EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Volume: 5
Issue: 10
462-467
Year: 2018

INTRA-ORAL SKELETALLY ANCHORED MAXILLARY PROTRACTION (I-SAMP) IN SKELETAL CLASS III MALOCCLUSION: AN OVERVIEW

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Article Received on 23/08/2018 **Article Revised on 13/09/2018** **Article Accepted on 03/10/2018**

ABSTRACT

Objective: There is an increasing tendency to prescribe maxillary orthopaedic treatment with skeletal anchorage, with the goal of enhancing the skeletal and minimizing the dentoalveolar effects – offering a management option for skeletal Class III dysmorphoses that otherwise they received surgical treatment in their adulthood. An update is provided to evaluate the effects on maxilla, mandible, dentoalveolar part, soft-tissue and airway of intra-oral skeletally anchored maxillary protraction (I-SAMP) for correction of skeletal Class III malocclusion. **Method:** A literature review has been made to consolidate the supporting scientific evidence in this field of Intra-oral skeletally anchored maxillary protraction (I-SAMP) in growing children having Class III malocclusion. A Medline (PubMed) search was made using the following MeSH terms: Malocclusion Class III therapy, Intraoral traction appliances, Bone plates, Skeletal anchorage, Maxillary protraction. **Results:** At present, many articles show that the incorporation of surgically inserted bone anchorage appliances (miniplates and miniscrews) has been seen to afford a lesser relapse rate and greater dentofacial orthopaedic correction due to its lesser dentoalveolar impact. Nevertheless, further randomized clinical studies are needed to firmly establish the quantifiable differences in terms of maxillary advance, mandible and TMJ effects, optimum traction appliance, optimum traction chronological age, and potential side effects.

KEYWORDS: Skeletal anchorage, Bone-anchored, Maxillary protraction, Intermaxillary elastics, Miniplates, Class III, Growth modification, Literature review.

INTRODUCTION

A Class III malocclusion, known as an "underbite", affects nearly 10% in whites and 19% in Asians and is one of the more common facial deformities.[1] The Indian population had a lowest prevalence rate of 1.2%.[2-4] Patients with this type of malocclusion often presents with a concave profile, retrusive paranasal region, lower incisor display on smile, protruded lower lip and a prominent chin.[2] Before the 1970s, many clinicians believed that a skeletal Class III skeletal malocclusion was primarily a problem with mandibular overgrowth.[5] As such, these clinicians would defer orthodontic treatment until growth of the patient was approaching and treat the patient with a combination of orthodontics and orthognathic surgery.[6,7] However, this would subject the patient to a socially and functionally handicapping malocclusion through their teenage years.

Nanda et al observed that the etiology of a Class III skeletal malocclusion can be due to a maxillary skeletal deficiency, mandibular skeletal prognathism, or a combination of the two.[7] Furthermore, Chang et al stated that maxillary hypoplasia is actually the primary etiology of most of skeletal Class III malocclusions and occurs in 65-67% of cases.[1,7] These studies showed that many patients who appeared skeletally Class III in fact had a normal positioned skeletal mandible and they only appeared to have a large mandible due to a deficient maxilla. As such, orthodontic researchers began to focus on treatment that could protract the maxilla downward and forward to reduce the relative protrusion of the mandible.

Oppenheim[8] in 1944 treated Class III patients with a chincup and spurs, attached via elastics to a soldered

maxillary lingual arch. Kettle and Burnapp[9] protracted the maxilla in cleft lip and palate patients by using chincup with spurs. Delaire[10] brought new perspective by introducing his facemask in which he modified chincup by incorporating an interlabial bow with spurs for attachment of elastics and a forehead support. Later on Delaire's facemask was modified by Petit in 1983, for which he claimed that with his design higher amount of protraction force could be applied on maxilla and shortens the duration of treatment.[11] Nanda[12] later on further modified the maxillary protraction mask with force application above the center of maxillary resistance and eliminated the anticlockwise rotation of the maxilla.

Haas[13] observed that maxillary expansion alone often causes the maxilla to advance and drop vertically, rotating the mandible clockwise. Haas corrected mild Class III malocclusions by using Class III elastics with palatal expansion.

Conventional treatments for the patients with skeletally Class III pattern involve the use of a protraction facemask with a device anchored to dentition (Dental anchored maxillary protraction- DAMP) to advance the maxilla. Studies have shown that young patients with Class III skeletal malocclusions can be treated with fairly high predictability with a conventional facemask appliance using dental anchorage.[14,15] Using maxillary protraction facemask with tooth-borne anchorage in these young growing patients, clinical studies have shown that 4mm of maxillary advancement can be predictably achieved within 8-12 months.[6,14,16] However, such appliances often have unwanted dentoalveolar changes which includes proclination of the maxillary incisors, lingual tipping of the mandibular incisors, extrusion and mesial tipping of the maxillary molars and also, clockwise rotation of mandible.[17,18]

Since dentoalveolar changes tend to be the most prone to relapse, it seems advantageous to minimize the unwanted dental movement while maximizing the orthopaedic correction.[19]

Paradigm shift to Skeletal anchorage for maxillary protraction

In recent years, the use of Skeletally anchored maxillary protraction (SAMP) for the orthopaedic correction of maxillary retrognathia has increased in order to prevent the dentoalveolar and skeletal side effects of tooth-borne devices and also to enhance maxillary protraction.[20-27] The two pilot studies on using miniplates as Extra-oral skeletal anchorage for maxillary protraction (E-SAMP) were published by Kercelli and Pektas et al in which they placed mini-plates on the lateral nasal wall and elastic force of 300-350gm was applied. The remarkable advancement in middle face and fullness in the soft tissue profile was achieved in the late mixed-dentition period.[23,24]

The timing for effective maxillary protraction with RME and facemask remains limited to the deciduous or early mixed dentitions,[26] while skeletally anchored miniplates and Class III elastics has been successful in the late mixed or permanent dentition phases.[23-25]

By using intermaxillary elastics between miniplates on zygomatic crests of the maxilla and in the anterior mandibular region, De Clerck et al[23] introduced a new view to the orthopaedic treatment of Class III malocclusions. With this approach, the extraoral face mask is no longer needed and intermaxillary traction can be applied 24 hours a day.[25]

De Clerck et al[23] proposed skeletal anchorage using upper and lower miniplates, together with intermaxillary elastics (I-SAMP), as a method for correcting skeletal class III malocclusions. This technique is referred to as ZAS (Zygoma anchorage system) or BAMP (Bone anchor maxillary protraction)[23], and involves four orthodontic miniplates (two on each side): the upper plates are inserted at first and second molar level (in the infrazygomatic crest), while the lower plates are inserted between the lateral incisor and the canine. The authors proposed more apical insertion with respect to the insertion of traction miniplates, in order to minimize possible root damage.[28] Surgical placement of the miniplates in young patients is complicated, since the maxillary alveolar height is limited and the lower canines have not yet erupted. As a result, orthopedic treatment with miniplates usually does not begin before 10 years of age. Delaying maxillary traction offers the advantage of a shorter post-orthopedic and adult treatment period, thereby reducing the influence of the skeletal Class III pattern.[23]

Hence in the light of the above mentioned clinical studies elaborating the outcomes and changes in the maxillofacial complex after application of intra-oral skeletally anchored Class III elastics, there was a need for a collective literature review to assess and evaluate the effects of I-SAMP on maxilla and related structures as well as on mandible, soft tissue and airway for better understanding of this new technique. Moreover, there is no consensus regarding indications, age for treatment, techniques, surgical procedures or the forces employed.

Indication

The best age for starting of this treatment seems to be around 12 for boys and 11 for girls.[29] The ideal age to start treatment depends on two factors: The complexity of interdigitation of the sutures and the bone quality at the infrazygomatic crest.[29] As beyond the above-mentioned age, the thickness of the bone in the maxilla is sufficient to obtain a stable mechanical retention of the screws. However, the growth potential in the sutures decreases with age. This may be explained by an increasing interdigitation degree of the sutures and increasing resistance against mechanical disruption.

Procedure

Surgical Procedure[29]

Usually the miniplates are placed under a short general anesthesia (outpatient care). For insertion of miniplates, a small mucoperiosteal flap has to be made. In the upper jaw, the miniplates are placed just in front of and parallel to the infrazygomatic crest (Fig.1).[30] Further away from the crest is to be avoided, as the external cortical bone is thinner. The plates are positioned so that the round connecting bar of the neck penetrates the soft tissues in attached gingiva, close to the mucogingival border. Furthermore, the lower part of the neck should be in touch with the alveolar bone surface. In the lower jaw, the miniplates are fixed between the lateral incisor and the canine. Authors advised not to prescribe antibiotics or anti-inflammatory medications after surgery. The patients are instructed to apply ice pack after surgery to reduce swelling, and to rinse with several times a day with sparkling water and chlorhexidine twice a day for 12 days. The patient covers the intraoral extension with wax for the first week after surgery. This decreases mechanical irritation of the lip until the swelling is resolved. The orthodontist ten days after surgery gives appropriate hygiene instructions on how to clean the bone anchors with a conventional soft tooth brush. Before and immediately after the surgery, the patient must be instructed not to touch the miniplate repeatedly by pressuring the tongue or fingers. This is the main reason why some mobility of the anchors may occur during the first weeks after surgery, without local signs of infection. Because of the smooth surface of this new object in the mouth, patients are tempted to touch it repeatedly with the tongue. To prevent the mobility of the anchor because of these unwanted forces, loading by elastics should be started no later than 2 to 3 weeks after surgery.

Fig. 1: Skull showing anatomic location of Miniplates.[30]

Force applied[29]

The loading of miniplates is started 2 to 3 weeks after their placement surgery and it is maintained for a total period of one year. De Clerck et al used a single loading protocol i.e. started with lighter forces of 100gm, mainly to avoid overloading of the upper miniplates. The choice of elastics depends on the distance between the upper and lower plates, which is related to

- The severity of the skeletal Class III
- The A-P position of the upper Bollard miniplates, depending on the inclination of the infrazygomatic crest.

Traction force of 100gm is started with the use of 5/16-in elastics. During the next three months, the force level is gradually increase to 1/4-in and 3/16-in elastics. The patient is instructed to replace the elastics at least twice a day. The final loading of minplates is definitely smaller than generally used in combination with a face mask. The traction force, which are used, do not exceed 200 to 250 gm representing the maximum resistance of cortical bone of the infrazygomatic crest.

RESULTS AND OUTCOMES

Skeletal Effects on the Midface

All patients showed a forward displacement of midface i.e. in the maxilla, zygomatic region, and maxillary incisors.[30]

The forward displacement in the horizontal plane is noted in every patient with the average advancement of 3.7 mm with a range difference from 1.5 mm to 8.5 mm.[30] One explanation for the high variations in treatment response between patients might be due to the diversity of the skeletal Class III discrepancy presented with a severe −5.0 mm overjet, while others manifested a mild edge-to-edge incisor relationship. Other reasons for the high variation on treatment response include compliance with elastics, skeletal age, and maturation of the cranial sutures at the onset of treatment. Because of the application of a continuous, forward traction on the maxilla results in a stretching of the fibers in the sutures and stimulation of bone apposition.

On doing the cranial base superimposition, the zygomas also showed a forward displacement of approximately 3.7 mm, while the incisors had a slightly higher advancement of average 4.3 mm. I-SAMP treatment produced a uniform forward displacement of the midface as a unit, which was suggested by a high correlation between the anterior movement of the maxilla, zygoma, and incisors. The circumaxillary sutures were examined to explain this phenomenon. The application of a continuous anterior traction force on the maxilla results in a stretching of the fibers in the sutures and stimulation of bone apposition. Because of the complex interdigitations in the zygomatico-maxillary sutures, the opening of this suture is lesser than when separation of the zygomatico-temporal, zygomatico-frontal and palatino-maxillary sutures. This may explain why both halves of the maxilla and the left and right zygoma move forward as one unit. It may be plausible that a constant force from the elastics effectively produced distraction of these sutures, resulting in the forward displacement of the entire midface. Recent animal studies have shown

that continuous elastic traction is more effective at expanding the sutures when compared with intermittent forces.[31] In comparison to face mask therapy, this skeletal anchorage method applies the forces directly on the bone surface of the jaws.

Skeletal Effects on the mandible and temporomandibular joint (TMJ)

The changes in the anterior mandibular region were more variable in both magnitude and direction than that of the maxilla. Many subjects exhibited a distal displacement of the chin, while some continued to grow in the expected normal forward direction.[32] While the anterior position of the chin remained in relatively the same position throughout the course of treatment (-0.1 mm), this was significantly different from the mean forward growth of 2.2 mm in matched untreated Class III subjects during the same time interval.[25] It also is interesting that I-SAMP and untreated Class III subjects showed nearly identical growth changes in the mandibular body length (gonion to gnathion) and ramus height (condylion to gonion), suggesting that the this protocol did not restrain endochondral growth of the mandible. So how was I-SAMP able to restrict the anterior-posterior displacement of the chin if it did not affect AP or vertical growth of the mandible? The answer lies in the posterior gonial region. All subjects showed distal displacement of the posterior surface of the ramus along with a closure of the gonial angle. This combined effect maintains the mandibular plane angle while producing a compensatory restraint of the chin. In addition, there was small mean posterior displacement of the condyles accompanied by an adaptive remodeling of the glenoid fossa. Long-term studies are needed to evaluate the stability of this compensatory mechanism as well as the health of the TMJ complex. There was bone apposition at the anterior eminence of the TMJ which correlates well with the posterior displacement of anterior surface of the condyle.

Effects on the Dental and Dentoalveolar Parameters

Study by Elnager et al[33] shown that maxillary advancement can be accomplished using skeletally anchored maxillary protraction protocols with elimination of teeth movements and dentoalveolar changes. Maxillary or mandibular arch depth did not change significantly before and after maxillary protraction. Similarly, after the observation period maxillary or mandibular intermolar width remains almost unchanged. Superimposition of the pretreatment and posttreatment or on comparing 3-dimensional digital models showed that no spontaneous improvement in transverse deficiency was seen after correction of the anteroposterior deficiency at this age. Therefore, in patients with transverse maxillary deficiency before or during the skeletally anchored protraction, the rapid maxillary expansion appliance should be added to improve the transverse deficiency.

Effects on the Soft tissue

The 3-dimensional soft tissue analysis showed significant treatment effects of this modality.[34] The major changes were observed in the upper lips, cheeks, and middle of the face, which had a significant positive sagittal displacement when compared to control group. The lower lip and chin area showed significant negative sagittal changes that indicated that the soft tissue growth in this area was restrained with backward displacement. The intra-oral skeletal anchored maxillary protraction protocols effectively improved the Class III concave soft tissue profile.

Effects on the Airway

From the previous study, they have concluded that skeletally anchored maxillary protraction is effective in restraining mandibular growth.[25,32,35] However the development of the oropharynx did not appear to affective by this restrain of anterior-posterior growth of the mandible.[36] As on comparing airway volumes, sagittal dimension, and minimum cross-sectional area (Choke point) between well matched (age and skeletal classification) I-SAMP and untreated Class III controls showed that increase in airway of the I-SAMP group was equivalent to natural growth in Class III subjects.

Association with RME

Interestingly as advocated by Liou[37] & Wang et al.[38], forward displacement of the maxilla was observed without disarticulation of the cranial sutures. The concept that loosening the circummaxillary sutures by applying RME helps to facilitate the orthopaedic effects of maxillary protraction is controversial. Vaughn et al.,[39] showed that there was no difference between maxillary protraction with rapid palatal expansion and without it. Moreover, a 3-dimensional study evaluated the effects of rapid maxillary expansion on the circummaxillary sutures.[40] The authors reported significant increases in the openings of the intermaxillary, internasal, maxillonasal, frontomaxillary, and frontonasal sutures, but no changes in the frontozygomatic, zygomaticomaxillary, and zygomaticotemporal sutures. Interestingly, the frontozygomatic, zygomaticomaxillary, and zygomaticotemporal were the most affected sutures in their study. These findings suggest that effective protraction of the maxilla can be obtained without loosening of the circummaxillary sutures.

Advantages and Disadvantages

Most of the clinicians have encountered more benefits than shortcomings in the orthopaedic treatment of skeletal Class III discrepancy using miniplates as skeletal anchorage device.

As this technique has no extra-oral component, it is being less restrictive and more comfortable than facemasks and make it possible to keep the elastic bands in place almost 24 hours a day.[41] There is a greater maxillary advancement[27,42-44] with negligible anti-

clockwise rotation of the maxilla and lesser clockwise rotation of the mandible.[44] At the lower traction force of elastics (up to 250 gm per side), greater improvement in overjet and molar relationship along with facial profile can be achieved.[41,42] There is a potential to attain maxillary advancement in older patients than with dentoalveolar anchorage.[44] Dental alignment can be performed at the same time by using it with a range of orthodontic devices such as archwires, elastics and springs.[44]

However, skeletal anchorage is an invasive surgical technique, needing two separate operations for the placement and removal of the miniplates under general anaesthetic or sedation.[45] Also in rare case, there is a possibility of failure of the skeletal anchorage (miniplates or miniscrews).[46]

Complications

Most common complication is loosening of the miniplate, especially in the maxilla, if it is a poor quality bone. Secondly but rarely a fracture of the anchor can occur after excessive bending of the round connecting bar during adaption to bony surface. If a miniplate is lost, it can be reinserted under local anaesthesia and treatment can be progressed or completed.[29]

CONCLUSION

The treatment of Class III malocclusions in growing patients remains a challenge in orthodontics, due to the high tendency towards relapse. At present, the incorporation of surgically inserted bone anchorage appliances (miniplates and miniscrews) offers a purely orthopaedic approach to treatment, with minimization of the undesirable side effects of the compensations achieved with traditional dentofacial orthodontics based on dentoalveolar anchorage. Nevertheless, these promising surgical miniplate-based orthopedic traction protocols must be contrasted by studies offering solid scientific evidence in order to optimize the age ranges, types of forces and types of orthopaedic systems, among other factors. This will help to maximize the orthopedic changes at maxillary and mandibular bone level and minimize the dentoalveolar effects and thus secure greater stability of the results obtained.

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