A comprehensive treatment plan prepared in collaboration with the patient's cardiologist can help avoid potential dangers during dental treatment for a cardiac patient. All drug prescriptions, surgical interventions, and overall management approaches should adhere to the latest guidelines and protocols.

Conflicts of interest

The authors declare no conflict of interest.

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Letter to the Editor

TWENTY-THREE YEARS OF HISTORY IN TRAINING IN AESTHETIC MEDICINE FOR GRADUATES IN MEDICINE AND DENTISTRY

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To the Editor,

The face plays an important role in relationships. The nose, eyes, and lips are pivots of the aesthetics of the face (1). During aging, a ptosis of the facial fat of the face can occur with the inversion of the beauty triangle (2).

Noninvasive facial reshaping procedures have increased in recent years, such as dermal filler, cold plasma, peeling, non-ablative radiofrequency, biostimulating, and traction threads. Important progress has been made thanks to a better knowledge of anatomical structures and their physiology, which allows aesthetical doctors to perform treatments with a high aesthetic yield.

Despite of the great advances achieved to date, facial lifting remains the most complex surgical procedure among the plastic surgery treatments of choice. Moreover, as with every surgical procedure, it is accompanied by several disadvantages, including breathing disturbances, atrophy, scars and fibrosis of the skin and soft tissues, infections, and even postoperative deformities, depending on the surgeon and the circumstances of facial reshaping (3). For all these reasons, aesthetic medicine treatments are acquiring increasing importance within the cosmetic field, preferring noninvasive treatment. Training and continuing education are fundamental for practicing aesthetic medicine (4).

Unfortunately, in Italy, there are no courses of study during degree courses. Aesthetic doctors are trained in post-graduate courses, such as master's degrees, but there is a lack of specialization courses in aesthetic medicine. Since 2002, a reproducible introductory course on aesthetic medicine for dental and medical graduates was established at the University of Chieti, training 20 doctors per year. This course helps dental and medical graduates to apply aesthetic medicine techniques and provides valuable information on the specialty itself.

The course has become a valuable training and marketing tool for private practice. Medical and dental school in Italy lasts six years. It starts immediately after high school, with two years of theoretical and practical classes followed by a four-year internship that includes professionalizing subjects. At the end of the internship, the successful student receives a degree in dentistry and can practice dentistry. Young dentists may work in any dental field, such as general dentists or specialists such as oral surgeons, orthodontists, and pediatric dentists. In Italy, too, aesthetic medicine is not a recognized specialty, although craniomaxillofacial surgery, dermatology, and plastic surgery are considered major players in aesthetic medicine and surgery. Practicing aesthetic medicine in Italy without having a specialty and without certification of a post-graduate course, even if it is possible, risks not being covered by professional insurance. To obtain a master's degree at the University of Chieti-Pescara, one must have completed a one-year training course.

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The Master program covers topics such as aging and rejuvenation with non-invasive techniques. Initially, Italian dentists could only treat the lower third of the face(5), but starting in 2023, they will be able to perform minimally invasive treatments on the entire face. This has increased the interest of Italian dentists in aesthetic medicine.

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Comparative Study

A GENDER-BASED COMPARATIVE STUDY OF THE RISK OF MALOCCLUSION AND OCCLUSAL TRAITS AMONG PRESCHOOL-AGE CHILDREN

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ABSTRACT

The aim of the present study was to evaluate and compare the risk of malocclusion according to gender using the Baby-Roma Index and occlusal traits in a sample of Albanian preschool-age children. Three hundred thirty children 3-6 years old were screened, and data were collected using the Baby Roma Index. The overall prevalence of malocclusion was 68.8%. None of the examined children was assigned to grade 5 (systemic problems). 46.2% of children (56 males and 49 females) had a score of 4. Similarly, among the children in grade 3, there were more males than females. 31% of participants were assigned minor/no treatment needs. There was no significant relationship between genders and index grades. The most observed frequency of molar relationship right (52.4%) and left (54.1%) sides was flush terminal plane. Distal step was less frequent (17.6% right side and 18.9% left side). There was no significant change in right and left molar relationships between genders. Class I canine relationships (62% right side) and 64% (left side) were the most frequent. There was no significant relationship between canine relationships and gender. Malocclusion was widespread among children included in the study. Almost half of them need orthodontic treatment. There were no gender-based changes in the risk of malocclusion and occlusal traits.

KEYWORDS: *Baby Roma Index, Albanian preschool children, occlusal traits*

INTRODUCTION

The first stage of occlusal development is the primary dentition stage, which begins with the eruption of the first tooth (1). The development of malocclusion begins during the primary dentition stage (2, 3) and can be accordingly detected (4).

Previous studies have confirmed that malocclusion observed in primary dentition represents a risk factor for the necessary orthodontic treatment of permanent dentition (5) and an increase in the frequency in the mixed dentition phase (6). Moreover, children with previous anterior open bite (AOB), increased overjet (OVJ), and posterior crossbite (CB) have a greater risk of having the same characteristics in the mixed dentition (7). The multi-factorial etiology of malocclusion includes mouth breathing and non-nutritive sucking habits.

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There are several consequences related to mouth breathing, including malocclusion, the deterioration of oral hygiene, increased prevalence of caries, periodontal diseases, and abnormal maxillofacial growth (8). Persistence of non-nutritive sucking beyond 3 years is implicated in malocclusions, such as AOB, PCB, and Class II molar relationship (9). Hence, it is important to intervene before the malocclusion stabilizes and escalates (3, 10). Interceptive treatments are known to be less invasive, less expensive, faster, and often reduce the need for other treatments (11).

There is concern about the necessity of assessing the need for orthodontic treatment in primary dentition when a wide variety of skeletal, dental, and functional factors, if unobserved, could adversely influence occlusion and craniofacial growth. Grippaudo et al. modified the ROMA (Risk of Malocclusion Assessment Index) index and targeted the age of primary dentition (Baby -ROMA Index). The index is divided into four main categories of problems: systemic, craniofacial, dental, and functional. Each category has a score (from 1 to 5) corresponding to the risk severity and an alphabet letter for each different type of malocclusion (12).

Epidemiological studies can assess the prevalence and establish the risk of malocclusions observed in preschool-age children, which in turn contributes to establishing the need for interceptive orthodontic treatment (13). Hence, considering the limited data regarding the prevalence and complete absence of previous data regarding the risk of malocclusion among Albanian preschool-age children, the aim of the present study was to evaluate and compare according to gender the risk of malocclusion using the Baby-Roma Index and occlusal traits in a sample of preschool age children visiting the University Dental Clinic.

MATERIAL AND METHODS

This descriptive cross-sectional study was conducted at the Dental Clinic of Albanian University, Tirana, Albania, from January 2022 to 2024. Only children with complete primary dentition with no history of previous orthodontic treatment were included in the study. The sample size (330) was calculated by applying the formula:

$$n= z^2 p (1 - p)/e^2$$

Involved children were examined by the authors of the study (E.K and E.G) at the Clinic. The presence of parents during the examination allowed us to collect all the necessary anamnestic data for the Baby Roma Index (12).

Thirty randomly selected children were double-examined for the intra-examiner and inter-examiner reliability tests through Cohen's Kappa coefficient. Both intra-examiner 0.82 and interexaminer 0.77 were considered optimal. Occlusal traits were assessed while each child was biting on his or her posterior teeth with the jaws in centric relation (maximal intercuspation).

The primary molar relationship of the maxillary and mandibular second primary molars for both sides in the vertical plane was classified according to Baume (14).

- flush terminal plane: the distal surfaces of upper and lower primary second molars are in one line with each other when the primary teeth are in occlusion;
- distal step: the distal surface of the lower primary second molar is distal to the distal surface of the primary upper second molar in occlusion;
- mesial step: The distal surface of the mandibular primary second molar was mesial to that of the maxillary primary second molar.

The primary canine relationship was also assessed on both sides (15) and classified as:

Class I: the cusp tip of the maxillary primary canine tooth was in the same vertical plane as the distal surface of the mandibular primary canine.

Class II: the cusp tip of the maxillary primary canine tooth was mesial to the distal surface of the mandibular primary canine.

Class III: the cusp tip of the maxillary primary canine tooth was distal to the distal surface of the mandibular primary canine.

Overjet (OVJ) expressed in (mm) was measured with a graduated periodontal probe from the mid-point of the labial surface of the most anterior lower central incisor to the mid-point of the labial surface of the most anterior upper central incisor.

Overbite (OVB) expressed in mm was measured with a graduated periodontal probe, which is the vertical distance between the incisal edges of the upper and lower central incisors. Spacing was recorded as present when the child had spacing between all teeth in the anterior segments of the maxilla and mandible and absent when there were no visible spaces or tooth rotation was present.

Anterior crossbite (CB) was recorded as present when one or more of the maxillary incisors/canine occluded lingually to the mandibular incisors/canine.

Posterior crossbite was recorded as present when one or more of the maxillary molars occluded lingually to the mandibular molars. Scissors bite was recorded as present when maxillary molars occluded to the buccal surfaces of the corresponding mandibular molars and/or mandibular molars occluded to the lingual surfaces of the corresponding maxillary molars.

Data were statistically assessed by descriptive analysis using the IBM SPSS Statistics 26.0 package program (IBM Corp., Armonk, New York, USA). The associations established between gender and risk of malocclusion Baby Roma Index and occlusal traits were performed using a chi-square test with a significance level set at 5%.

RESULTS

Table I depicts the observed frequency according to index grades. The overall prevalence of malocclusion is 68.8%. None of the examined children was assigned to grade 5 (systemic problems). According to index grades, the most prevalent is from grade 4 caries and early loss of deciduous teeth (35.6%). With reference to grade 4, our result indicates that the prevalence of CB >2mm or lateral shift (4n) is 8.8%, and the prevalence of negative OVJ is 4.8%. Regarding grade 3, the most prevalent is displacement >2mm (3o) 7.8%, and open bite > 4mm (3p) 3.6%.

In grade 2, the most prevalent malocclusion is OVJ 3-6mm (2h) 17.8% and CB<2mm or no lateral shift (2n) 9.3%. The functional problem also belongs to grade 2, and according to Table I, the most prevalent is thumb/finger sucking habit (2w) 24.9% and oral breathing/OSAS (2x) 19.6%.

Table I. *Frequency of Index grades.*

Systemic problems	**Index grade**	**Present**
Maxillo-facial Trauma		
with condylar fracture	5a	0%
without condylar fracture	2a	0%
Congenital Syndromes/Malformations	5b	0%
Postural/ Orthopaedic Problems	2c	0.9%
Medical or Auxological Conditions	2d	0%
Inheritance of malocclusion	2e	2.4%
Craniofacial Problems		
Facial or Mandibular Asymmetries	4f	0.6%
TMJ dysfunctions	4g	1.2%
Outcomes of trauma or Surgery		
of the craniofacial district	5j	0%
Maxillary Hypoplasia /		
Mandibular Hyperplasia		
OVJ<0	4k	4.8%
Dental Problems		
Maxillary Hyperplasia		
/ Mandibular Hypoplasia		
OVJ>6mm	3h	6.2%
3mm<OVJ<6mm	2h	17.8%
Caries and Early Loss		
of DeciduousTeeth	4l	35.6%
Scissor bite	4m	0%
Crossbite		
>2mm or lateral shift	4n	8.8%
<2mm or no lateral shift	2n	9.3%
Displacement		
>2mm displacement	3o	10.1%
>1mm – absence of diastema	2o	9.6%
Open bite		
>4mm	3p	8.4%
>2mm	2p	6.6%
Hypodontia up to 2 teeth	3q	0.6%
more than 2 teeth	4q	0%
Supernumerary teeth	4q	1.2%
OVB>5mm	2r	2.1%
Poor oral hygiene	2t	24.8%
Functional Problems		
Parafunctions (bruxism, jaw		
clenching)	2v	4.8%
Thumb/finger Sucking Habit	2w	24.9%
Oral breathing /OSAS	2x	19.6%
None of the problems		31.2%

Table II shows the frequency and comparison of the risk of malocclusion related to gender; 46.2% of children (56 males and 49 females) scored 4. Similarly, among the children in grade 3, there were more males than females. 31% of participants were assigned minor/no treatment needs. There was no significant relationship between genders and index grades (Table II).

Table II. *Comparison of index grades according to gender.*

Index grades	Female	Male	*p-value*
Minor/ no treatment need	37	33	
Borderline	21	31	0.229
Treatment need 4	49	56	

Results of occlusal traits observed and comparison according to gender are shown in Table III. The most observed frequency of molar relationship on the right (52.4%) and left (54.1%) side was a flush terminal plane. Distal step was less frequent (17.6% right side and 18.9%). There was no significant change in right and left molar relationships between genders.

Class I canine (62% right side) and 64% (left side) were the most frequent. There was no significant relationship between canine relationships and gender (Table III).

Table III. *Comparison of occlusal traits according to gender.*

	Female	Male	*p-value*
Right molar			
Flush terminal plane	54	65	0.707
Mesial step	37	31	
Distal step	19	21	
Left molar			
Flush terminal plane	63	60	0.628
Mesial step	36	44	
Distal step	24	19	
Right canine			
Class I	77	64	0.955
Class II	33	28	
Class III	12	13	
Left canine			
Class I	82	65	0.628
Class II	25	26	
Class III	14	15	

DISCUSSION

The aim of the present study was to evaluate and compare, according to gender, the risk of malocclusion using the Baby-Roma Index and occlusal traits in a sample of Albanian preschool-age children. Previous studies have consistently shown that malocclusion is widespread among preschool-age children, with prevalence rates of 42%, 81.44%, and 89% (6, 16, 17). Indeed, the results yielded from the present study revealed a predominance of children with malocclusion (68.8%) compared to children without malocclusion. Other authors using the same index have also pointed out almost similar frequency of malocclusion, 69%-71% (18, 19).

Apart from prevalence, the Baby Roma Index enables the categorization of the malocclusion with reference to the risk severity. Scores 4 and 5 require an immediate orthodontic treatment (12). 46.2% of our sample had a score of 4. Like Govil (18), who also found that most of the sample had a score of 4 that required an immediate treatment need, and the most frequent malocclusions from this category were caries and early loss of deciduous teeth 35.6%. Dental caries is the main reason for the early loss of deciduous teeth, affects the development of normal occlusion, and increases the need for orthodontic treatment at later stages (20, 21).

Results from various studies show that apart from being closely associated with oral habits (10, 22), the prevalence of posterior CB increases during the transition from primary to permanent dentition (23). The prevalence of posterior CB >2mm in our study was 8.8%, the second most prevalent malocclusion from scale 4. The overall prevalence of CB in our study (18.1%) agrees with the reported prevalence among Slovenian (15.2%) and Spanish children (19.7%) (10, 24).

A score of 3 indicates the presence of a malocclusion, which can persist or worsen; therefore, patients will be assessed again before the growth spurt. OVJ >6mm, open bite >4mm, and displacement >2mm are included in the score of 3. The available literature suggests that these malocclusions are highly prevalent among preschool-age children (6, 25, 26).

The frequency of score 3 in our result (22.8%) is higher than the frequency observed by Grippaudo (9%) and Singh (12.3%) (18,19). A possible explanation for this change is that displacement >2mm was more frequent among children included in this study (10.1% vs 5.1% and 1.4%). The presence of spacing has a strong impact on the eruption of permanent teeth and the establishment of occlusion. Consequently, the absence of spacing increases the occurrence of malocclusion and the necessity of orthodontic treatment (27). In addition to a significant relationship between caries and crowding, a previous study among Albanian preschool children also found that children without maxillary spacing were more susceptible to caries (17).

While a score of 1 is only a routine check-up to monitor the occlusion, a score of 2 is more exposed to the action of risk factors. Mouth breathing and bad oral habits were confirmed as risk factors from a study among Italian preschool children using the same index as in the present study that found a significant association between malocclusion traits such as AOB, increased OVJ, and CB (28). Results yielded from this study [thumb/finger sucking habit (2w) 24.9% and oral breathing/OSAS (2x) 19.6%] are in line with previous reports that similarly found that oral habits and mouth breathing are widespread among children of preschool age (26, 28).

Comparisons according to gender were among the aims of the study. Neither the risk scores nor occlusal traits showed statistically significant differences between females and males. There are various conclusions from other studies using other classification methods regarding gender differences in any malocclusion trait. The study involving Libyan children, except for OVB, did not find significant differences for OVJ, crowding, and CB (4).

Among German children, cross-bite and open-bite were recorded significantly more often in girls (29). Similarly, a study to evaluate the prevalence of subjects needing an interceptive orthodontic treatment (IOTN) found that CB and oral habits were more prevalent among females (11). Ovsenik, in her study, found that posterior CB was more frequent in females, but the difference was not significant (24). Additionally, a study involving Greek children found no significant gender differences in the sagittal relationships of second primary molars and primary canines (30).

CONCLUSIONS

By recognizing the risk of malocclusion during the primary dentition stage, which is already established and directly related to risk factors confirmed in this study, early detection is paramount in preventing the severity and subsequent orthodontic treatment needed in permanent dentition.

Increased awareness from pediatricians, considering that they perhaps examine preschool children more frequently than orthodontists, will benefit both children and parents.

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Case Report

A RARE CASE OF BILATERAL INTERNAL CAROTID ARTERY DISSECTION IN EAGLE SYNDROME: A MINIMALLY TRANSORAL SURGICAL APPROACH

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ABSTRACT

Eagle's syndrome is a condition associated with the elongation of the styloid process or calcification of the stylohyoid ligament, which is responsible for polymorphic head and neck symptoms, often resulting in delayed diagnosis. Two variants can be distinguished, as initially described by Eagle, the stylohyoid syndrome as a classic type and the stylocarotid syndrome as a vascular type; the latter can involve a dramatic evolution such as internal carotid dissection (ICD). The most commonly proposed curative treatment is styloidectomy, which allows complete resolution of symptoms in the great majority of cases and can be performed via a transoral or a transcervical approach. This paper aims to describe a rare case of bilateral internal carotid artery dissection (ICD) due to Eagle Syndrome and review available literature on the clinical features and treatment. We present the case of a 46-year-old male patient manifesting pharyngeal foreign body sensation, dysphagia, and neck and throat pain exacerbated by head movements, with evidence on CT scans of elongation of the styloid apophyses bilaterally in close proximity to the cervical portion of the internal carotid artery (cICA). Computer tomography angiography showed smooth bilaterally tapering of the mid portion cICA; therefore, ICD due to Eagle syndrome was diagnosed, and transoral styloidectomy was performed. In the literature, there are no cases of bilateral ICD derived from Eagle Syndrome treated with an intraoral approach.

KEYWORDS: *Eagle syndrome, styloid process, parapharyngeal space, internal carotid artery dissection, neck pain*

INTRODUCTION

The styloid process is a cylindrical, slender, needle-like projection of varying lengths, averaging 2 to 3 cm. It projects from the inferior portion of the petrous temporal bone, lying inferior and anterior to the external auditory meatus, anteromedial to the mastoid process, and anterior to the stylomastoid foramen; its tip is located between the internal and external carotid arteries, posterior to the tonsillar fossa. It offers attachment to the stylohyoid ligament, the

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stylomandibular ligament, and the stylohyoid, stylopharyngeus, and styloglossus muscles, grouped under the styloid diaphragm.

Significant vessels and nerves surround the styloid process: the internal jugular vein, internal carotid artery (well as its branches, the lingual artery, facial artery, superficial temporal artery, and the maxillary artery), and glossopharyngeal nerve (cranial nerve, CN, IX), vagus nerve (CN X), accessory nerve (CN XI) and a segment of the sympathetic chain lie medial to the styloid process; the external carotid artery and one of its branches, the occipital artery, hypoglossal nerve (CN XII) and facial nerve (CN VII) run along its lateral side.

Abnormalities in the stylohyoid complex were first identified in animals by Vesalius in 1543, while the first description in humans was published by Marchetti in 1656; the synthomatic elongation of the styloid process instead was first described in 1937 by Eagle, who first used the term ‘‘stylalgia’’ to assess a cervicofacial pain associated with abnormal length of the styloid process (1).

The cut-off value most commonly used to define a long styloid process is 30 mm. However, only 4–10% of patients with elongated processes report pain, and it is often an incidental finding on imaging (2). The clinical pattern could be explained by the peculiar anatomic relationship that SP acquires with many neurovascular structures and some muscles involved in swallowing. They are related to a long styloid process or ossification of the stylohyoid ligament, which leads to compression/impingement of adjacent neurovascular structures (3-4).

Eagle categorized the stylohyoid syndrome as classic and stylocarotid types (1). The former seems facilitated by fibrosis phenomena in the tonsillar fossa following tonsillectomy or minor cervical trauma, and it’s considered a whole intermittent compressive neuropathy involving different branches of cranial nerve (V, VII, IX, X); symptoms most commonly reported are cervicofacial pain with radiated otalgia or temporomandibular joint pain exacerbated by hyperextension, sudden neck movements or swallowing, migraine, hypopharyngeal globus sensation, dysphagia, odynophagia, tinnitus or even dysphonia or trismus (5). The latter is related to impingement on carotid vessels and associated sympathetic nerve plexus, causing referred pain (parietal/periorbital) in those areas supplied by the affected carotid branch,

Horner’s syndrome or even cerebrovascular manifestations such as visual disturbances, presyncope, syncope, dizziness or transient ischemic attacks, and cerebral ischemia due to direct arterial compression, arterial dissection, and thrombo-embolism of ICA (6). Furthermore, Zamboni et al. (7) describe a third type, the jugular variant, related to extrinsic compression of the internal jugular vein between an elongated styloid process and the transverse process of C1, in which symptoms such as headache, numbness, and dizziness may be related to impaired cerebral venous outflow and subsequent endocranic venous hypertension leading even to peri-mesencephalic sub-arachnoid hemorrhage.

A comprehensive anamnesis and accurate physical examination are essential elements in the diagnostic work-up. Pharyngeal palpation, especially of the tonsillar space, reveals an elongated styloid process and generally elicits existing pain. A reliable diagnostic test has been proposed, consisting of injecting 3 mL of 2% lidocaine into the tonsillar fossa, demonstrating Eagle’s syndrome when the pain is relieved. This test is an excellent predictive factor of a good response to styloidectomy (8).

Different imaging modalities have been advocated as diagnostic tools, such as orthopantomography and plain radiographs of the skull in L-L views. Still, the reference one is a CT scan with 1 mm sections and 3D reconstruction, which provides a detailed analysis of the styloid process, the degree of ossification of stylohyoid ligament, and neurovascular anatomical relations. CT-Angiographic can provide further information regarding carotid flow, especially if stroke or dissection is suspected.

Once the diagnosis is confirmed, the treatment of ES can be conservative or surgical. Medical management can be proposed when the patient refuses surgery and can give good but only temporary results and include analgesics such as non-steroidal anti-inflammatory agents, steroid injections, antidepressants, or anticonvulsants (9). Styloidectomy is the surgical treatment of choice for the alleviation of Eagle syndrome symptoms. It involves shortening the styloid process, leaving approximately 1 cm behind to minimize the facial nerve injury risk. If there is calcification of the stylohyoid ligament, then it is appropriate to remove a portion of that ligament as well. The surgical approach can be transoral or transcervical and aims to achieve partial or complete styloid resection.

The purpose of this article is to describe a clinical case that presented the first Eagle syndrome with bilateral internal carotid dissection (ICD) performed with a minimally invasive transoral technique.

CASE REPORT

We describe the case of a 46-year-old male patient addressed to the Maxillofacial Unit of IRCCS Istituto Ortopedico Galeazzi in Milan (Italy), complaining of polymorphic head and neck symptoms, such as pharyngeal foreign

body sensation, dysphagia, neck and throat pain exacerbated by head movements, even though neck pain was the major symptom. He experienced repeated vomiting episodes, which caused his neck to hyperflex. A detailed medical history and complete examination were performed, and the patient was classified as ASA 2. The head and neck clinical examination included careful evaluation of extension, flexion, and rotation neck movements and palpation of the tonsillar fossa, lateral pharyngeal wall, and the area between the mastoid apex and mandibular angle in an attempt to trigger the patient's discomfort. Palpation of the tonsillar fossa triggered the patient's pain.

A computed tomography (CT) and a 3-D reconstruction were performed (Fig. 1). This CT revealed an elongation of the styloid apophyses bilaterally, 4.5cm in length, bilaterally in close proximity to the cervical internal carotid artery (cICA). MRI did not show evidence of acute or prior strokes.

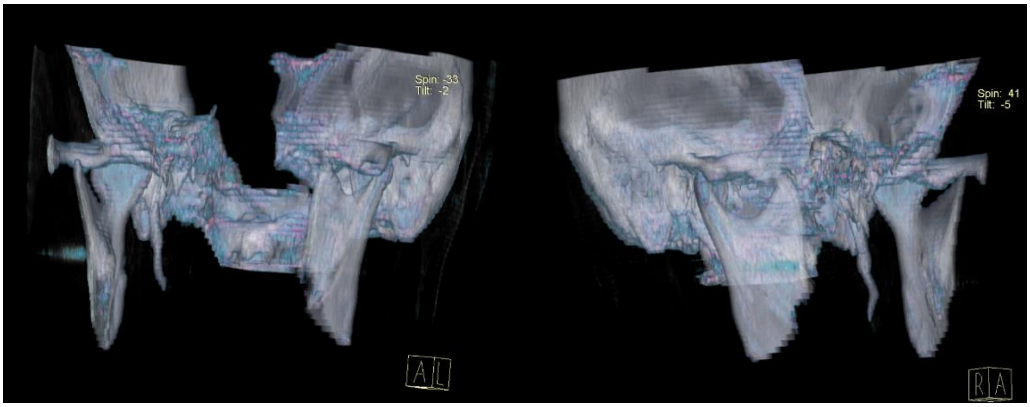

Fig. 1. *3D CT reconstruction revealing elongation of the styloid apophyses bilaterally, about 4.5cm in length.*

Finally, the computer tomography angiography (CTA) showed smooth bilateral tapering of the mid-cervical portion of cICA, 3 cm above its origin, which suggested carotid dissection (Fig 2).

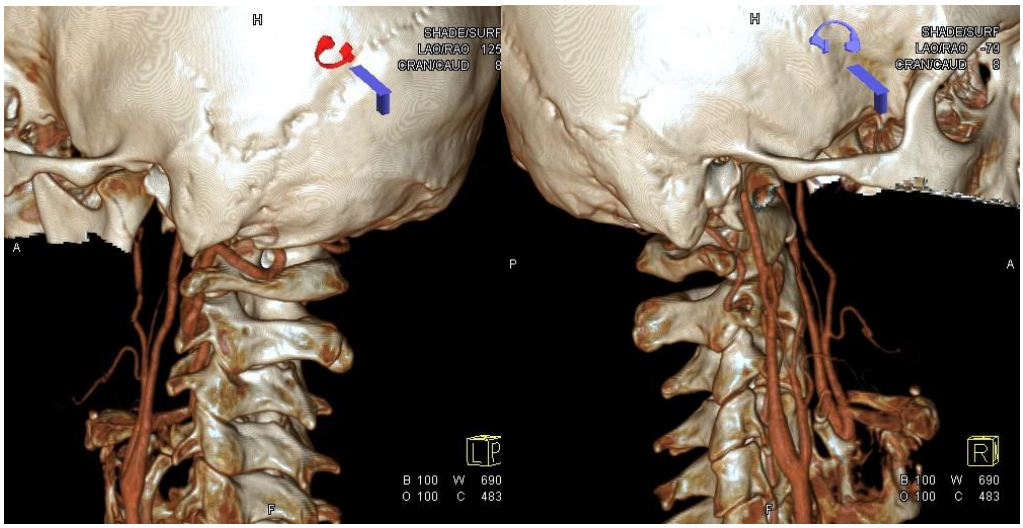

Fig. 2. *VR reconstruction of computer tomography angiography (CTA) showing smooth bilaterally tapering of the mid-cervical portion cICA, 3 cm above its origin, more evident on the right side, suggestive of carotid dissection.*

Dissections due to Eagle syndrome were diagnosed. The surgical approach contemplated a transoral approach using the technique described by Torres et al. (10). The patient underwent general anesthesia and was positioned with the head in extension. McIvor's retractor was used to perform a correct approach from the point of view of visualization of the surgical field, opening the mouth, and pushing the tongue down. Palpation of the region was performed to detect the

tip of the styloid process. After mucosa incision, dissection and exposure of the styloid process were carefully performed until the entire length of the styloid apophysis was clearly visible, preserving tonsils. Then, after its periosteum was incised and dissected, styloid apophysis was exposed, and the enveloping muscles were removed (Fig. 3).

Fig. 3. *Surgical detail: transoral exposure of the left styloid process.*

Then, isolated styloid apophysis, detached stylohyoid ligament from the tip of the SP with Metzembaum scissors, clamped with Kelly hemostatic forceps, was subsequently resected close to its base (Fig. 4).

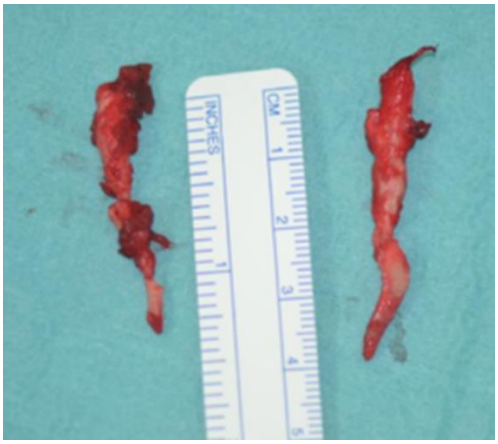

Fig. 4. *Surgical specimen: right and left styloid process resected.*

Bleeding was controlled with bipolar-diathermy forceps, and the mucosal incision closed with 3.0 Vicryl interrupted sutures. The patient was discharged after two days. The only complication during the post-operative period was a cervical subcutaneous emphysema on the right side, which resolved spontaneously.

Approximately four weeks and 3 months after discharge, the patient was evaluated in the clinic. The patient reported a complete resolution of symptoms.

DISCUSSION

Eagle syndrome is a rare pattern of symptoms (0.16% of the general population) due to the conflict with adjacent anatomical structures by an elongated styloid process or a calcified stylohyoid ligament. In 1986, Langlais described a radiographic classification: Type I - pattern represents an uninterrupted elongated SP, Type II, characterized by the SP apparently being jointed to a calcified SL by a single pseudo-articulation, and Type III – consists of interrupted segments (11).

There are no treatment guidelines for Eagle syndrome with carotid dissection (12-15). An indication for endovascular treatment can be extrapolated from the NASCET trial—Dissection causing greater than 70% stenosis. Three-dimensional reformatting of CT imaging is paramount in diagnosing stylocarotid syndrome (16). Some authors have proposed that the only definitive treatment for any symptomatic variant of Eagle syndrome is styloidectomy (17-18).

Two surgical approaches for treating Eagle's syndrome are described in the literature: cervical and intraoral. The cervical approach provides a vertical skin incision of 4 cm in length performed from the posterior border of the mandibular

angle along with the anterior edge of the sternocleidomastoid muscle, SCM. Once the platysma is dissected, the investing layer of deep cervical fascia is excised. The head of the submandibular gland is mobilized superiorly, while the SCM and posterior digastric muscle belly are retracted posteriorly to expose the styloid process (19). The advantages of the cervical approach are favorable surgical exposure and a low risk of infection. Possible complications are facial nerve damage and an unaesthetic cervical scar. The advantages of the intraoral approach include a small incision, limited dissection, shorter operative time, absence of drainage, and a short stay in the hospital. Disadvantages are limited surgical exposure, higher risk of infection, and subcutaneous emphysema.

In the literature, there are no cases of bilateral ICD derived from Eagle Syndrome that were treated with an intraoral approach. There is not yet a validated surgical protocol for these cases, and the intraoral approach has to be considered a convenient choice (20-22).

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

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Case Study

MAGNETIC RESONANCE IMAGING OF INTRAMASSETER HEMANGIOMA. EVALUATION OF TWO CASES

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ABSTRACT

This article aims to evaluate the Magnetic Resonance Imaging (MRI) semeiotic aspect of an intramuscular hemangioma in the masseter of two patients and review the literature regarding the diagnostic possibilities of MR imaging in interpreting the characteristics of benign and malignant types of this intramuscular lesion in order to ensure a correct diagnosis and treatment. Two patients, aged 29 and 25 years, underwent an MRI examination using a 1.5 Tesla superconducting magnet (Siemens, Erlangen, Germany), with a dedicated surface coil, in one case before and after administering a paramagnetic contrast agent (gadolinium). In both cases, MRI showed the intramuscular haemangioma both with and without the use of the paramagnetic contrast agent. MR images, taken before and after administering the paramagnetic contrast agent, provide important information about the type of intramuscular lesion analyzed, by which it is possible to differentiate a benign mass from a malignant one.

KEYWORDS: *Magnetic Resonance Imaging, MRI, hemangioma, Masseter muscle*

INTRODUCTION

Currently, every benign vascular pathology is referred to as a hemangioma. However, there are vascular pathologies with different evolutions; some have a tendency to regress after the physiological skeletal growth period, while others retain a certain capacity for local infiltrative growth with a tendency to relapse. Vascular and skin lesions were studied by Mulliken et al. in 1982, who provided a classification based on growth data and endothelial characteristics, dividing them into hemangiomas and vascular malformations (1).

Hemangioma is a benign vascular tumor with a particularly rapid growth tendency during the neonatal period, followed by a slow involution phase (2). During the growth of the neoformation, endothelial hyperplasia with multiple laminations of the basement membrane is evident, followed by fibrotic involution and a reduction in the cellular component during the involutionary period.

Vascular malformations are present at birth, grow during the development of the individual, and do not undergo involution; on the contrary, they can increase in size following trauma or hormonal stimuli (2). The head and neck are the regions where vascular malformations occur most frequently, followed by the trunk and limbs. Intramuscular hemangiomas (IMHs) are rare, benign vascular tissue tumors, occurring in approximately 0.8% of all hemangiomas (3-

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5). Their recognition is important for the clinician because the location and the evolutionary characteristics might suggest erroneous interpretations of malignancy.

The definitive diagnosis is established only by histological examination. Less than 15% of IMHs occur at a level of the head and neck, where the masseter muscle appears to be the most frequent site of origin, followed by the trapezius and sternocleidomastoid muscles (6-12). Depending on the size of the blood vessels that compose them, there are three categories of hemangiomas: the capillary type, the cavernous type, and the mixed type (3, 4, 6, 12-15). A palpable mass is present in 98% of cases (3, 4, 16); some IMH can pulsate, and it is possible to perceive a noise or a tremble (3).

These lesions are typically studied using ultrasound (US), magnetic resonance imaging (MRI), or computed tomography (CT). Radiological examinations are crucial for evaluating the signs of benignity or malignancy of the lesion, as well as its vascularization and enhancement. The use of diagnostic methods that do not involve ionizing radiation is strongly recommended by the European Dental Radiology guidelines (17). The US is useful for evaluating the presence of IMH in superficial sites. A color-doppler ultrasound provides morphological and vascular information without the risk of ionizing radiation. If an intraosseous or intramuscular hemangioma is suspected, a contrast-enhanced MRI would be the imaging modality of choice and is considered superior to a CT scan (18).

In the maxillofacial region, MRI is the gold standard for the study of temporomandibular disorders (TMD) (19) but is also highly recommended for vascular pathologies because it permits vascularization without a contrast agent, while CT exam with intravenous contrast allows you to evaluate the enhancement.

Peripheral enhancement without progression throughout the mass suggests a lesion that is probably not primarily a vascular entity. Peripheral enhancement progressing to the center (low flow) is typical of venous malformation. In contrast, rapid enhancement throughout the mass characterizes an arterial malformation and, if accompanied by flow voids, an arteriovenous malformation (20). In cases of sudden lesion growth, uncontrollable pain, major functional disorders, necrosis of the overlying skin tissue, thrombocytopenia, or facial deformity, surgical therapy is recommended (9, 21).

The removal of IMH must include the resection of a significant portion of the surrounding muscle tissue, as the infiltrative capacity along the muscle bundles is the primary cause of any relapses (22, 23).

CLINICAL CASES

For the MRI examination, a 1.5 Tesla superconducting magnet and a dedicated surface coil were used. Multiplanar Spin-Echo (SE), Turbo-Spin-Echo (TSE), and Turbo Inversion Recovery Magnitude (TIRM) scans, T1 and T2-weighted sequences have been carried out. To evaluate the enhancement, in one case, 0.2 cc/kg of an intravenous gadolinium-based contrast agent (GBCA) was administered to the patient, and images were acquired using the fat suppression (FS) technique.

Case one

A 25-year-old female presented with swelling in the right masseteric site of taut-elastic consistency without signs of pulsation. The swelling was mobile on superficial levels but not dissociable from the muscle tissue. It was neither painful nor tender but exhibited slight tenderness. There were no signs of ongoing inflammation or local sweating.

The swelling had developed slowly in 3-4 years, with rapid growth in the last 6 months, at the site of a previous intervention of surgical removal of a muscular hernia of the masseter, interpreted clinically as relapse. The swelling deformed the features of the face, especially during chewing, since the contraction of the masseter determined its clear protrusion.

The MRI showed an oval formation (about 3.5 x 2.7 cm), homogeneous and slightly hypointense in T1 compared to the masseter signal; slightly uneven and hyperintense on T2 and homogeneous e markedly hyperintense in T2-weighted TIRM sequences, with slightly lobulated margins, which de-square muscle tissue without infiltrate it; the cortex of mandible appears only slightly thickened compared to the contralateral, but not eroded (Fig. 1).

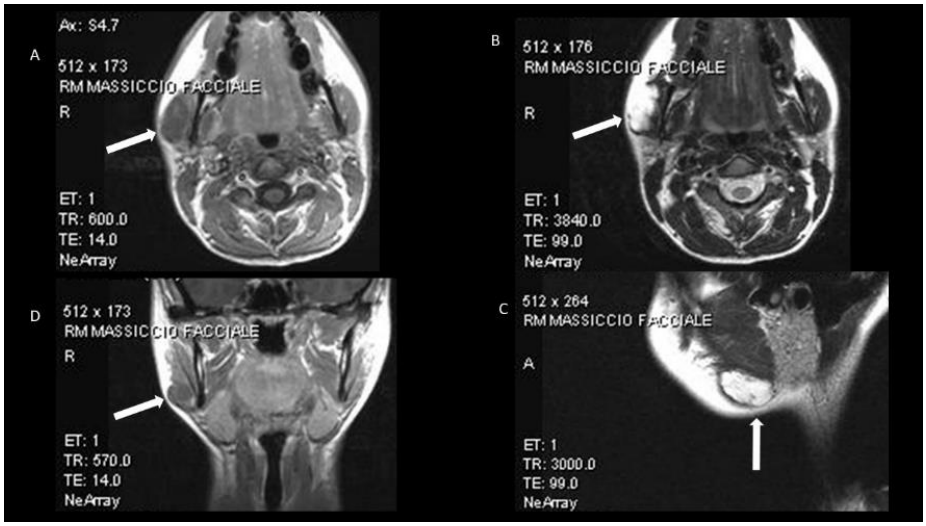

Fig. 1. *TSE T1 W image on the axial plane (**A**), TSE T2 W image on the axial plane (**B**), TSE T2 W image on the sagittal plane (**C**), TSE T1 W image on the coronal plane (**D**). The white arrows indicate the presence of a hemangioma within the masseter muscle.*

Case two

A 29-year-old woman with facial asymmetry caused by a swelling that had appeared about 18 months earlier and whose limits were not well demarcated. The patient did not report any painful symptoms, nor were they spontaneous or provoked. An MRI was performed. An oval lesion (about 4 x 1.5cm) with mixed structure non-homogeneous on T1 and non-homogeneous and hyperintense on T2, with slightly lobulated margins, was shown. Compared to the previous case, the lesion presented a greater number of fibrous septa inside and a minor homogeneity of hyperintensity in T2-weighted sequences.

Furthermore, within the lesion, some areas appeared hypointense in both T1 and T2, attributable to phleboliths or thrombosis. After administration of GBCA, the lesion showed the characteristic enhancement of hemangioma (Fig. 2).

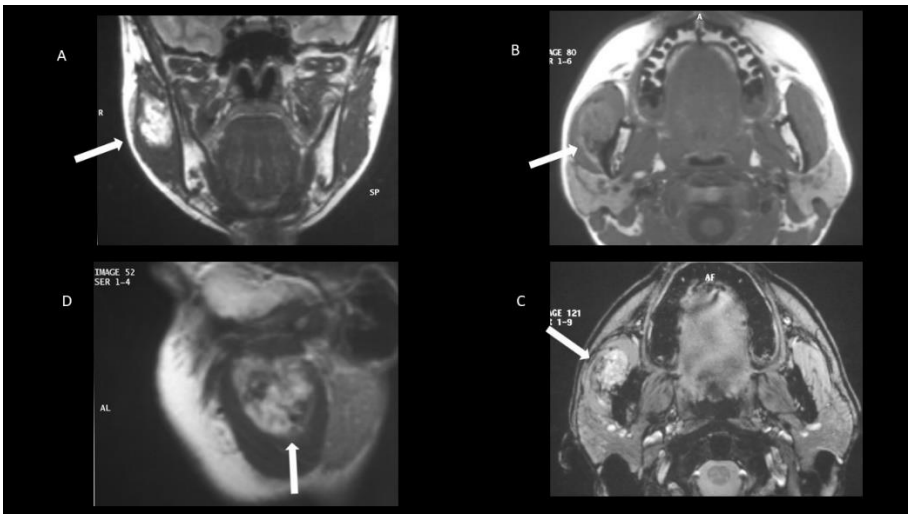

Fig. 2. *TSE T2 W image on the coronal plane (**A**), TSE T1 W image on the axial plane (**B**), TSE T1 FS W image after GBCA on the axial plane (**C**), TSE T2 W image on the sagittal plane. The white arrows indicate the presence of a hemangioma within the masseter muscle.*

DISCUSSION

Differences between benign and malignant lesions in early MRI studies to evaluate the nature of a mass inside soft tissue were considered insignificant by several authors (24-28).

The impossibility of characterizing the nature of such a mass based on the appearance of the margins and the intensity and homogeneity of the signal was highlighted by Kransford et al. (29). In the majority of the lesions they studied, the signal intensity was similar to that of muscle in the T1-weighted images and equal to or higher than the fat signal in the T2-weighted ones.

On the contrary, there are studies that demonstrate the validity of MRI in differentiating lesions within the soft tissue (30) and in distinguishing between benign and malignant tumors based on the characteristics of the signal obtained (31-33), especially with diffusion-weighted sequences, which enable the characterization of laterocervical lymph nodes (34).

In particular, in the study by Berquist et al. (31), the nature of 95 soft tissue lesions was defined. According to certain parameters considered by them, such as signal homogeneity and the characteristics of the margins, a sensitivity of 94% was achieved. From these results, it can be deduced that, in the majority of cases, a benign lesion would show well-defined margins, homogeneous signal intensity, and no invasion of bone or neuro-vascular structures. On the contrary, a malignant one would appear with irregular margins, nonhomogeneous signal intensity, and a tendency to invade bone and neurovascular structures.

In a study by Teo et al. (35), the presence of small hypointense areas in the context of a non-homogeneous, predominantly hyperintense area is reported as characteristic of a hemangioma, which is attributed to fibro-adipose septa or small clots formed within the vessels. Three radiological signs such as the lobulated shape, the strong enhancement after introduction of GBCA in T1 weighed sequences, and the presence of hypointense areas in T2 weighted sequences, would be sufficient conditions to avoid a biopsy, as they are indicators of a strong probability of a haemangiomatous lesion.

In another study conducted in 2000 by Kern et al. (36), a substantial semilogical similarity between hemangiomas and venous vascular malformations is highlighted. However, it was simple to differentiate an IMH from a lymphatic vessel malformation thanks to the absence of enhancement of the latter. MRI makes it easy and less invasive to diagnose IMH and can be considered the gold standard due to the absence of ionizing radiation. Additionally, with MRI angiography sequences, it is possible to highlight the afferent vascular branches of the lesion (37) even without the use of GBCA. However, CT appears to be more sensitive not only in detecting the presence of endosseous lesions and malformations (38) but also in showing calcifications in the soft tissue context.

Calcifications from phlebolithiasis are characteristic of hemangiomatous lesions, and the presence of this finding in CT, therefore, is highly indicative of IMH (2, 39-42). Such calcifications are typically laminated, with a radiopaque center and a spherical appearance (2, 41); they result from thrombotic formations within vessels, characterized by calcium, phosphate, and apatite deposits that subsequently organize into crystals. In MRI, such calcific findings appear as areas of flow void signal, and they are not easily identifiable in the signal area relating to the examined tissue.

Hyperintensity in T2-weighted sequences indicates the presence of free water in the context of stagnant blood within large vessels, while a low signal suggests the presence of fibro-adipose septa arranged between the vessels. In T1 weighted sequences, the adipose tissue shows a high signal intensity in the context of a hypointense blood area, which later to intravenous GBCA appears hyperintense and contrasts very well in the context of the muscle, which is visible as an area of medium intensity both in T1 and T2 weighted sequences, that easy visualize the IMH and its extension and infiltration in the surrounding tissue.

CONCLUSIONS

MRI can highlight certain morphological and signal features, such as late and persistent contrast enhancement, a lobulated form that does not infiltrate the surrounding tissue, and the presence of phleboliths, which allow for differentiation of these lesions from other malignant pathologies, including squamous cell carcinoma, adenoid cystic carcinoma, and malignant lymphoma. Furthermore, MRI angiographic sequences enable optimal visualization of the lesion and its surrounding vascular branches.

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Academic Dissertation

ENAMEL WEAR CAUSED BY MONOLITHIC ZIRCONIA CROWNS FOLLOWING THREE MONTHS OF CLINICAL USE

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ABSTRACT

To compare the amount of tooth wear induced by monolithic zirconia crown restorations placed in the posterior region with natural tooth wear on the contralateral side. Twenty-five patients in need of single crown restoration were included in this study. Crown preparation was performed according to clinically indicated guidelines, and definitive crown impressions were obtained using PVS material. Gypsum master cast models were fabricated, and single crown dies were sectioned. Crowns were milled using a CAD-CAM procedure from monolithic zirconia blocks, Prettau Anterior Multistratum (ZirconZahn, South Tirol, Italy), by the ZirconZahn method. The crowns were cemented and adapted intraorally. An impression was obtained immediately following crown insertion of both dental arches. Following three months of functional loading, the patients were recalled to obtain a second impression using the same procedure. The cast models were then optically scanned using a lab scanner (ZirconZahn S600 Arti scanner), and the resulting 3D surfaces were exported in STL file format and imported into CloudCompare reverse engineering software for analysis. The zirconia crown antagonists, as well as the contralateral tooth antagonists for all 25 cases, were segmented, and tooth wear was assessed as the negative space (wear surface difference) between the two surfaces. The root mean square (RMS) surface difference in millimeters between the two impressions was quantified. The resulting tooth wear was quantified in an Excel sheet and saved for statistical analysis. All patients presented for recall with no dropouts. SPSS statistical analysis software was used for analysis. Mean tooth wear of the zirconia crown antagonist was (10µm±1.05µm) and in the contralateral was (8µm±1.4µm) following three months of functional loading, and the differences were statistically significant at P=0.48. No crowns were lost, chipped, or dislodged at the follow-up visit. Within the limitations and the short follow-up period of this study, it can be concluded that tooth wear induced by monolithic zirconia restoration did not differ from naturally induced wear on the contralateral side. Further research is needed to corroborate the findings of this investigation.

KEYWORDS: *tooth wear, monolithic zirconia, dentistry, lab scanner, three-dimensional models*

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INTRODUCTION

Zirconia ceramics, which meet the demands of patients and dentists for a metal-free, tooth-coloured, and biocompatible restorative material, are increasingly used in prosthetic dentistry. Clinical success of zirconia-based crowns and fixed dental prostheses has been demonstrated by several studies (1, 2). High-strength zirconia is generally layered with veneering porcelain, which is prone to fracture due to a weak interface. Therefore, zirconia-fixed dental prostheses without veneering ceramic, known as monolithic zirconia reconstructions, are currently popular. Advantages of using these crowns include a conservative preparation, as there is no need to maintain space for the veneer porcelain. Additionally, the technique-sensitive procedure of veneering is also eliminated. Monolithic zirconia crowns can be polished using various techniques or glazed before definitive cementation (3, 4). However, various authors have recommended the use of polished zirconia as it causes less wear of the antagonist enamel under in vitro conditions. (3, 5-7). On the other hand, the increasing application of monolithic zirconia in dental applications raises questions such as tooth colour reproduction, long-term chemical stability, final surface state, and wear behaviour (8). In addition, chipping has been reported to be a major complication due to the superior hardness of zirconia surfaces (Hv≈1200 GPa), which is roughly double that of porcelain, leading to concerns that excessive wear to the antagonists has been raised (9-12).

Loss of tooth structure is most prominently seen in the form of carious lesions. Yet, with caries prevalence declining thanks to the introduction of fluoride-containing toothpastes, an increased interest in loss of tooth substance through another process, tooth wear, has emerged. In a physiological situation, the degree of annual vertical tooth wear rarely exceeds 50 µm (3, 5, 13), but it tends to progress with age. Tooth wear is a multi-factorial condition, which can be classified based on the underlying etiology into attrition, abrasion, abfraction, and erosion. It is important to recognize tooth wear to distinguish between pathological and physiological wear, which indicates the need for treatment. However, tracing tooth wear is only possible if the loss of tooth structure is visible to the practitioner, which is not always the case. The clinically employed indices are limited in their ability to monitor tooth wear progression in early or moderate stages since the amount of tooth substance loss is not readily visible to the practitioner (8). Therefore, alternative techniques for quantifying early tooth wear have been proposed. Techniques relying on digitizing the patient's dental casts have been previously described (6, 7).

In vitro studies have shown that antagonist wear rates are significantly dependent on the surface texture of zirconia materials (14, 15). Glazed zirconia seems to cause greater antagonist wear than polished zirconia (15, 16).

The aim of this clinical study is to quantify the enamel wear caused by glazed monolithic zirconia to the antagonist crown following three months of occlusal load and to compare the wear of two natural contralateral antagonists on the same patient. The null hypothesis was that glazed monolithic zirconia crowns and natural teeth cause comparable wear of opposed enamel under similar clinical conditions.

MATERIALS AND METHODS

This prospective clinical trial was approved by the local clinical investigation's ethics Committee, Kosovo Dental Chamber, Nr 001.

All participants gave informed consent. The study was conducted in accordance with the Declaration of Helsinki and the principles of Good Clinical Practice (GCP). A total of twenty-five patients were included in this project. The average age was 27, ranging from 18 to 45 years, with 13 males and 12 females, 23 premolars and 2 molars. Inclusion criteria consisted of:

- ≥ 18 years of age;
- medical indication for a crown;
- no systemic or local conditions presenting a contraindication for a crown;
- need a natural (not crowned) opposing antagonist and two natural (not crowned) contralateral antagonistic teeth;
- teeth with fillings were allowed if at least one occlusal contact point was enamel;
- smoking < 20 cigarettes/day.

Potential subjects who met any of the following criteria were excluded from participation in this study:

- missing occlusal contact points on the enamel of the contralateral antagonists;
- patients showing any signs of developmental enamel defects, fluorosis, parafunctional habits, temporomandibular joint disorder, calcium metabolic disorders, or osteoporosis will be excluded from the study;
- poor motivation;
- inability to sign an informed consent.

Tooth preparation

Teeth were treated, twelve in the upper jaw and thirteen in the lower jaw. Chamfer finish lines were prepared with a circumferential reduction of the tooth substance between 1 and 1.5 mm, in accordance with the remaining hard tissue. The preparation margin was placed at a gingival level whenever possible, and in any case, not exceeding 1 mm of subgingival depth. All internal edges were rounded. The preparation's divergence angle was approximately 6° (17-18).

After tooth preparation, a provisional restoration was placed using a temporary resin-based material (LuxatempTM Crown, DMG Dental Milestones Guaranteed, Hamburg, Germany). The patients were then scheduled for the final adjustment of the preparation and polishing.

Impression technique and crown fabrication procedure

A double cord technique was used to allow a correct display of the finish line for the final impression (Best Cord #000 and Best Cord #00; PPH Cerkamed, Stalowa Wola, Poland). A disposable soft tissue retractor (Optragate; Ivoclar Vivadent, Schaan, Liechtenstein) was placed to retract the lips and the cheeks. For final impressions, a vinyl polysiloxane (VPS) material was used (Elite PP Putty and Light Body Zermack, Rovigo, Italy) in standard rigid plastic trays (Directed Flow Impressions Tray, 3M ESPE, Seefeld, Germany) (Fig. 1).

Fig. 1. *Definitive impression with silicone.*

The antagonist arch impression was taken using the same material, and the bite was registered with Voco Registrado Clear (Voco, Cuxhaven, Germany), which was then sent to the participating laboratory. Working casts of type IV gypsum, Sherahardrock (Shera, Lemfcorde, Germany), were subsequently made. The crowns were made of high, translucent zirconia Prettau Anterior Multistratum (ZirconZahn, South Tirol, Italy) by the ZirconZahn method, that is, fabrication of non-veneered, monolithic crowns by first 3D scanning of the working casts and working dies (ZirconZahn S600 Arti scanner)

The design of the dental restoration was performed by the technician using CAD/CAM software (EXOCAD Design Software). The digitally adjusted data was transferred to a milling machine (ZirconZahn M1), which then cut the zirconia crown to its final form. After the milling process, the crowns were adapted, and the occlusal surfaces were characterized with fine-diamond burs before sintering (Edenta, Au, Switzerland). The crowns were sintered at 1500°C, resulting in shorter sintering times for 3 h in a high-temperature sinter furnace (Zirconzahn S300). After sintering, the crowns, particularly the occlusal surfaces, were polished using the Zirconia Polisher Wheel Pink from Zirconzahn. After polishing, the crowns were glazed with a glaze recommended by the manufacturer, Zirconzahn Glaze Plus. They were then stained and characterised using shading pastes (Zenostar Color Zr) to match the natural tooth colour. Crowns were then stained with ICE 3D Stains by Enrique Steger. In the end, firing of the glaze at 850 °C for 2 min (Ivoamat 2500**) completed the manufacturing process in a laboratory (Fig. 2).

Fig. 2. *Crown stained with ICE 3D stains by Eneique Steger.*

Cementation procedure

After receiving the crowns in the clinic, occlusion, aesthetics, and perfect fit were checked. If necessary, the occlusion was adjusted, and the crown was returned after occlusal adjustment with a fine bur (Edenta, Au, Switzerland) for glazing. Before permanent cementation, the abutment tooth was cleaned with Tubulitec (GP Dental Sweden). Permanent cementation was made with glass-ionomer cement Fuji Plus (GcEurope, Leuven, Belgium) (Fig. 3).

Fig. 3. *Crown after permanent cementation.*

After permanent cementation,0-3 days for tooth wear analysis, another impression was taken with a vinyl polysiloxane (VPS) (Elite PP Putty and Light Body Zermack, Rovigo, Italy), than cast from gypsum and 3D scanning of casts was similar to the procedure followed for crown manufacturing (ZiconZahn S600 Arti Scanner) (Fig. 4). Three months following functional loading, a second impression was taken using the same protocol like in the first impression.

Fig. 4. *Scanning of the working casts.*

Data analysis

The scanned STL files were imported into CloudCompare software for analysis. At first, the 3D models were checked for artifacts. All surfaces were then superimposed and aligned using software tools. The iterative closest point (ICP) algorithm was used to superimpose the two surfaces. The ICP algorithm calibrates a rigid transformation matrix consisting of three rotation and three translation parameters (19). Fig. 5 demonstrates the import procedure of the STL model into the reverse engineering software.

Fig. 6 demonstrates the matching procedure of initial rough alignment of the two surfaces and Fig. 7 alignment after cropping of the block and Fig. 8 matching results of comparison pairs limited only to the teeth and Fig. 9 show fine aline, the alignment results (surface distance measurements)The mean distance was measured through the software between each step of simulated tooth wear using the sound original tooth as reference.

Fig.10 shows automatically generated results after fine alignment, presented to us: minimum distance, maximum distance, average distance, sigma, and maximum error (Fig. 5-10).

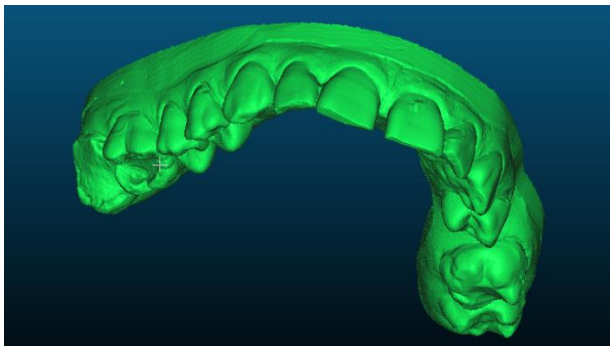

Fig. 5. *Import procedure of the STL model into software.*

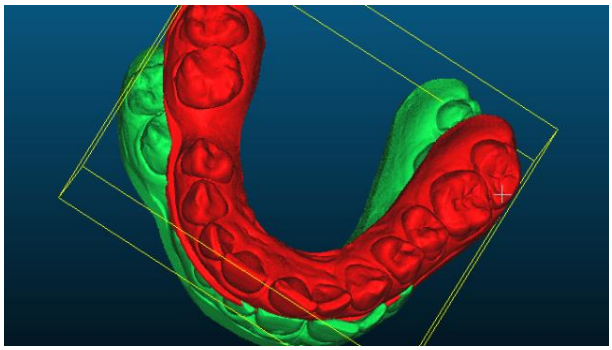

Fig. 6. *The two models (immediately post-cementation at 3-month follow-up).*

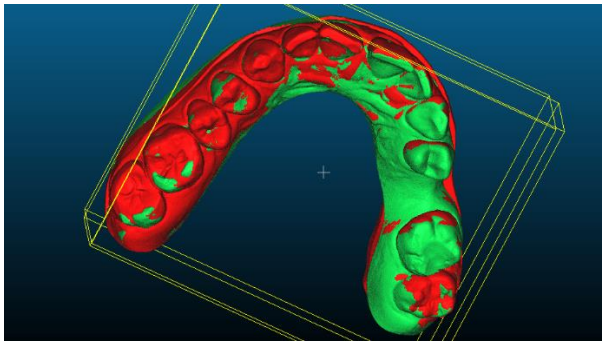

Fig. 7. *Rough alignment of the models.*

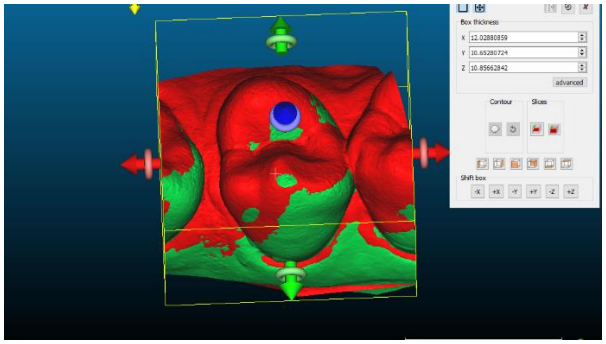

Fig. 8. *Definitive alignment after model cropping.*

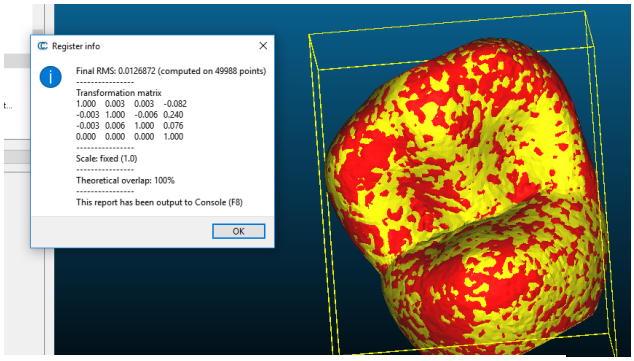

Fig. 9. *The alignment results (surface distance measurements).*

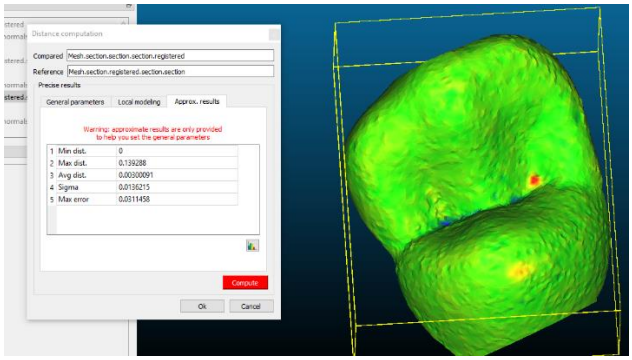

Fig. 10. *Occlusal cusp-fossa contact of the antagonist.*

RESULTS

Data was analyzed in SPSS (PASW Statistics v. 18 for Windows, SPSS Inc., Chicago, IL). Descriptive statistics of the mean average distance were calculated for each comparison pair.

Precision of the scanning procedure was calculated as the mean distance between repeated scans for each tooth. All patients presented for recall with no dropouts. SPSS statistical analysis software was used for analysis. Mean tooth wear of the zirconia crown antagonist was (10μm±1.05μm) and (8μm±1.4μm) following three months of functional loading, and the differences were statistically significant at P=0.48. No crowns were lost, chipped, or decemented at the follow-up visit (Table I).

Table I. *Follow-up visit.*

Patient nr.	Name (I	Age	Gend	Tooth	Min. Dist.	Min. Dist	Max. Dist.		Avg. Dist.		Sigma		Max error	
					Antag.	Contr.	Antag.	Contr.	Antag.	Contr.	Antag.	Contr.	Antag.	Contr.
1	**A.B.**	25	F	**35**	**0**	0	**0.222**	**0.063**	0.009	0.003	**0.027**	**0.012**	0.024	0.022
2	**A. SH.**	18	F	**25**	**0**	0	**0.188**	**0.116**	0.011	0.005	**0.027**	**0.016**	0.028	0.025
3	**B. SH.**	18	M	**35**	**0**	0	**0.121**	**0.191**	0.005	0.004	**0.018**	**0.018**	0.027	0.028
4	**M. Z.**	25	F	**46**	**0**	0	**0.202**	**0.182**	0.004	0.003	**0.02**	**0.015**	0.041	0.041
5	**I.M.**	29	F	**34**	**0**	0	**0.215**	**0.079**	0.004	0.002	**0.019**	**0.011**	0.024	0.028
6	**B.M.**	32	F	**44**	**0**	0	**0.155**	**0.144**	0.011	0.003	**0.024**	**0.014**	0.025	0.022
7	**F. SH.**	21	M	**14**	**0**	0	**0.122**	**0.198**	0.004	0.007	**0.015**	**0.021**	0.025	0.027
8	**SH. B.**	20	M	**14**	**0**	0	**0.198**	**0.141**	0.021	0.004	**0.031**	**0.017**	0.024	0.028
9	**E. B.**	25	F	**25**	**0**	0	**0.203**	**0.353**	0.009	0.037	**0.028**	**0.053**	0.028	0.025
10	**F.M.**	36	M	**15**	**0**	0	**0.297**	**0.182**	0.012	0.006	**0.028**	**0.021**	0.029	0.025
11	**A.G.**	24	F	**24**	**0**	0	**0.278**	**0.173**	0.011	0.008	**0.029**	**0.022**	0.025	0.022
12	**V.RR.**	21	M	**44**	**0**	0	**0.233**	**0.252**	0.018	0.013	**0.039**	**0.031**	0.031	0.031
13	**N.A.**	22	F	**24**	**0**	0	**0.231**	**0.156**	0.012	0.008	**0.032**	**0.021**	0.025	0.023
14	**B.Z**	45	M	**45**	**0**	0	**0.102**	**0.198**	0.008	0.006	**0.021**	**0.021**	0.029	0.029
15	**F.U.**	35	M	**15**	**0**	0	**0.185**	**0.186**	0.007	0.008	**0.023**	**0.021**	0.024	0.026
16	**S.H.**	38	F	**34**	**0**	0	**0.262**	**0.091**	0.017	0.006	**0.044**	**0.016**	0.031	0.026
17	**L.Z.**	34	F	**24**	**0**	0	**0.151**	**0.111**	0.011	0.006	**0.022**	**0.018**	0.023	0.024
18	**K. O.**	21	F	**34**	**0**	0	**0.198**	**0.198**	0.014	0.009	**0.032**	**0.026**	0.029	0.031
19	**M. B.**	22	F	**24**	**0**	0	**0.255**	**0.218**	0.024	0.009	**0.039**	**0.024**	0.027	0.024
20	**G. Y.**	30	M	**45**	**0**	0	**0.096**	**0.215**	0.007	0.006	**0.021**	**0.022**	0.034	0.034
21	**Y. K.**	20	M	**36**	**0**	0	**0.285**	**0.111**	0.011	0.005	**0.033**	**0.019**	0.045	0.039
22	**A. D.**	21	M	**25**	**0**	0	**0.218**	**0.464**	0.015	0.023	**0.032**	**0.049**	0.031	0.022
23	**M. P.**	35	M	**25**	**0**	0	**0.172**	**0.098**	0.006	0.006	**0.019**	**0.017**	0.026	0.024
24	**K. N.**	34	M	**35**	0	0	**0.114**	**0.112**	0.007	0.006	**0.016**	**0.02**	0.019	0.025
25	**M. B.**	26	M	**34**	**0**	0	**0.131**	**0.167**	0.014	0.007	**0.027**	**0.021**	0.029	0.027

DISCUSSION

This study was conducted to evaluate the amount of tooth wear induced by monolithic zirconia restorations and to compare it with the naturally occurring tooth wear on the contralateral side, using an objective computer analysis method to monitor tooth wear progression. The results indicate that tooth wear caused by monolithic zirconia did not exceed the physiological tooth wear rate of 9µm at a similar follow-up period (20). In this study, the second intact tooth on the contralateral side was used as a reference surface. Earlier studies employed models modified for improved reference or used landmarks as a reference (7, 21, 22). This study demonstrates that, for reference, a single sound crown is sufficient as a reference surface during the matching procedure. We expect that even a smaller reference surface, like a small restoration, will be sufficient for a good matching procedure.

Mean average distances calculated are affected by the amount of sound surface, as this surface is considered in the calculation. These values, therefore, do not accurately reflect the extent or location of applied tooth wear. This can be solved by considering the location of dental wear when selecting a region of interest (ROI) prior to calculating surface distance, so that only affected surfaces are included in the average distance calculation. However, due to technical constraints of the software, this approach was not adopted in this investigation. Additionally, the STL files provided by the manufacturer contained artifacts, even though these did not appear after scanning. This might have influenced average distances during calculation. Prior to scanning, the ZirconZhan lab scanner requires the operator to spray a contrast powder on the teeth to negate reflection.

Since spraying is performed manually, it is susceptible to human error, making it difficult to predict the exact thickness of the powder layer. Additionally, after spraying, flakes of powder may sometimes be visible. As the scanning of the surfaces has an accuracy on a micrometer scale, these factors could influence the calculated mean average distance. Not all chair-side optical scanners require the application of a contrast medium.

Previous research has reported similar findings to those of the current investigation. Stober et al. reported 16 µm of tooth wear following 3 months of functional loading (1). They used digital subtraction photography to assess the amount of tooth wear. However, this technique is two-dimensional and does not represent surface topology as precisely as the 3D surface matching technique. Lohbauer et al. reported a maximum vertical tooth surface loss of 200 µm in the antagonist following 2 years of functional loading (12). However, maximum dimensional changes are prone to susceptibility to outliers caused by dimensional changes during the SEM scanning procedure. Mean surface loss values could be significantly lower than the maximum errors and, therefore, of little clinical relevance. In an in vitro investigation by Stripetchdanond et al., monolithic zirconia restoration was found to induce comparable tooth wear to composite resins and less than that of glass ceramics (23).

CONCLUSIONS

Within the limitations of the current study and its short follow-up time, it can be stated that full-prep monolithic zirconium crown restorations on natural abutments exhibit comparable tooth wear to the average annual enamel loss. Further research is needed to corroborate the results of this investigation.

Conflicts of interest

The author declares that there was no conflict of interest. The study was entirely internally funded by the principal investigator, with no external industry funding.

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Investigative Study

EFFECT OF TOOTHPASTE BASED ON SODIUM FLUORIDE AND ZINC LACTATE ON BACTERIAL CONTROL

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ABSTRACT

To assess the anti-plaque effects of a toothpaste containing sorbitol, zinc-lactate, and sodium fluoride (TCSF) in subjects with moderate plaque-induced gingivitis, a total of 10 patients with gingivitis were enrolled. None of these patients had previously been treated for periodontal disease and demonstrated radiographic evidence of bone loss. Inclusion characteristics included good general health, with both male and female subjects aged 18–70. Informed consent was obtained from all individual participants included in the study. Patients underwent professional oral hygiene (POH) and were instructed to use toothpaste TCSF at home twice a day for 2 weeks. Microbial analyses were performed prior to POH and at the end of the second week, and the results were statistically compared to the initial findings. The Student t-test was used to identify statistically significant results. All subjects completed the study. The results showed statistically significant reductions in total bacterial loading. The overall conclusion was that TCSF toothpaste was highly effective in significantly reducing bacterial load, demonstrating its comprehensive benefits as a dentifrice.

KEYWORDS: *toothpaste, bacterial, oral microbiota, plaque*

INTRODUCTION

Home-based oral hygiene is a crucial element in preventing oral diseases, such as dental caries and periodontal disease (1-2). These pathologies are strongly influenced by the presence and proliferation of pathogenic bacteria within the oral cavity. Poor dental hygiene can lead to cavities, gingivitis, periodontitis, tooth loss, halitosis, fungal infections, and gum disease. Adequate daily oral hygiene helps reduce the bacterial load, thereby preventing the onset of these diseases. The use of a toothbrush is the most important measure for oral hygiene, with evidence suggesting that electric toothbrushes provide a significant benefit compared to manual toothbrushes in terms of plaque reduction, both in the short and long term. However, it is also relevant that using toothpaste improves oral hygiene.

The oral microbiota is a complex ecosystem composed of billions of microorganisms that coexist in a balanced state. This ecosystem includes both commensal bacteria, which perform beneficial roles, and potential pathogens, which can cause diseases when the balance is disturbed. Understanding the general concepts of the oral microbiota is essential for developing effective strategies to prevent and treat oral infections.

Previous studies have evaluated the effectiveness of different oral hygiene practices and products in reducing the bacterial load present in the oral cavity (3-5). These works have provided data for the use of specific oral hygiene products as an integral part of strategies to prevent oral diseases.

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The most effective way to prevent the development of dental diseases is to control the production of dental plaque, a thin, soft layer that deposits on teeth, gums, and all appliances present in the mouth through microbial action. Dietary sugars, particularly sucrose, contribute to plaque formation, and their presence increases the rate and thickness of plaque formation.

Removing plaque from teeth and surrounding areas is essential for maintaining a healthy mouth (6-10). There are various tools that patients can use for oral hygiene, including manual toothbrushes, electric toothbrushes, interdental brushes, dental floss, and mouthwash. The literature has attempted to demonstrate which method is most effective, but this does not alter the fact that the crucial point is to perform home hygiene procedures.

In this context, we conducted a preliminary study on a commercially available toothpaste to evaluate its effectiveness in reducing oral bacterial load.

MATERIAL AND METHODS

From September to October 2023, 10 healthy patients were randomly selected. Patients were in the 18-70 age group. Subjects have not received any surgical or non-surgical periodontal therapy. The patients were excluded from the study if they met any of the following criteria: (1) pregnancy; (2) a history of taking antibiotics or using antibacterial mouth rinses for the past 6 months; (3) smoking, drug, or alcohol abuse. Subjects participating in the study followed a detailed verbal description of the procedure and signed consent forms.

Patients underwent professional oral hygiene (POH) and were instructed to use Meridol (TCSF) toothpaste at home twice daily for 2 weeks. A total of 10 patients were selected. All patients underwent POH at the baseline measurement. Prior to POH, microbial analysis was performed. Then, POH was completed after two weeks; microbiological samples were collected again from the sites in each patient, using sterile paper tips.

For bacteria analysis, sites were isolated using cotton rolls. Sterile, absorbable paper points (size 60) were used for collecting subgingival samples, which were then immediately transferred to the microbiological laboratory for processing. Aggregatibacter actinomycetemcomitans (AA), Porphyromonas gingivalis (PG), Tannerella forsythia (TF), Treponema denticola (TD), Fusobacterium Nucleatum (FN), Campylobacter rectus (CR), and Total Bacterial Loading (CBT) were evaluated.

Real-time polymerase chain reaction

Oligonucleotide probes were designed based on 16S rRNA gene sequences from the Human Oral Microbiome Database (HOMD 16S rRNA RefSeq Version 10.1), comprising 845 entries. All the sequences were aligned to find either a consensus sequence or less conserved 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 conserved sequence of the 16S ribosomal RNA gene. The second reaction detected and quantified all selected bacteria in multiplex PCR assays. This reaction included a total of twelve primers and six probes that were highly specific for each species. Oligonucleotide concentrations and PCR conditions were optimized to ensure sensitivity, specificity, and the absence of inhibition in cases where target amounts were unbalanced. Absolute quantification assays were performed using the Applied Biosystems 7500 Sequence Detection System. The amplification profile was initiated by a 10-minute incubation period at 95°C to activate polymerase, followed by a two-step amplification consisting of 15 seconds at 95°C and 60 seconds at 57°C for 40 cycles. All these experiments were performed, including non-template controls to exclude reagent contamination.

Plasmids containing synthetic DNA target sequences (Eurofin MWG Operon, Ebersberg, Germany) were used as a standard for the quantitative analysis. Standard curves for each target were constructed in two triplex reactions, using a mix of the same number of plasmids in serial dilutions ranging from 101 to 107 copies. A linear relationship was observed between the threshold cycle values and the log of the copy number across the entire range of dilutions (data not shown). 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 the calculation of the relative amount of red complex species. To prevent contamination of samples and the polymerase chain reaction, plasmid purification and handling were performed in a separate laboratory using dedicated pipettes.

Statistical analysis

The SPSS program and a paired simple t-test were used to detect statistically significant differences.

RESULTS

Both clinical and microbiological parameters showed improvements. After 15 days of TCSF toothpaste, microbiological analysis showed a significant reduction of total bacterial loading (Table I).

Table I. *Mean amounts of specific bacterial species before (1) and after (2) treatment.*

Paired sample test									
		Pairwise differences					t	Df	Sig. (2-code)
		Mean	Standard deviation	Mean Error	95% confidence interval for the difference				
					inferior	superior			
Couple 1	AA1-AA2	51 50000	105.9	33.5	-24.3	127.3	1.536	9	159
Couple 2	PG1-PG2	-10000	31623	10000	-32622	12622	-1.000	9	.343
Couple 3	TF1-TF2	59. 3	155.7	49.2	-52.1	170.7	1.204	9	.259
Couple 4	TD1-TD2	-10000	4.2	1.3	-3.1	2.9	-075	9	.942
Couple 5	FN1-FN2	-327.2	1585.6	501.4	-1461.5	807.1	-653	9	.530
Couple 6	CR1-Cr2	70000	18.8	5.9	-12.7	14.1	118	9	.909
Couple 2	TBL1-TBL2	315099.9	252639.2	79891.5	134372.6	495827.1	3.944	9	.003

AA: Aggregatibacter actinomycetemcomitans; PG: Porphyromonas gingivalis; TF: Tannerella forsythia; TD: Treponema denticola; FN: Fusobacterium nucleatum; CR: Campylobacter rectus; TBL: total bacteria loading. Total bacterial loading was significantly reduced after treatment.

DISCUSSION

Dental plaque is recognized as a significant etiological factor in the development of dental caries and plaque-induced gingival diseases. Mechanical removal of plaque through toothbrushing, toothpaste, and mouth rinses helps counteract the accumulation of pathogenic plaque, thereby contributing to the prevention of these conditions. Effective and therapeutic plaque control is a crucial aspect of personal hygiene, and the appropriate use of TCSF toothpaste is documented as an effective tool among plaque control measures.

Preliminary results indicate that the use of TCSF as an adjunctive treatment is associated with a reduction in the plaque index post-treatment. Studies have shown that TCSF toothpaste helps reduce plaque and gingivitis. Most research on TCSF toothpaste focuses on periodontitis, a prevalent, chronic, nonspecific, and immunological disease of the periodontal tissues caused by microbial infections. TCSF toothpaste reduces plaque, gingivitis, and bleeding without showing a significant effect on clinical attachment loss.

The investigated toothpaste is composed of the following main components: Sodium Fluoride (NaF) and Zinc. Sodium Fluoride (NaF) is primarily used to reduce the prevalence of caries and to improve enamel remineralization (11) The antibacterial and cariostatic effects of fluorides are widely accepted, and the widespread use of fluorides has been attributed to the decline of dental caries in Western countries in recent years (12). Fluorides primarily act by forming fluorapatite crystals, which have greater resistance to organic acids than the hydroxyapatite crystals of tooth enamel. It has also been shown to reduce the production of organic acids in cariogenic bacteria such as Streptococcus mutans (13). Zinc, present in this toothpaste as Zinc Lactate, is a non-toxic, non-cumulative essential trace element. Zinc inhibits the pathway of glucose uptake by Streptococcus mutans, Streptococcus Sanguis, and Actinomyces Naeslundii, and the metabolism of glucose to lactic acid. This helps reduce plaque formation and maintain a healthy microbial balance within the oral cavity (14-18).

It can be hypothesized that the ability of TCSF toothpaste to promote antibacterial activity likely contributes to an overall improvement in oral hygiene for the patient. Further investigation may be necessary to fully understand the mechanism of action of sodium fluoride and confirm its long-term benefits in managing dental diseases associated with bacterial plaque.

CONCLUSIONS

The results of this clinical study are very promising regarding the benefits of using TCSF toothpaste as a complement in the standard treatment of gingivitis. It helps reduce the plaque index and bacterial load, leading to an overall improvement in the patient's oral health. It is therefore essential to motivate and raise awareness among patients about oral health, explaining the importance of proper oral hygiene at home.

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Case Report

VERSATILITY OF SKELETAL ANCHORAGE IN SKELETAL CLASS III MALOCCLUSION TREATMENT: A CASE REPORT

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ABSTRACT

Skeletal class III malocclusion is one of the most complex, with severe complications including deterioration of function and aesthetics. The aim of this paper is to report the versatility of skeletal anchorage (SA) during the treatment of a skeletal class III hyperdivergent patient with anterior crossbite with severe space discrepancy due to the mesial movement of the maxillary first permanent molar. The patient was 12.8 years old and in the late mixed dentition stage. Treatment began with bone-borne maxillary expansion with 4 palatal mini-screws. After expansion, a mandibular plate was inserted, and class III elastics were attached to the hooks incorporated in the maxillary expansion appliance. At the subsequent visit, a molar band was bonded on the first permanent molar on the left with a distalizing spring. Nine months later, all the permanent teeth erupted, and fixed orthodontic treatment was initiated.

KEYWORDS: *skeletal class III, malocclusion, skeletal anchorage, maxillary expansion*

Orthodontists are aware of the difficulties of treating skeletal class III malocclusion. Skeletal class III malocclusion is one of the most complex, with severe complications, including deterioration of function and aesthetics. Such complexity seems related to the multifactorial etiology and various combinations of morphologic traits (1, 2). Moreover, during growth, the continuous advancement of the mandible relative to the maxilla worsens the skeletal class III malocclusion (3). Skeletal class III malocclusion is included among malocclusions that may benefit from early treatment. In addition to greater skeletal changes (4-6), early treatment improves dental and facial aesthetics and promotes a more favorable environment for normal growth (7, 8).

Results from various studies show that the combination of rapid maxillary expansion (RPE) with the forward pull of the maxilla by the protraction facemask (FM) is effective in treating maxillary retrusion in growing children (9, 10). They report similar outcomes such as forward movement of the maxilla and A-point increase of SNA and ANB angle, clockwise rotation of the mandible, and decrease of SNB angle. However, anchorage loss and dental compensations occur (11). A recent study observed a tendency for reestablishment of the skeletal Class III growth pattern after maxillary protraction therapy, which was caused by more significant protrusion of the mandible relative to the maxilla (12).

Clinical application of temporary skeletal anchorage (SA) constantly shows improved results in treating skeletal class III malocclusion (13, 14). Using miniplates or mini-screws helps overcome the side effects of the commonly used protocol consisting of rapid maxillary expansion and protraction facemask (RPE-FM) (15-17).

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Known to have a concave profile (18), these patients will benefit from improved facial esthetics provided by SA. Moreover, a favorable psychosocial effect is expected by improving facial esthetics in teenagers rather than postponing a surgical approach until the completion of growth (19).

The aim of this paper is to report the versatility of SA in the treatment of a skeletal class III hyperdivergent patient with severe space discrepancy due to the mesial movement of the maxillary first permanent molar.

CASE REPORT

A 12.8-year-old boy sought orthodontic treatment at the School of Specialization in Orthodontics Albanian University, Tirana, Albania. He was in overall good health without any systemic disease. Apart from not being satisfied with his front teeth, he reported difficulty during mastication. Intra-oral examination revealed anterior crossbite and missing space for teeth nr 13, 23, 25. Extra orally, the profile was concave, and the lower lip protruded (Fig. 1).

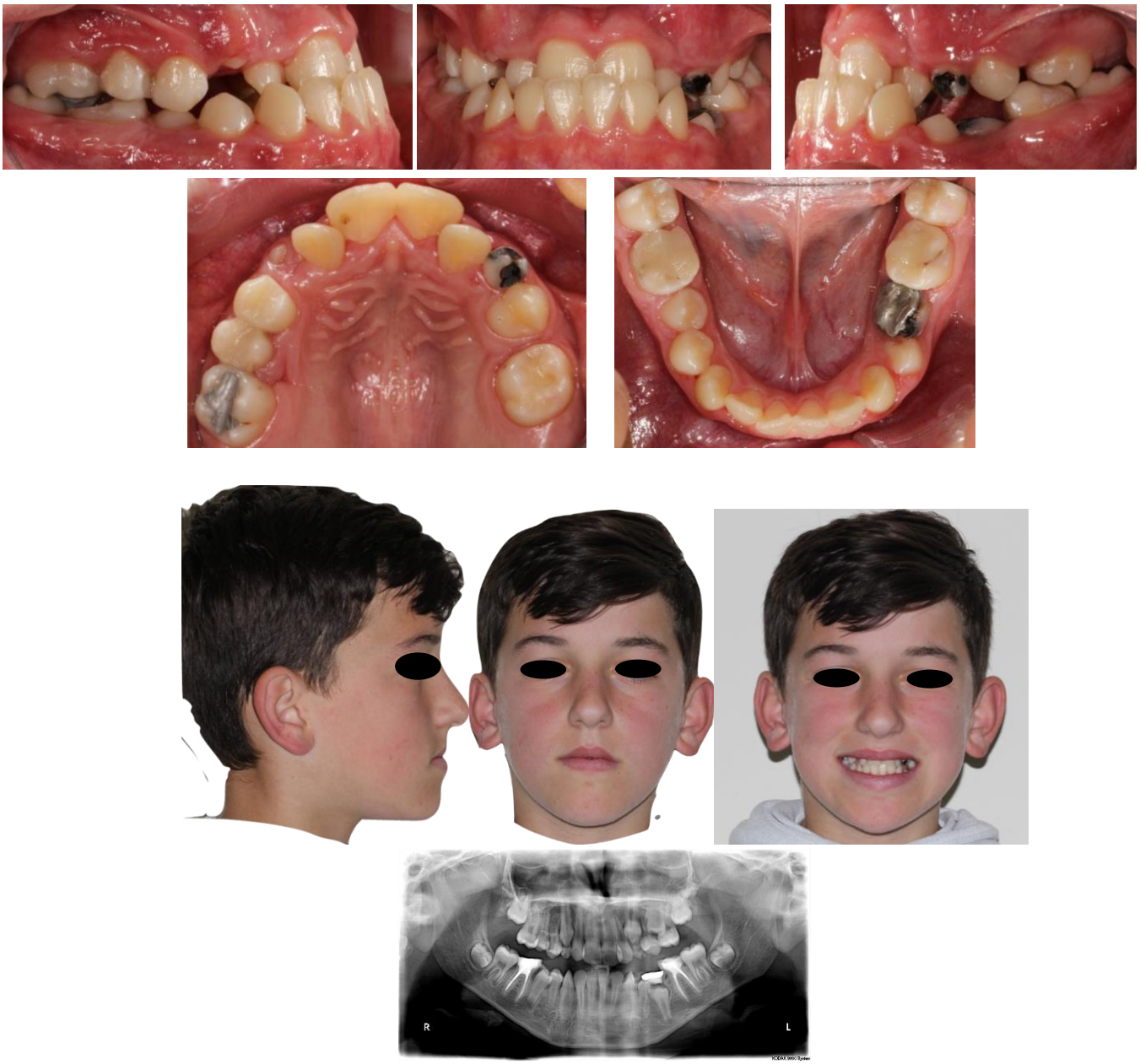


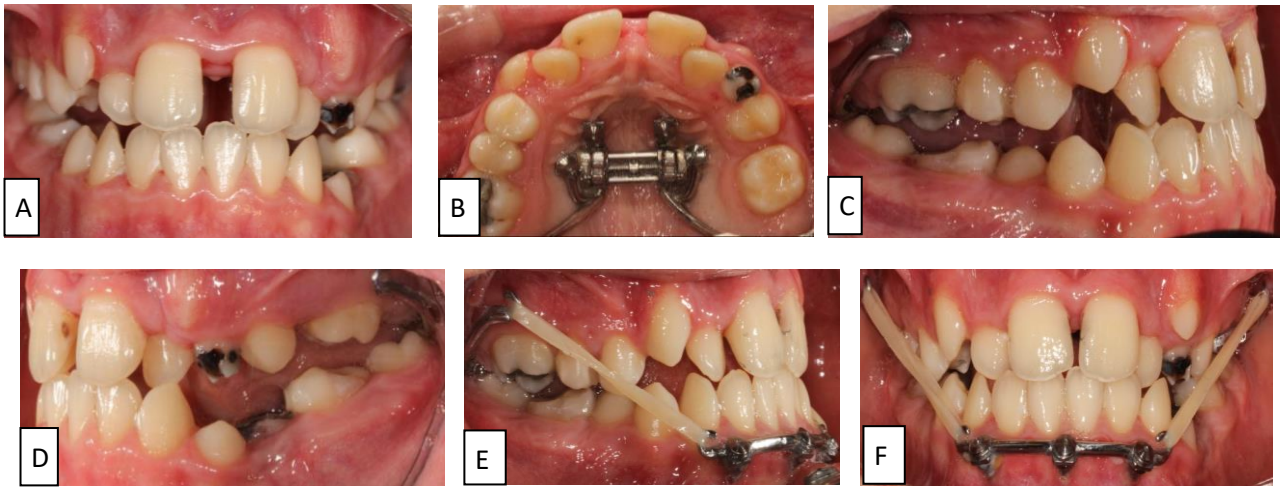
Fig. 1. *Pretreatment intraoral, extraoral and panoramic radiograph.*

Radiographic examination confirmed that space was partially missing for teeth nr 13 and 23 and completely for nr 25. The patient was in the late mixed dentition stage, and skeletally, the maturation stage was CS2. Pretreatment cephalometric analysis (Table I) confirmed the diagnosis of skeletal class III malocclusion (ANB angle -1.45°, Witts -7.45mm) with hyperdivergent vertical pattern (GoGn^Sn 39.30°, FMA 33.43°).

Table I. *Pre and post-treatment cephalometric measurements.*

Cephalometric measurement	Pretreatment	Post-treatment
SNA	78.83°	82.38°
SNB	78.28°	80.80°
ANB	-1.45°	1.58°
A-N|FH	-5.24mm	-1.48mm
Po-N|FH	-11.08	-5.86mm
Wits Index	-7.45mm	-0.21
GoGn^Sn	39.30°	38.68°
FMA	33.43°	33.23°
MM	30°	31.04°
U1-APo	1.9mm	4.6mm
L1-APo	4.75mm	5.30mm°
U1^MAX	110.3°	114.7°
L1^MAND	84.19°	87°

Rapid maxillary expansion was performed with the bone-borne (BB) appliance as described by Annaruma (20). A removable plate was given to eliminate occlusal interferences. The parents were instructed to activate the screw twice a day for one week. The following activation protocol was required: twice a day for 2 weeks. At the next appointment, the mid-palatal was opened, so it was decided to continue with the digitally planned mandibular plate with 2 mini screws and hooks for class III elastics. 5/16-inch (16oz) class III elastics were delivered to the patient (Fig 2. A-D). The patient was instructed to change elastics once per day and wear the elastics 24 hours per day. A customized molar band was bonded on the maxillary first permanent molar one month after protraction. A pendulum spring was then attached to the expander (Fig 2. E-H). Nine months after concomitant use of maxillary protraction and unilateral distalization, all maxillary permanent teeth erupted (Fig 2. I-L); therefore, it was decided to start fixed orthodontic treatment to create space for tooth nr 12 and 22. Night use of class III elastics was recommended. It took 23 months to finish orthodontic treatment.



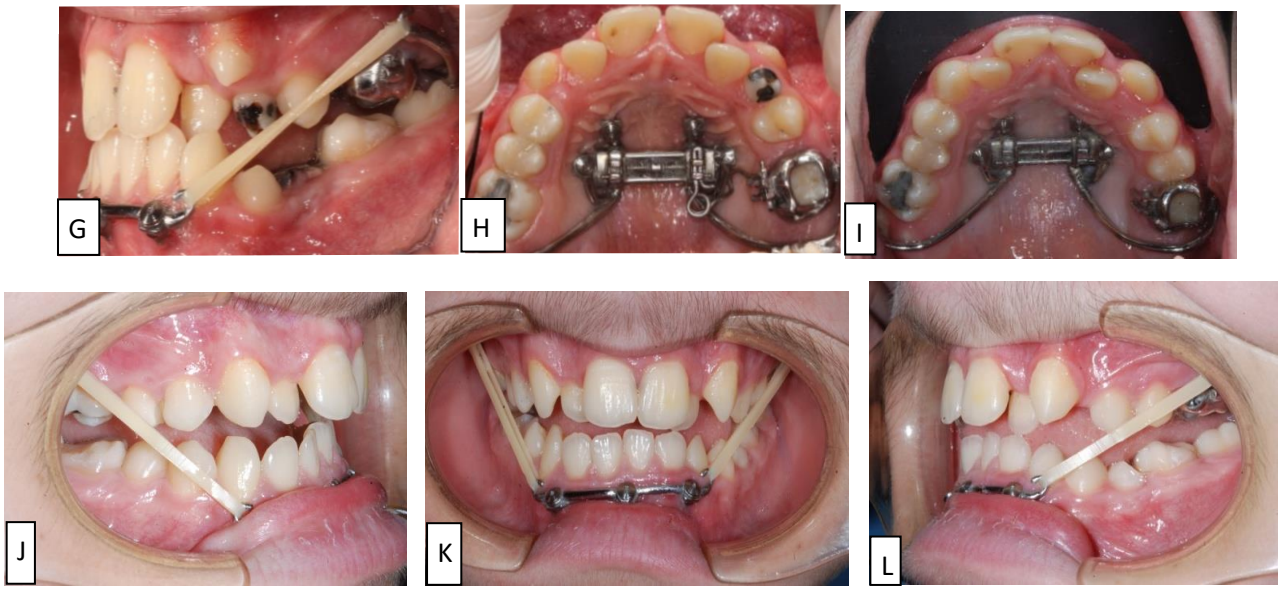


Fig. 2. *Clinical photos during treatment.*

Treatment results

At the end of the treatment, all objectives set at the beginning were achieved. As shown in Fig. 3. A-E, intraorally optimal overjet and overbite, class I canine, and molar relationship were obtained. Moreover, the patient achieved and appreciated a significant smile and profile improvement (Fig. 3. F-H). The panoramic X-ray showed good root parallelism with no signs of resorption. Cephalometric measurement performed at the end of treatment (Table I) confirms that the profile improvement was due to skeletal maxillary protraction using MARPE (3.55° of change in SNA angle, 3.76mm of Point A advancement). Furthermore, the applied protocol did not worsen the pretreatment hyperdivergent pattern except for a slight increase (1.04°) of MM angle.

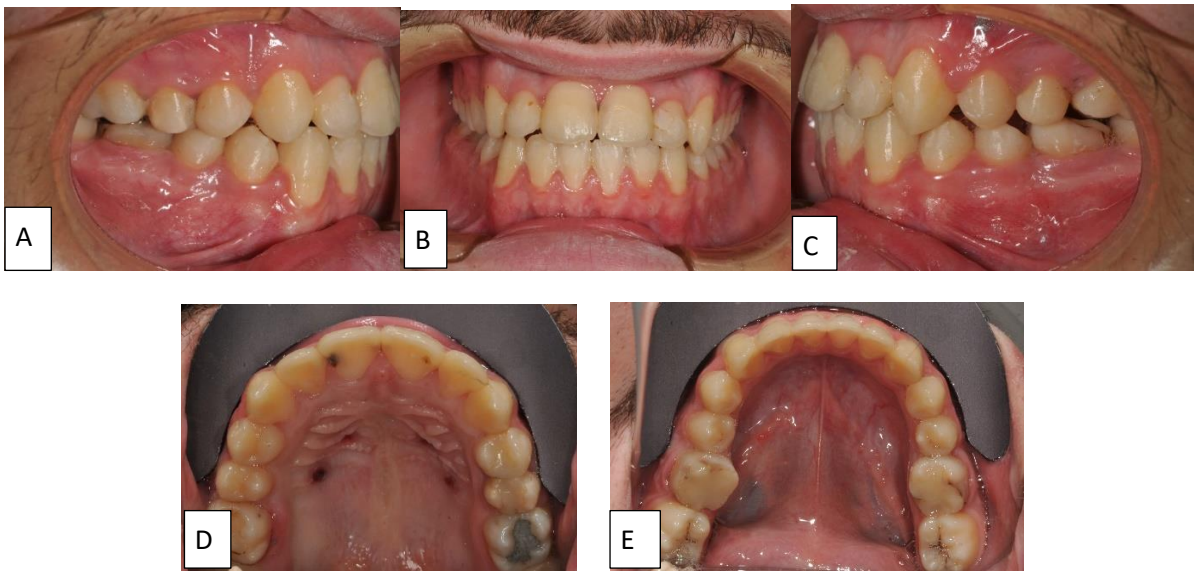


Fig. 3. *Intraoral, face, and profile post-treatment; panoramic radiograph.*

DISCUSSION

Alongside being in the late mixed dentition stage, which is not considered the optimal time to start treatment of skeletal class III malocclusion with the RME-FM protocol (21), his skeletal discrepancy would not be corrected with orthodontic camouflage (22). Hence, it was decided to use the BAMP protocol, which among favorable skeletal (14,17) outcomes reduces patient compliance to wear a face mask (23).

Post-treatment cephalometric measurements indicating that the selected protocol produced significant maxillary protraction (3.76mm of point A and 3.55 increase of SNA angle) are similar to other studies (24-26). According to De Clerk (23), the anterior displacement of the maxilla and the minimal mandibular growth resulted in a clear reduction in facial concavity. Moreover, correcting an anterior crossbite, the patient's main complaint, contributed to better facial esthetics. Such improvement, part of the treatment's objectives, increases self-esteem (8).

The reported advantages of BAMP, such as better control of vertical changes, lack of clockwise rotation of the mandible, and (17) retroclination of the lower incisors, were observed in our patient. Moreover, lower incisors were proclined at the end of the treatment. A similar result observed in a previous study was attributed to the increased tongue pressure after the elimination of anterior crossbite and the increased distance between the upper and lower incisors, which in turn allowed the lower incisors to tip forward (26). In line with previous studies (27, 28), the upper incisors were found to be more proclined in our patient but without exceeding normative value.

Of particular importance for the success of orthodontic treatment, especially complex cases, as in the present study, is the generation of a list of specific problems (29). Consequently, interaction among possible solutions to specific issues is likely so that solving one problem may make another worse. In addition to preventing unwanted side effects, SA allows multiple simultaneous or sequential tooth movements (30). Hence, we took advantage of the palatal screw of the bone-borne expander to simultaneously expand and distalize on the left side. Without interrupting class III elastics and by the activation of the pendulum spring, impaction of tooth nr 25 was avoided. Another important factor to be added among the advantages obtained in the present case report is that the surgical guides and the BB expander were digitally planned, avoiding complications, decreased chair time, and greater patient comfort (31).

CONCLUSIONS

Skeletal Class III malocclusion presents significant treatment challenges, particularly in hyperdivergent patients with severe maxillary constriction. This case report demonstrates that the combined use of BAMP and a multibracket fixed appliance allows for effective maxillary expansion and protraction while providing a versatile approach to comprehensive orthodontic correction. Skeletal anchorage enhances treatment efficiency, offering a non-surgical alternative for selected cases. Long-term follow-up and further studies are needed to confirm the stability of the results and refine treatment protocols.

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