Chapter 29

# Corticotomy and Miniplate Anchorage for Treating Severe Anterior Open-Bite: Current Clinical Applications

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## 1. Introduction

Anterior open bite (AOB) is a term used if there is localized absence of occlusion anteriorly when the remaining teeth are in occlusion; it is commonly one of the main symptoms of an overall dentofacial deformity. Diagnosis, treatment, and retention can be difficult because this malocclusion has numerous correlated etiologic factors. Clinically, it is grouped into 2 main categories: dental or acquired open-bites which have no distinguishing craniofacial malformations, and skeletal open bite with superimposed craniofacial dysplasia. [1]

The cause of an anterior open bite is multifactorial and can be attributed to a combination of skeletal, dental, and soft-tissue defects. Vertical malocclusion develops as a result of the interaction of many different etiologic factors including thumb and finger sucking, lip and tongue habits, airway obstruction, and true skeletal growth abnormalities. The etiologic factors play an important role in diagnosis. Heredity, unfavorable growth patterns and incorrect jaw postoure are the characteristics of skeletal AOB. Besides depending on where the thumb is placed, a number of different types of dental problems can develop. Malocclusions of the late mixed or permanent dentitions, caused by thumb sucking are not self-corrected and surely orthodontic treatment is necessary. Due to oral respiration, the mandible is postured inferiorly with the tongue protruded and resting against the oral floor. This postural alteration induces dental and skeletal modifications similar to those caused by thumb sucking. This may cause excessive eruption of the posterior teeth, leading to an increase in the vertical dimension of the face and result in development of AOB. Additionally, tongue habits cause an AOB or they develop secondarily to thumb sucking. In skeletal AOB the tongue habit acts as a secondary factor which helps to maintain or exacerbate the condition. Many

orthodontists have had a discouraging experience of completing dental treatment, with what appeared to be good results, only to discover that the case had relapsed because the patient had a tongue thrust swallowing pattern. AOB is frequently observed in orthodontic practice. While 17.7% of children in the early to mixed dentition period present with an open bite of 1–12 mm [2], even after an improvement in orofacial dysfunctions [3], AOB is still diagnosed in 2.9% of adult Caucasian Americans [4]; it is an increasingly recognized major orthodontic problem. Patients with AOB malocclusion can be diagnosed clinically and cephalometrically; however, diagnosis should be viewed in the context of the skeletal and dental structure. Accurate classification of this malocclusion requires experience and training. Simple AOB during the exchange of primary to permanent dentition usually resolves without treatment. However, complex skeletal AOB that extend farther into the premolar and molar regions, and those that do not resolve by the end of the mixed dentition years may require orthodontic and/or surgical intervention. Most skeletal AOB cases are characterized by excessive vertical development of the posterior maxilla and usually have excessive eruption of posterior teeth accompanying AOB. [5] Treatment for AOB ranges from observation or simple habit control to complex surgical procedures. Successful identification of the etiology improves the chances of treatment success. Vertical growth is the last dimension to be completed, therefore treatment may appear to be successful at one point and fail later. Some treatment may be prolonged, if began early. When orthodontic or surgical intrusion of the overerupted maxillary teeth is performed, the mandible rotates closed at rest and in function, resulting in open-bite closure. [6] Different treatment modalities have been used for this purpose such as orthognathic surgery, conventional orthodontic appliances and combined methods. Orthodontic treatment options include functional appliances, and orthopedic devices. Intrusion of the overerupted molar teeth by traditional orthodontic methods is hardly possible in adult patients; there is therefore no real alternative to a combined orthodontic and surgical approach because the condition tends to recur after orthodontic treatment alone. In adult patients, combined approaches of surgery and orthodontic appliances make it possible to complete orthodontic treatment in a fast and predictable manner. [7]-[11] In the present chapter, advantages and disadvantages of current treatment protocols and corticotomy-facilitated compressive force procedure using orthodontic anchor plates applications are discussed in light of the current clinical literature.

## 2. Current clinical applications for treating severe AOB

### 2.1. Traditional orthodontic treatment options for AOB

Long-term skeletal and dental stability has been a concern because of the influence that the neuromusculature has on the repositioned jaws and the stability of teeth after vertical orthodontic mechanics required for closing open bites. Traditional treatment modalities include compensating orthodontics, functional appliances, and orthopedic devices. Orthodontic treatment involves extrusion of incisors or intrusion of molars. These therapies show relatively stable results for younger patients. In young patients, the vertical maxillary growth can be controlled with a high-pull headgear or a functional appliance with bite blocks. Once

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excessive vertical development of the posterior maxilla has occurred, only two treatment options are available for the correction of an openbite. Elongation of the anterior teeth leaves the skeletal component of the deformity unchanged. However, traditional techniques are concluded to produce only relative intrusion of the molars and have a limited effect in providing sound anchorage. [12] The ideal period to begin open bite treatment is during the mixed dentition; if the malocclusion is corrected during the deciduous dentition, it will recur because of continued growth changes. In the mixed dentition, the most important step in correcting an open bite associated with abnormal habits is to eliminate the habits with behavior-modification techniques, accompanied by speech therapy; if necessary, a removable functional appliance with a vertical crib can be used. It is important to present this treatment to the child as an aid and not as a penalty. In about half of the patients, thumb sucking ceases immediately, and the anterior open bite closes relatively quickly. After the habit is eliminated, it is important to maintain the appliance for 3 to 6 months. However, when the open bite is associated with skeletal features such as an increased mandibular plane angle, anterior face height, and extruded posterior teeth, it is necessary to redirect maxillary growth with molar intrusion, to rotate the mandible in an upward and forward direction. [13] On the other hand, if the skeletal relationship is the primary cause of the AOB and control of the sucking habit is limited, the prognosis is poor. [14] The treatment of choice for this problem is to reduce the vertical dimension by reducing the height of the posterior teeth. The difficulty of managing anterior open-bite malocclusions is not only in obtaining the correct diagnosis, but also in treating a successful facial and dental result. The orthodontist's challenge is to minimize molar extrusion during treatment to prevent downward and backward mandibular rotation. The early treatment strategy of skeletal AOB is based on inhibition of the vertical development or intrusion of the buccal dentoalveolar structures by means of bite-blocks or extraoral appliances, thus producing upward and forward rotation of the mandible into a more horizontal, rather than vertical growth direction. Early interception offers psychological benefits and the potential for condylar growth. Nonsurgical options usually require longer treatment times and greater patient compliance. Although attempts to limit the increase in vertical dimensions by at least 1 of the above approaches were done by orthodontists, posterior bite-blocks proved to be effective in producing condylar growth and forward rotation of the mandible. To actively intrude the posterior teeth, active components in the form of magnets and springs have been suggested. [13]-[23]

The design of spring-loaded bite-blocks was first described by Woodside and Linder-Aronson. These blocks are activated from time to time, and they supply additional force in the neuromuscular system, in addition to the forces of the masticatory muscles that are exerted by the passive posterior bite-blocks. Because of its peculiar design, it was thought that the same appliance could also act as a habit-breaking appliance. With this appliance, the patient must apply active force to close his mouth, and this acts as a distraction device. By intruding the posterior teeth, the mandible autorotates upward and forward. This form of treatment is advantageous because it corrects the AOB and simultaneously reduces the total anterior facial height. The increase in muscle strength because of its oral dynamic effect ensures a stable result. A modified acrylic occlusal splint along with spring-loaded bite blocks have been used to correct the skeletal AOB during the mixed dentition was shown to be efficient, but

its correct indication and control are of fundamental importance. Many approaches have been suggested to modify this early developmental pattern, but only posterior bite-blocks proved to be effective in producing condylar growth and forward rotation of the mandible. [14]-[23] To actively intrude the posterior teeth, Iscan et al., Akkaya and Haydar suggested the use of a spring-loaded bite-block. When adult patients are treated using classical orthodontic appliances, the duration of the treatments increase and risks such as root and marginal alveolar bone resorption, undesired movements of anchorage teeth, and relapse occur. Dental stability after vertical orthodontic mechanics is unpredictable and is prone to relapse. [24] Relapse is multifactorial and can involve skeletal and dentoalveolar components.

### 2.2. Orthognathic surgery techniques for AOB

Orthognathic surgery techniques for the treatment of AOB have been used for many years. The most frequently performed surgical procedures for AOB is correction via superior repositioning of the maxilla via LeFort I osteotomy, posterior segmental maxillary osteotomy, and vertical ramus osteotomy. Early attempts to close an AOB with mandibular procedures were mainly segmental [25], but were soon replaced by posterior impaction of the maxilla at LeFort I level as this was thought to be more stable. [26]-[28] If the mandible does not rotate into the correct position after the maxilla is impacted, 2-jaw surgery is required. The fear of surgery or general anesthesia and other factors may lead a significant proportion of patients to refuse surgery. Fewer than half of their patients who had sought orthodontic treatment for long-face problems accepted the recommended orthognathic surgery. Proffit et al., considered that a patient with a skeletal long-face problem who refused surgical correction was better left untreated. However, after initially successful correction of the vertical dimension by a combined treatment with a multibracket appliance and bimaxillary osteotomies, some of these patients with primary open bite may after treatment, experience a vertical relapse with a reduction in the overbite, or the reappearance of the anterior open bite. At post-treatment follow-up, the relapse rate ranged from 12% to roughly 30% depending on the type of treatment [29]-[34] In patients with severe AOB, secondary orthodontic therapy or repeated surgery may become necessary. The main indication for treatment of an AOB by posterior maxillary impaction is the presence of posterior maxillary vertical maxillary excess, which is common. About one third of patients who present with orthognathic concerns have vertical maxillary excess. It is also reported that about 60%of patients with it also have an openbite, or a tendency to an openbite. [35] It follows that many patients who are operated on to correct AOB may require maxillary surgery. Where the vertical and anterior–posterior position of the maxilla is within reasonable limits there is less of an indication to operate on the maxilla, except when it is thought to be the most stable technique to close an AOB. Although many studies have reported better stability with a maxillary procedure, the patients are heterogeneous and include those with appreciable vertical maxillary discrepancies. [36],[37] Few compare or report on cases where the maxilla was in a favourable position without a posterior vertical maxillary extension. The height of the mandibular ramus and the clinical state of the condyles are factors only recently emphasised as useful contributors to aiding the decision about the choice of procedure. [35]

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Patients with a short mandibular ramus, normal condyles, no sign of ongoing resorption, and a well positioned maxilla would lend themselves to a mandibular sagittal split osteotomy (MSSO) alone as the procedure of choice. There have been few publications about mandibular surgery alone, with the few studies published including sample sizes of only 15–30. [38],[39] This may reflect the limited number of cases that are appropriate for such a procedure, or may reflect the blanket treatment selected by many, based on the heterogeneous case-mix previously analyzed, which universally suggests more stability with maxillary surgery. [40] Studies that describe or compare mandibular anticlockwise rotational movements alone do not clarify the technique of sagittal split osteotomy, and whether this was conventional or modified. In particular, with reference to the posterior extension of the cutinthe medial ramus, ensuring a split that allows part of the medial pterygoid to remain attached to the proximal segment and to stripping of the pterygomasseteric sling, medial pterygoid, and stylomandibular ligament from the distal segment. [35] These manoeuvres during a modified medial ramus osteotomy named as "short split technique" [26] reduce the risk that the medial pterygoid muscle may contribute to forces that encourage relapse when closing an AOB with the mandible. Other factors thought to contribute to relapse are the stretching of nonmuscular soft tissue and neuromuscular activity. Both factors are thought to adapt early postoperatively rather than cause relapse. Various studies have suggested that rigid fixation confers greater stability than other methods in the closure of AOB. [41] It has been suggested that rigid fixation using positional screws in the closure of an AOB may confer better surgical stability than semirigid mini-plates, and was therefore the preferred method used by the surgeons in this study. [36],[38],[41],[42]

Although maxillary osteotomy is done regularly with few complications, morbidity still exists and can be life threatening, especially if there is severe bleeding. In clinical practice, some patients who need closure of an AOB may also require an increased prominence of the chin. This would necessitate advancement genioplasty if the correction of the AOB was to be achieved by maxillary surgery only. Anticlockwise rotation of the mandible has the esthetic advantage of addressing this deficit, and avoids the risks and morbidity associated to advancement genioplasty as an additional procedure. Although there are few published reports, a growing numbers of surgeons are attempting and reporting MSSO technique to close AOB. [35],[38]-[40] Bimaxillary surgery, although advocated in the closure of AOB, may present a higher risk of morbidity than either maxillary or mandibular surgery alone. Published evidence has recognized the risks of relapse with this procedure [37],[43] and means that care must be taken in calculating the definite need for double jaw surgery to optimize the risk-to-benefit ratio for the patient.

This surgical procedure has not been well accepted because of rigid fixation, the need to use bone grafts and membranes, severe bleeding, longer duration of hospitalization, the risk of dental and periodontal problems that may occur when the bone segments are rapidly and excessively separated and increased risk of relapse. [44]

### 2.3. Titanium implants or bone anchors for AOB

AOB due to posterior maxillary dentoalveolar hyperplasia can be closed without orthognathic surgery. Osseointegrated implants serve as absolute anchorage for the intrusion of over-erupted teeth; and, after tooth movement, can be used as restorative abutments. Patients who do not need prosthetic rehabilitation may benefit from a removable skeletal anchoring device that can be placed outside the dentition. Absolute anchorage can only be achieved if the anchorage devices are fixed in bone. Such devices include miniplates, miniscrews, palatal implants, onplants and dental implants. Anchorage control is a prerequisite for the success of orthodontic treatment. Loss of dental anchorage during orthodontic treatment leads to uncontrolled occlusion results. Recent clinical studies regarding AOB suggesting the use of skeletal anchors with fixed Edgewise appliances, demonstrated that incorporation of skeletal anchors was an excellent alternative to traditional orthodontic treatment methods and may provide a significant amount of maxillary and/or mandibular molar intrusion for AOB. The pure titanium miniplates that are well-known in maxillofacial trauma and orthognathic surgery comply with these criteria.[11],[45]-[52] Several studies have examined the effects of miniplates as anchors for orthodontic distal and intrusive movements. [11],[12],[53]-[57] Miniplates placed outside the maxillary and mandibular dentition functioned as onplants, and the screws functioned as implants, making rigid anchorage possible. Rigid anchorage results from osseointegration of both anchor plates and screws. Although there have been some promising casereports, there are few studies on the posttreatment complications of miniplates used for orthodontic anchorage. Umemori et al., Sherwood et al. and Akay et al. reported that the miniplates in their studies were quite stable. However, some patients developed chronic infections related to the miniplates. Nowadays, for upper or lower molar intrusion, orthodontic implants, miniscrews and modified titanium miniplates are used and recommended by different investigators. In a study by Xun et al. on 12 patients with open bite malocclusions, upper and lower molars were intruded 1.8 mm and 1.2 mm, respectively, in a mean of 6.8 months with the use of micro-screws as anchors. Several reports document that screw-type implants have been successful anchoring units in general. [46],[56]-[59] Miyawaki et al. found that the 1-year success rate of screws with 1.0-mm diameter was significantly less than that of other screws with 1.5-mm or 2.3-mm diameter or than that of miniplates. When compared with mini or micro-screws, titanium anchor plates hold the advantage of functioning as sound anchorage units against increased force levels. [11],[12],[51]-[53],[55]-[61] Furthermore, a high-mandibular plane angle was found to be a potential risk factor for the failure of screw-type implant anchors and the use of miniplates in patients with high mandibular plane angles were suggested when micro-screws were risky to insert.[56] In a clinical study Akay et al. treated adults with AOB, using titanium screws of 2.3 mm diameter and 7, 9, 13 mm lengths and their results correlated with recent studies by Sherwood et al., Chung et al., De Clerck et al., Miyawaki et al., Erverdi et al., Choi et al., and Erverdi et al. concluding that miniplates placed at zygomatic butresses and buccal bone above the roots of premolars remained stable following application of intrusive forces. In this study, no signs of mobility of titanium screws placed in the palatal bone were observed.

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Sherwood et al. and Erverdi et al. supported orthodontic forces by implanting titanium miniplates at the lower face of the zygomatic process of maxilla aiming to correct skelatal AOB. Sherwood et al.2002 demonstrated a mean upper molar intrusion of 1.99 mm with intrusive forces continued for 5.5 months in four patients whereas Erverdi et al.2004 reported a mean maxillary molar intrusion of 2.6 mm in 10 patients after a mean of 5.1 months. Yao et al.2005, used a combination of a buccal miniplate and palatal miniscrew in 18 patients and buccal and palatal miniscrews in 4 patients who had overerupted maxillary molars. They reported that the mean intrusion of maxillary first molars was 3 to 4 mm in a mean of 7.6 months.Titanium miniplates implanted in the zygomatic buttress area can serve as absolute anchorage for maxillary molar intrusion. Recent studies suggesting the use skeletal anchors with fixed Edgewise appliances demonstrated that incorporation of skeletal anchors was an excellent alternative to traditional methods and may provide a significant amount of maxillary and/or mandibular molar intrusion. [12],[47],[48],[50]-[53],[61]-[63]

Titanium miniplates are strongly recommended for temporary skeletal anchorage. Both the placement and the removal of the plates are minimally invasive procedures with only slight discomfort to the patient and with no serious side effects. The dense cortical bone of the zygomatic buttress area is an ideal miniplate anchorage site for maxillary molar intrusion. Development of miniature bone anchors have made this clinically feasible and practical. In the literature, a wide range of intrusion forces between 100 and 900 g was suggested for intrusion of maxillary molars, in nongrowing individuals. [45],[47],[50],[52],[64],[65] However, the optimal force to be applied following corticotomy is not clear.[11] Park et al. used 200-300 g of force for intrusion of maxillary posterior teeth with 3 roots, without a corticotomy procedure. After a buccal and palatal corticotomy Akay et al. applied an intrusion force of 200-300 g on each molar and two premolars, considering that with force level less than 200 g, intrusion may be delayed and alveolar bone may heal prematurely. On the other hand, a force level greater than 300 g may stimulate root resorption. It has been suggested that subapical corticotomy procedure decreases the risk of root resoption because the bone blocks are moved with the teeth. [9],[11],[52],[66],[67]

### 2.4. Corticotomy assisted maxillary impaction with bone anchor miniplates

Patients with skeletal AOB are considered the most difficult to manage because the condition tends to recur after treatment, particularly after single-jaw osteotomy. [32],[68] Patients would almost certainly prefer a less invasive surgical procedure with little or no risk and less discomfort. Additionally, a slow change in the facial appearance may be more acceptable for some patients than a sudden one. Besides local rather than general anesthesia, a decreased operation time, and a shorter duration of hospitalization can reduce costs.[69] A combination of subapical corticotomy and orthodontic treatment supported with bone anchors may be an alternative method for skeletal AOB correction in adult patients who would like to consider a rather rapid treatment option. Recently, surgically assisted orthodontic treatment for severe AOB has been described that has the advantages of corticotomy facilitated orthodontic treatment using orthodontic-skeletal anchorage miniplates. Combined approaches of surgery and orthodontic appliances make it possible to complete orthodontic

treatment in a rapid and predictable manner. Anchor plate or implant appliances allow reliable and expedient orthodontic treatment with minimal orthodontic anchorage loss. It has been suggested that corticotomy procedure decreases the risk of root resoption because the bone blocks are moved with the teeth; this compression osteogenesisis osteoplasty technique is based on the distraction osteogenesis phenomenon. [7]-[11],[57],[66],[71],[72]

Chung et al.used an orthodontic anchor plate system in his clinical study. According to the study, the teeth were moved in a block of bone that was connected to other teeth and anchored via low-density medullary bone and the block was repositioned on an outpatient basis using anchor plates and orthodontic elastics under local anaesthesia. Although this method is also indicated for open-bite patients without anterior–posterior dentofacial problems, the author's new surgical approach decreases the time required for treatment by allowing rapid movement of a block of teeth and bone. It is widely accepted that the utilization of corticotomy before orthodontic treatment allows positively accelerated tooth movement thereby shortening active treatment time with less risk of root resoption and more stable results as well. [9],[11],[52],[66],[67] Akay et al. recently described the efficacy of this technique in combination with a buccal and palatal corticotomy using a bone anchor miniplate system. After one-step corticotomy, the posterior teeth were moved in a block of bone that was connected to other teeth and anchored via low density medullary bone (Figs. 1a-d).

Although corticotomy has become an alternative technique for maxillofacial surgeons, there is no consensus in the literature regarding corticotomy assisted bone anchors application used in maxillary impaction, type of bone anchors used, effects of the new technique on the TMJ, teeth or skeletal structures, the cause and amount of relapse and whether or not overcorrection is necessary. Clinical results of Akay et al. showed that this operation can be performed succesfully under local anesthesia without sedation in cooperative patients.

There are some controversies regarding the type of corticotomy before bone anchor miniplates are inserted.

**Subapical corticotomy technique used by Akay et al.:** Under local anesthesia the corticotomies are performed prior to implantation of skeletal anchors. The vertical cuts begin 2 to 3 mm above the alveolar crest and extend 5 to 6 mm beyond the tooth apicies. The vertical cuts are made within the compact bone barely reaching the medullary bone on the mesial side of the most anterior tooth and on the distal side of the most posterior tooth to be intruded. A horizontal cut is then made 4 to 5 mm above the apices of the relevant teeth and connected to the 2 vertical cuts. The resection gap is 3 to 4 mm wide to facilitate the intrusion. These cuts are made on both the buccal and palatal sides so that the block of bone is retained only by the medullary bone.

For intrusion of molars, zygoma anchors with three holes (Surgi-Tec, Brugge, Belgium) are adjusted to fit the contour of the bone of each zygomatic process of the maxilla using a plate shaping kit and fixed by three 2.3 mm wide and 7 to 9 mm length miniscrews (Surgi-Tec, Brugge, Belgium). In order to intrude premolars, miniplates with two holes (Surgi-Tec, Brugge, Belgium) are attached 6-7 mm above the roots of relevant teeth and are stabilized by titanium screws (2.3 mm in diameter and 5-7 mm in length (Surgi-Tec, Brugge, Belgium).To

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prevent any possible buccal tipping of posterior treeth during intrusion, two titanium screws (2.3 mm in diameter and 13 mm in length, Surgi-Tec, Brugge, Belgium) are implanted in the palatal region between the molars and between the premolars bilaterally, these aided as anchors for applying additional palatal force vectors (Figs. 2-4).

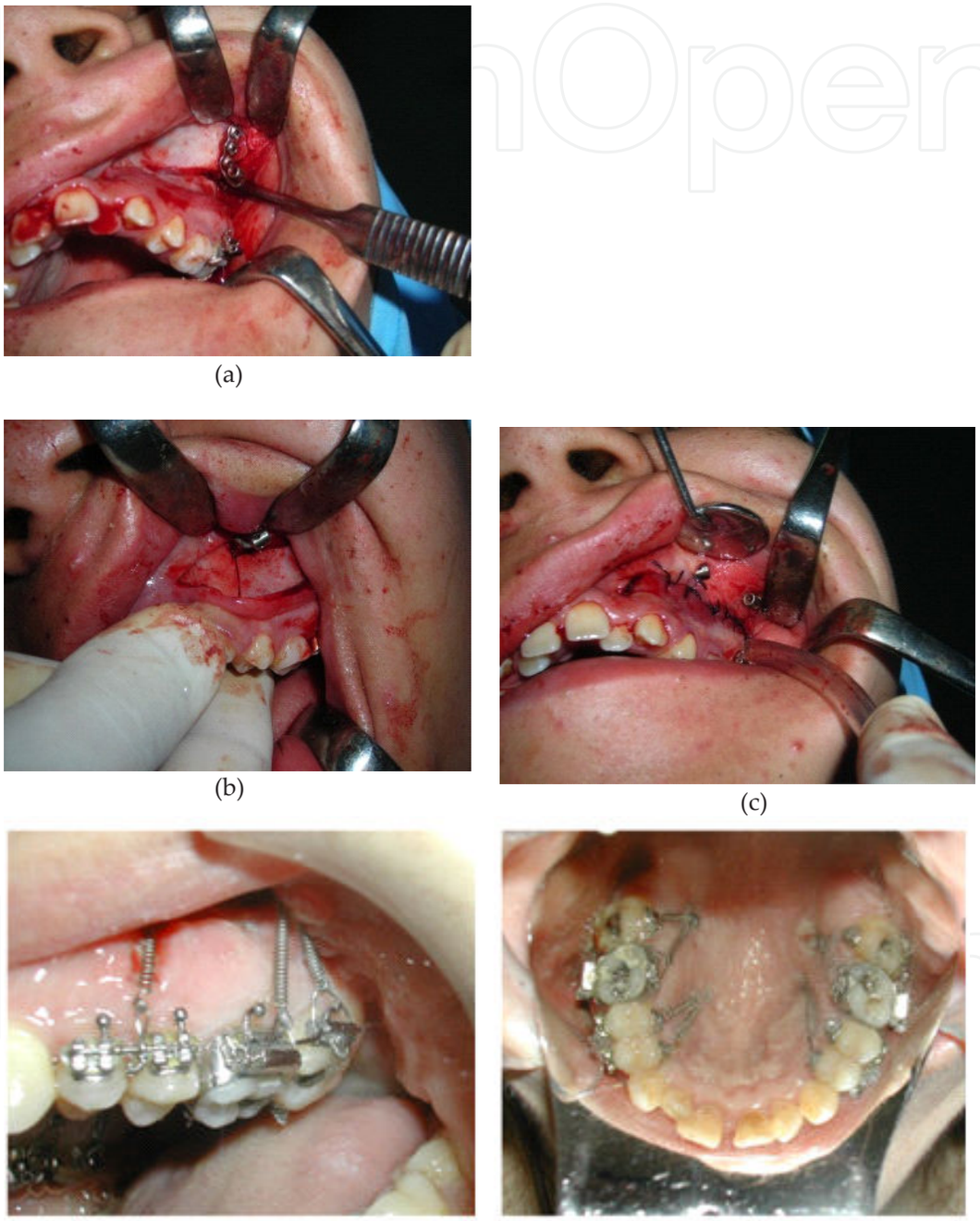

**Figure 1.** a) Operative photograph showing miniplate bone anchor insertion. (b) The horizontal and vertical corticotomy on the buccal surface. (c) Postoperative clinical appearance showing bone anchor position (d) Postoperative clinical photograph showing intrusive force application (buccal view left, palatal right).

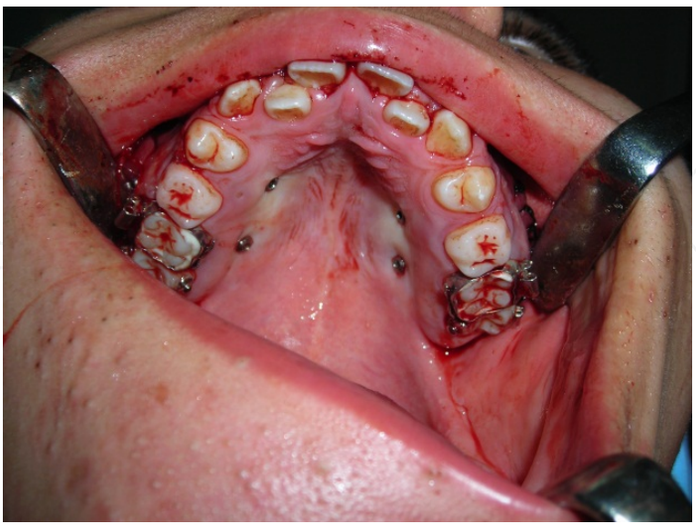

**Figure 2.** Clinical appearence of screws implanted in the palatal region between the molars and between the premolars bilaterally.

(a)

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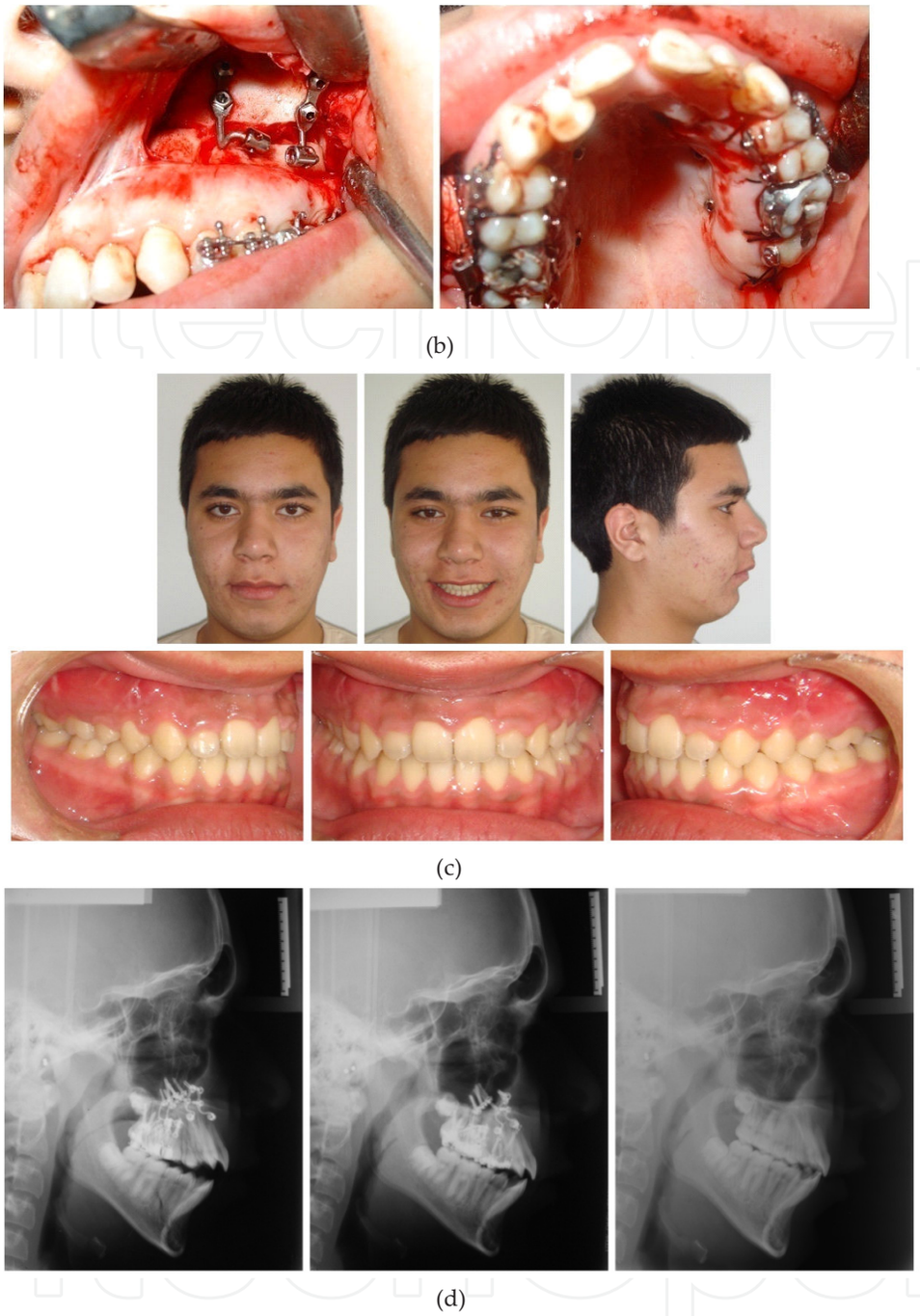


**Figure 3.** a. Clinical appearence of Case 1 and preoperative intraoral photographs showing severe anterior open bite. b. Intraoperative photograph showing buccal and palatal corticotomy and buccal miniplates and palatal screws insertion. c. Postoperative facial photographs and occlusion after completion of orthodontic treatment. d. Cephalometric views preoperatively, during molar intrusion and after completion of orthodontic treatment.

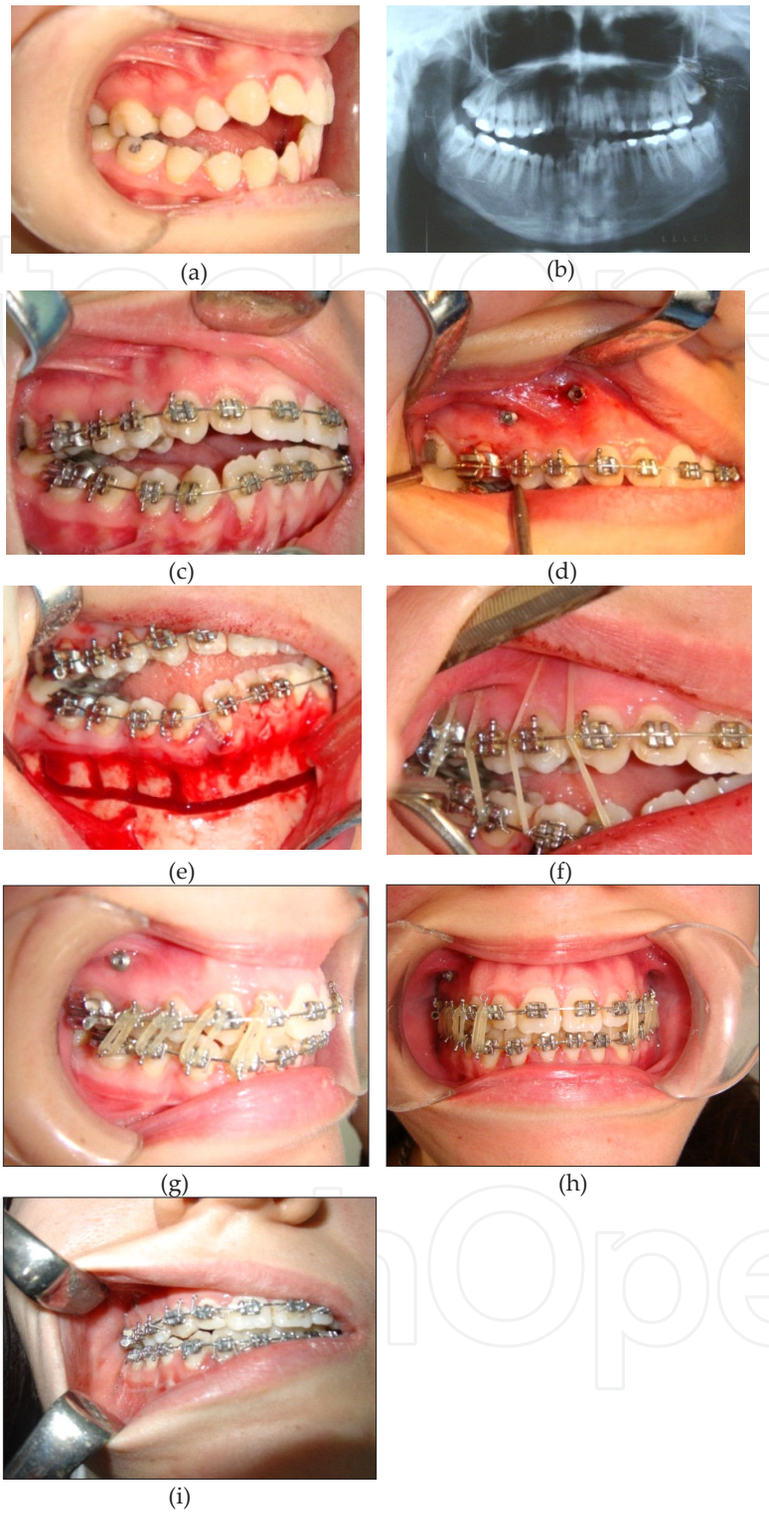


**Figure 4.** a. Clinical appearance of case 2 and (b) preoperative ortopantomograph showing severe open bite. c. Orthodontic preparation and (d) screw applications on the maxilllary posterior buccal cortex. e. The corticotomy on the mandibular buccal surface and (f) compression force activated using elastics. g. Lateral and (h) anterior clinical photographs during dentoalveolar osteogenesis. i. Postoperative photograph showing occlusion after completion of orthodontic treatment.

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According to clinical study by Kanno et al., the two-stage segmental corticotomy technique may be performed under local anaesthesia with intravenous sedation and avoiding the need for conventional orthognathic surgery. Although complex double-jaw surgery is considered a relatively routine intervention for patients with severe anterior open bite, bimaxillary surgery under general anaesthesia may lead to complications necessitating intense postoperative care. [32],[68],[73] None of the postoperative complications, including root resorption, loss of tooth vitality, periodontal problems, pocket formation and segmental malunion, were observed that have been associated with less invasive surgical treatments. [10],[11],[70],[71] Although AOB may be improved by concurrent counterclockwise rotation of the mandible and molar intrusion with skeletal anchor plates, the molar intrusion is limited, the new combined technique allows postoperative adjustment of the bone/teeth segments to the ideal position using a gradual compressive force over a shortened treatment period. [10],[11],[57] An orthodontist performed post-surgical management on an out-patient basis. Reliable control of the corticotomy-facilitated teeth/bone segments has been reported in studies on bone biology and remodelling with compressive induction. [10],[11],[70],[71] According to these authors, no postoperative relapse and complications, such as infectios, dentoalveolar fractures, TMJ symptoms, dental or periodontal problems, loss of tooth vitality, segmental malunion, loss of anchorage and fracture of miniplates and screws were observed during or after corticotomy surgery.

## 3. Conclusion

AOB is a common problem in orthognathic practice that causes functional and esthetic handicaps on affected patients and it is frequently discussed in orthodontics. Its management varies and it is one of the most challenging disorders to treat. The orthodontic and surgical approach to the treatment of skeletal AOB is still debated, and the results are still controversial. Diagnosis, treatment, and retention can be difficult because this malocclusion has numerous correlated etiologic factors. The earlier this malocclusion is corrected, the better the prognosis will be, especially when the problem is skeletal. Treatment is usually not necessary until permanent teeth erupt (approximately at the age of 6 year). There are different treatment modalities for AOB in the literature. However, many surgeons find it difficult to decide which technique offers better results, and are also uncertain about the factors which might influence their techniques of choice. Many adult patients with AOB are significantly compromised, requiring a multidisciplinary approach to treatment. It is very important to consider surgical and dental concerns during AOB treatment planning. The relapse rate is high with all the techniques in current use. The cause of relapse is multifactorial and one of the main factors is the type of osteotomy used. Corticotomy-facilitated bone anchor applications for treating AOB has become increasingly popular as an alternative to many conventional orthognathic surgical procedures. For patients with mild to severe abnormalities of the AOB, this combined technique has increased the number of treatment alternatives. Although long-term follow-up of occlusion stability is required, the recent evidence suggest that a corticotomy-facilitated compressive force procedure using orthodontic anchor

plates is an effective means of treating patients with severe AOB, however further multicenter studies with a larger population are necessary to precisely evaluate postoperative relapse, other clinical complications and skeletal and dental changes in the long term. Further studies with different designs of titanium miniplates for orthodontic anchorage might be helpful in identifying factors for decreasing the incidence of complications. Improvement of the technique and devices used, with an adjusted protocol, could lead to a reduction in the number of complications.

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## References

[1] Subtelny, J.D. & Sakuda M., (1964) Open-bite: diagnosis and treatment. *AmJ Orthod* Vol.50, pp:337-358

[2] Tausche, E., Luck O., Harzer W.,( 2004) Prevalence of malocclusions in the early mixed dentition and orthodontic treatment need. Eur J Orthod Vol.26, No:3,pp: 237-244

[3] Ermel, T., Hoffmann J.& Alfter G., et al. (1999) Long-term stability of treatment results after upper jaw segmented osteotomy according to Schuchardt for correction of anterior open bite. *J Orofac Orthop Vol.*60, No:4, pp:236-245

[4] Proffit, W.R., Fields H.W. Jr.& Moray L.J., (1998) Prevalence of malocclusion and orthodontic treatment need in the United States: estimates from the NHANES III survey. *Int J Adult Orthodon Orthognath Surg*Vol.13, No:2, pp:97-106

[5] Schudy, F.F.(1965). The rotation of the mandible resulting from growth: itsimplications in orthodontic treatment. *Angle Orthod*Vol.35, pp:36-50

[6] Bell, W.H. & Proffit W.R.,(1980) Open bite. In: Bell WH, Proffit WR, White RP.eds. Surgical Correction of Dentofacial Deformities. Philadelphia, PA:Saunders, pp: 1058-1209

[7] Kole, H., (1959) Surgical operations on the alveolar ridge to correct occlusal abnormalities. *Oral Surg Oral Med Oral Pathol* Vol.12, pp: 515–529

[8] Kerdvongbundit, V., (1990) Corticotomy—facilitated orthodontics. *J Dent Assoc*Thai Vol.40, 284–291

[9] Hwang, H.S.&Lee K.H., (2001) Intrusion of overerupted molars by corticotomy and magnets. *Am J Orthod Dentofacial Orthop*Vol.120, pp:209-216

[10] Kanno, T., Mitsugi1 M.&FurukiY., et al., (2007)Corticotomy and compression osteogenesis in the posterior maxilla for treating severe anterior open bite.*Int J Oral Maxillofac Surg*Vol. 36, pp: 354–357

[11] Akay, M.C., Aras A. & Günbay T., et al., (2010) Enhanced Effect of Combined Treatment with Corticotomy and Skeletal Anchorage in Open-bite Correction. J Oral Maxillofac Surg, Vol.67.No.3, pp: 563-569

[12] Sherwood, K.H., Burch J.G., Thompson W.J.,(2002) Closing anterior open bites by intruding molars with titanium miniplate anchorage. *Am J Orthod Dentofacial Orthop* Vol.122, pp:593-600

[13] Altuna, G.&WoodsideD.G., (1985) Response of the midface to treatment with increased vertical occlusal forces. *Angle Orthod* Vol.55,pp:251-263

[14] Cozza, P., Baccetti T.& Franchi L., et al., (2005) Sucking habits and facial hyper divergency as risk factors for anterior openbite in the mixed dentition. *Am J Orthod Dentofacial Orthop*Vol.128, pp:517-519

[15] Dellinger, E.L. )1986)A clinical assessment of the active vertical corrector, a nonsurgical alternative for skeletal open bite treatment. *Am J Orthod*Vol.89, pp:428-436

[16] Woods, M.G.&Nanda R.S., (1988)Intrusion of Posterior Teeth with Magnets. *The Angle Orthodontis*, Vol. 58, No:2, pp: 136-150

[17] Kalra, V.&Burstone C.J., (1989) Effects of a fixed magnetic appliance on the dentofacial complex. *Am J Orthod Dentofacial Orthop*Vol.95, pp:467-478

[18] Kiliaridis, S., Egermark I.&Thilander B., (1990) Anterior open bite treatment with magnets. *Eur J Orthod*Vol.12, pp:447-457

[19] Barbre, R.E.&Sinclair P.M.,(1991); A cephalometric evaluation of anterior open bite correction with the magnetic active vertical corrector.*Angle Orthod*Vol.61,pp:93-102.

[20] Akkaya,S.&Haydar S., (1996) Post-retention results of spring-loaded posteriorbite-block therapy. *Aust Orthod J*,Vol.14, pp:179-183

[21] Kuster, R &Ingervall B.,(1992) The effect of treatment of skeletal open bite with two types of bite-blocks. *Eur J Orthod*Vol.14, pp:489-499

[22] Iscan, H.N., Akkaya S.&Koralp E., (1992) The effects of the spring-loaded posterior bite- block on the maxillofacial morphology. *Eur J Orthod* Vol.14, pp:54-60

[23] Iscan, H.N.& Sarisoy L.,(1997)Comparison of the effects of passive posterior bite-blocks with different construction bites on the craniofacial and dentoalveolar structures. *Am J Orthod Dentofacial Orthop* Vol.112, pp:171-178

[24] Denison, T.F.,KokichV.G.&ShapiroP.A., (1989) Stability of maxillary surgery in open bite Versus non-open bite malocclusions. *Angle Orthod* Vol.59, pp:5–10

[25] Kloosterman,J., (1985) Koele's osteotomy: A follow-up study. *J MaxillofacSurg* Vol. 13:59–63.

[26] Epker, B.N.&Fish L. (1977) Surgical-orthodontic correction of open-bite deformity. *Am JOrthod*Vol.;71, pp:278–299

[27] Swinnen, K., Politis C. & Willems G., et al.,(2001) Skeletal and dento-alveolar stability after surgical-orthodontic treatment of anterior open bite: a retrospective study. *Eur JOrthod*Vol.23, pp:547-557

[28] Schmidt L.P. & Sailer H., (1991) Long-term results of surgical-orthodontic treatment of open bite deformity by a LeFort-I osteotomy. *Swiss Dent* Vol.27, No:29,pp:31–32

[29] Epker, B.N.(1981) Superior surgical repositioning of the maxilla: long term results.*J Max-Fac Surg*Vol.9, pp: 237-246

[30] Lo, F. & Shapiro P., (1998) Effect of presurgical incisor extrusionon stability of anterior open bite malocclusion treated with orthognathic surgery. *Int JAdult Orthod Orthognath Surg*Vol.13, pp:23–34

[31] Espeland, L., Dowling P.A. & Mobarak .KA., et al., (2008) Three-year stability of open-bite correction by 1-piece maxillary osteotomy. *Am J Orthod Dentofacial Orthop* Vol.134, No:1,pp:60-66

[32] Fischer, K., Von Konow L. & Brattstrom V. (2000)Open bite: stability after bimaxillary surgery—2-year treatment outcomes in58 patients. *Eur J Orthod*Vol. 22, pp:711–718

[33] Hoppenreijs, T.J., van der Linden F.P. & Freihofer H.P., et al., (1996) Occlusal and functional conditions after surgical correction of anterior open bite deformities. *Int J Adult Orthodon Orthognath Surg*Vol.11, No:1,pp:29-39

[34] Hoppenreijs, T.J., Freihofer H.P. & Stoelinga P.J., et al., (1997) Skeletal and dento-alveolar stability of LeFort I intrusion osteotomies and bimaxillary osteotomies in anterior open bite deformities. A retrospective three-centre study. *Int J Oral Maxillofac Surg* Vol.26, pp:161-175

[35] Reyneke, J.P. & Ferretti C., (2007) Anterior openbite correction by LeFort I or bilateral sagittal split osteotomy. *Oral Maxillofac Surg Clin North Am* Vol.19, pp:321–328

[36] Hoppenreijs, T.J., Freihofer H.P. & Stoelinga P.J., et al., (2001) Stability of Orthodontic Maxillofacial surgical treatment of anterior openbite deformities. Ned Tijdschr Tandheelkd Vol.108,pp:173–178

[37] Proffit, W.R., Bailey L.J.& Phillips C, Turvey TA.(2000) Long-term stability of surgical open bite correction by LeFort I osteotomy. *Angle Orthod*Vol.70, pp:112-7

[38] Oliveira, JA & Bloomquist, D.S. (1997)The stability of the use of bilateral sagittal split Osteotomy in the closure of anterior openbite. *Int J Adult Orthodon Orthognath Surg*Vol.12, pp:101–108

[39] Reitzik, M., Barer P.G. & Wainwright W.M., et al., (1990); The surgical treatment of skeletal anterior open-bite deformities with rigid internal fixation in the mandible. *Am J Orthod Dentofacial Orthop* Vol.97, No:1, pp:52-57

[40] Bisase, B., Johnson P. & Stacey M., (2010) Closure of the anterior openbite using mandibular Sagittal split osteotomy. *British J Oral Maxillofac Surg* Vol.48, pp:352–355

[41] Blomqvist, J.E., Ahlborg G. & Isaksson S., et al., (1997)A comparison of skeletal stability after Mandibular advancement and use of two rigid internal fixation techniques. *J Oral Maxillofac Surg.*Vol.55, pp:568–575

[42] Forssell, K., Turwey T.A. & Philips C., et al., (1992)Superior repositioning ofthe maxilla combined with mandibular advancement: mandibular" RiF improves , stability. *Am J Orthod Dentofac Orthop* Vol.102, pp:-342-350

[43] Proffit, W.R., Turvey T.A. & Phillips C., (2007) The hierarchy of stability and predictability in orthognathic surgery with rigid fixation: an update and extension. *Head Face Med*Vol.30, No:3, pp:21

[44] Martin, D.L.,(1998) Transverse stability of multi-segmented Le Fort I expansion procedures (Master's thesis). Dallas: Baylor College of Dentistry

[45] Park, H.S., Kwon T.G. & Jang B.K., et al.,(2004) Treatment of open bite with microscrew implant anchorage. *Am J Orthod Dentofacial Orthop*Vol.126, pp:627-635

[46] Park, H.S., Lee S.K. & Kwon O.W., (2005) Group distal movement of teeth using microscrew implant anchorage. *Am J Orthod Dentofacial Orthop*Vol.75, pp:602-609

[47] Park, H.S., Kwon O.W. & Sung J.H. (2006) Nonextraction treatment of an open bite with micro screw implant anchorage. *Am J Orthod Dentofacial Orthop*Vol.130,pp: 391-402

[48] Yao, C.C., Wu C.B., Wu H.Y., et al., (2005) Maxillary molar intrusion with fixed appliances and mini-implant anchorage studied in three dimensions. *Angle Orthod*Vol.75, pp :754-760

[49] Kuroda, S., Sakai Y. & Tamamura N., et al.,(2007) Treatment of severe anterior open bite with skeletal anchorage in adults: Comparison with orthognathic surgery outcomes. *Am J Orthod Dentofacial Orthop*Vol.132, pp:599-605

[50] Xun, C., Zeng X., & Wang X.,(2007) Microscrew Anchorage in skeletal anterior openbite treatment. *Angle Orthod* Vol. 77,pp:47-56

[51] Erverdi, N., Keles A. & Nanda R., (2004) The use of skeletal anchorage in open bite treatment: a cephalometric evaluation. *Angle Orthod*Vol.74, pp:381-390

[52] Erverdi, N., Usumez S. & Solak A. (2006) New generation open-bite treatment with zygomatic anchorage. *Angle Orthod*Vol.76, pp:519-526

[53] Umemori, M., Sugawara J. & Mitani H, et al., (1999) Skeletal anchorage system for open-bite correction. *Am J Orthod Dentofacial Orthop*Vol.15, pp:166–174

[54] Daimaruya, T., Nagasaka H. & Umemori M., et al., (2001) The influences of molar intrusion on the inferior alveolar neurovascular bundle and root using the skeletal anchorage system in dogs. *Angle Orthod*Vol.71,pp:60-70

[55] De Clerck, H., Geerinckx V. & Siciliano S., (2002) The zygoma anchorage system. *J Clin Orthod*Vol.36,pp:455-459

[56] Miyawaki, S., Koyama I. & Inoue M., et al., (2003) Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. *Am J Orthod Dentofacial Orthop*Vol.124, pp:373–378

[57] Sugawara, J., Baik U.B. & Umemori M., et al., (2002) Treatment and post-treatment Dentoalveolar changes following intrusion of mandibular molars with application of a skeletal anchorage system (SAS) for open bite correction. *Int J Adult Orthod Orthognath Surg*Vol.17, pp:243-245

[58] Liou, E.J., Pai B.C. & Lin J.C., (2004) Do miniscrews remain stationary under orthodontic forces? *Am J Orthod Dentofacial Orthop*Vol.126,pp:42-47

[59] Chen, C.H., Chang C.S. & Hsieh C.H., et al.,(2006) The use of microimplants in orthodontic anchorage. *J Oral Maxillofac Surg*Vol.64,pp:1209-1213

[60] Choi, B.H., Zhu S.J. & Kim Y.H. (2005) A clinical evaluation of titanium miniplates as anchors for orthodontic treatment. *Am J Orthod Dentofacial Orthop*Vol.128, pp:382-384

[61] Chung, K.R., Kım Y.S. & Linton J.L., et al., (2002) The miniplate with tube for skeletal anchorage. *J Clin Orthod*Vol.36, pp::407-412

[62] Costa, A., Raffini M., & Melsen B., (1998) Miniscrews as orthodontic anchorage:a preliminary report. *Int J Adult Orthod Orthognath Surg Vol.*13,pp:201-209

[63] Seres, L. & Kocsis A., (2009) Open-bite closure by intruding maxillary molars with skeletalanchorage. In: Bell W, Guerrero C. eds. Distraction Osteogenesis of the Facial Skeleton. Hamilton, Ontario, Canada: BCDecker, pp:215-220

[64] Park, Y.C., Lee S.Y & Kim D.H., et al., (2003) Intrusion of posterior teeth using miniscrew implants. *Am J Orthod Dentofacial Orthop*Vol.123, pp:690-694

[65] Carano, A., Siciliani G. & Bowman S.J. (2005) Treatment of skeletal open bite witha device forrapid molar intrusion. *Angle Orthod Vol.*75, pp:736-746

[66] Suya H. Corticotomy in orthodontics. In:Hösl E, Baldauf A, editors. Mechanical and biological basis in orthodontic therapy. Heidelberg: Hüthig, 1991, p.207-226

[67] Mostafa, Y.A., Tawfik K.M., El-Mangoury N.H., (1985) Surgical-orthodontic treatment for overerupted maxillary molars. *J Clin Orthod*Vol.19, pp:350-351

[68] Burford, D. & Noar J.H., (2003) The causes, diagnosis and treatment of anterior open bite. *Dent Update Vol*. 30, pp: 235–241

[69] Proffit, W.R., White R.P. & Sarver D.M.,(2003)Long face problems. In: Proffit WR, White RP, Sarver DM, eds. Contemporary Treatment of Dentofacial Deformity. St Louis, MO:Mosby, pp:464-506

[70] Sen, C., Kocaoglu M. & Eralp L., et al., (2004) Bifocal compression-distraction in the acute treatment of grade IIIopen tibia fractures with bone and soft tissue loss: a report of24 cases.*J Orthop Trauma*Vol. 18, pp: 150–157

[71] Kawakami, T., Nishimoto M. & Matsuda Y., et al., (1996) Histological suture changes following retraction of the maxillary anterior bone segment after corticotomy. *Endod Dent Traumatol* Vol.12, pp:38–43

[72] Chung, K.R., Oh M.Y. & Ko S.J. (2001) Corticotomy-assisted orthodontics. *J Clin Orthod* Vol.35, pp: 331–339

[73] Panula, K., Keski-Nisula L., Keski-Nisula K., et al., (2002) Costs of surgical-orthodontic treatment in community hospital care: an analysis of the different phases of treatment. *Int J Adult Orthod Orthognath Surg*Vol.17,pp:297-306

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