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Class III Treatment by Combining Facemask (FM) and Maxillary Skeletal Expander (MSE)

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Abstract

Class III malocclusion can be treated dentally as well as skeletally depending on the nature of the problems and the skeletal maturity of the patients. When young patients present skeletal discrepancy, use of a facemask (FM), with or without palatal expansion, is one of the traditional approaches. This treatment modality involves utilization of maxillary dentition as an anchorage unit, often resulting in

excessive flaring of the upper incisors by forward movement of maxillary dentition, and an increase in the vertical dimension of the lower face by buccal tipping and extrusion of maxillary posterior dentition, especially in high angle cases. In recent years, incorporating micro-implants (MI) with expansion and protraction devices in various ways, in order to avoid the unwanted dental side-effects, resulted in significantly better outcomes. One popular application is the use of a micro-implant-assisted rapid palatal expander (MARPE), by incorporating the MI with an expansion device, in order to promote bone anchored expansion, and by applying FM force against MARPE, in order to promote bone anchored protraction.

Among countless designs of MARPE, the Maxillary Skeletal Expander (MSE) has unique features that produce unique treatment results. MSE causes expansion of the entire midface, disrupting all peri-maxillary structures. When MSE is applied in combination with FM, almost negligible vertical side effects are observed, the existing antero-posterior dental compensation can be reversed, the maxilla advances efficiently in large magnitude, and the skeletal protraction is possible even in older growing patients. Combining FM and MSE has also resulted in some skeletal protraction even in mature patients, simulating distraction-like movement, which gives hope of discovering a novel non-surgical orthopedic treatment modality for Class III adult patients.

Introduction

The description of Class III malocclusion is based on a particular dental relationship, but the etiology of such a relationship is often skeletal discrepancy between maxilla and mandible. Common findings of Class III malocclusion are retrognathic and narrow maxilla, prognathic and wider mandible, and often a combination of both. In most cases, dentitions are compensated with buccally and labially inclining mandibular dentition and with lingually and palatally inclining mandibular dentition. Class III malocclusion can be corrected dentally, but the preferable treatment option is a skeletal correction through growth modification when the malocclusion stems from skeletal disharmony. The FM treatment encourages the growth of maxilla in the forward direction by applying protraction force to the perimaxillary sutures[1]. The FM is often used in conjunction with a rapid palatal expander (RPE) [2]. Besides expanding the narrow maxilla, some believe that disarticulating or loosening perimaxillary sutures can aid in protraction of maxilla, and significant antero-posterior changes in skeletal complex has been reported with the use of FM and palatal expander[3]. However, both the palatal expander and FA are tooth-borne appliances, and result in undesirable side effects[4]. Often maxillary teeth are compensated for the skeletal disharmony in Class III patients, exhibiting buccally tipped posterior teeth and proclination of anterior teeth. With tooth-borne expander and FM, these buccal tipping of the posterior teeth and flaring of the anterior teeth can become worse.

Combining micro-implants to maxillary expander became popular in recent years[4,5,6]. Many investigators have developed their own unique micro-implant assisted rapid palatal expanders (MARPE), widely varying in anchor location, size of the implants, relative position of jackscrew to the skeletal anchor, activation protocols, etc. Some MARPEs are purely bone-borne and others are more hybrid in nature. Because of these differences, many conflicting results have been published. Generally, MARPE promotes skeletal expansion with less dental side-effects, and skeletal expansion is possible in more mature patients compared to the traditional maxillary expander. The maxillary skeletal expander (MSE) is a unique breed of micro-implant assisted rapid palatal expander (MARPE) [7,8,9,10]. Among many differences, MSE is positioned superior and poster aspect of the palate with four long implants engaging the palatal bone bi-cortically. The expansion force in the posterior region of the palate has decisive advantage in overcoming the resistance from zygomatic buttress bones and pterygopalatine sutures, and the posterior expansion is possible in contrast to many other MARPE and booth-borne expanders. Bi-cortical engagement is also more effective in delivering expansion force to the skeletal structures with less strain to the implants, and MSE can influence more distant structures by promoting more parallel expansion from the frontal view[11]. These differences in attributes allows MSE to forcefully expand the entire midfacial complex, disarticulating perimaxillary sutures and extending its impact to more distant structures.

When a facemask (FM) is combined with MARPE, a protraction device is combined with a bone-borne or hybrid expander. The previous studies indicated that FM combined with MARPE provided better outcomes with varying differences from the traditional approach with tooth-borne devices[12, 13]. Previously discussed dental side effects were largely eliminated. Combining MSE and FM for Class III treatment has proven to be a potent tool in managing Class III patients. Because MSE can successfully disarticulate the sutures in midfacial area, not only the maxilla but the entire midface can be advanced. The impact FM and MSE have on midfacial structure will be closely examined in this section.

Maxillary Skeletal Expander (MSE)

Maxillary Skeletal Expander (MSE) has been evolving since 2005, when micro-implants became available for orthodontic use in the USA, as there were many other micro-implant assisted rapid palatal expanders (MARPE) developed independently throughout the orthodontic world. In the mid-2000s, the MARPE idea began to spread through scientific meetings such as the Asian Implant Orthodontic Conference (AIOC) and World Implant Orthodontic Conference (WIOC). Thereafter, a few publications followed; however, the application of implants with expanders has been in use for quite some time by many clinicians prior to this first batch of MARPE publications. Many more publications followed, and a variety of MARPE designs and treatment results was introduced, with them often contracting with one another[4,5,6]. These contradictions and different findings were inevitable since expansion force vectors and magnitude varied greatly between some MARPE. The majority of them yielded “V-shaped” expansion with more expansion in the anterior and inferior aspects of the maxilla, similar to traditional expanders.

MSE was specifically designed to produce relatively parallel expansion by anchoring the posterior part of the palatal bone in bi-cortical manner[7,8,9,10]. MSE is shown in Figure 1. The main body of the device with expansion screws is designed to be positioned and fixated to the palatal bone, immediately anterior to the soft palate, using four micro-implants. Parallel holes, 1.8 mm internal diameter, are drilled into the four corners of the main body, 2 mm thick. They function as guides for proper implant insertion and also prevent tipping of the implants during the insertion and activation. After cementing MSE, four implants, 1.8 mm in diameter and 11 mm in length, are placed through the parallel holes using a manual driver. The snug fit of implants with 1.8 mm in diameter inside the 1.8 mm hole stabilizes implants against tipping during the expansion. By using 1mm implants, they provide 5-6 mm of palatal bone engagements, ensuring bi-cortical penetration. By forcing the maxilla to expand in the posterior and superior regions by posterior positioning and bicortical engagement, all perimaxillary structures undergo disarticulation and torsion. Figure 2 illustrated that MSE influences the entire midfacial structure. Besides the midfacial expansion, a forward and downward movement of the maxilla was clearly illustrated. These results were not limited to young patients, but also for mature patients in the advanced age group.

The more mature the patient, the faster expansion is required in order to build adequate inter-sutural tension for initial disarticulation. A diastema will typically appear after a successful split, and the activation rate can be slower onwards since the resistance has been reduced significantly.

Facemask and MSE

The facemask enhances the growth of the maxilla by applying protraction force to the perimaxillary sutures utilizing dentition as anchors. A maxillary rapid palatal expander

(RPE) can be used to expand the narrow maxilla and also to disarticulate perimaxillary sutures, which may further promote the forward movement of maxilla when combined with FM. Some investigators believed that maxillary expansion during protraction is important, demonstrating significant skeletal and dentoalveolar changes with the simultaneous use of FM and RPE[3, 14]. A finite element model (FEM) study illustrated upward and forward rotation of the maxilla with maxillary protraction alone, but there was no rotational movement of the maxilla when 4 mm of maxillary expansion was combined with protraction. The displacement of the maxilla in all three dimensions was greater when FM and RPE were used together. However, growth modification by use of FM, with and without maxillary expanders, has been studied and revealed to have no significant difference between them by others. The tooth-borne expander causes dentoalveolar changes with some skeletal expansion, but not enough to make a significant difference in aiding protraction movement. Several authors reported that sutural loosening by alternating rapid expansion and constriction of maxilla resulted in more anterior displacement of maxilla when combined with FM[15]. This treatment protocol mimics distraction osteogenesis, causing effective disarticulation. This decisive disarticulation of perimaxillary suture by the expander seems to be the key in promoting efficiency and effectiveness of maxillary protraction by the use of FM.

As MARPE is used to expand the maxilla, FM can be applied for bone-borne protraction. Several studies have indicated success in utilizing this treatment approach to achieve forward and downward movement of the maxilla without unwanted dental side effects[12, 13]. When MSE is used, not only can a protraction without dento-alveolar changes be achieved, but the components of the midfacial complex can also disarticulate and loosen by the disruptive nature of this appliance. This effective disarticulation of perimaxillary sutures by MSE causes a distraction-osteogenesis-like phenomenon, further enhancing the impact of FM. Combining a protraction force to this fluid structure causes tremendous forward movement of the maxilla in a short period of time.

A tooth-borne FM and RPE often leads to proclinination of already flared maxillary incisors and anterior tipping of the molars from protraction, and buccal tipping of maxillary dento-alveolar process from expansion. A clockwise rotation of the mandible as a result of anterior and buccal tipping of molars from protraction and expansion can lead to detrimental consequences, especially during the treatment of high angle patients. Vertical control during the expansion and protraction is much more manageable with MSE because it causes insignificant buccal tipping of the maxillary posterior teeth during the expansion and prevents anterior tipping of the maxillary molars during the protraction[10, 12]. The entire apparatus is attached to the palatal vault superiorly and posteriorly near the mid-palatal suture, and expansion and protraction force is directed to the midpalatal and perimaxillary sutures rather than to the dentition. Furthermore, MSE not only prevents further proclination of maxillary incisors, but often allows them to spontaneously decompensate themselves as the skeletal relationship improves.

The FEM studies demonstrated the significantly favorable force distribution with MSE is used[10]. The Figure 3 illustrates that the expansion force is isolated mainly to the palatal bone with MSE, in contrast to the RPE expansion with more force distribution to the dentition. The lateral view illustrates that significantly more force is applied to the zygomatic buttress bone when RPE was used, whereas more force was applied to the internal structures and less to the lateral aspect of the maxilla, implying that the rotational movements of the buccal segment is limited with MSE. Figure 4 illustrates that pure skeletal protraction is possible when a FM is used with MSE[12].

The novel approach using MSE and FM for Class III treatments can produce decisively superior results by closely controlling, eliminating and reversing the adverse side-effects (buccal and anterior tipping of the molars, and proclination of the incisors) associated with the traditional bone-borne approach. In addition, this new approach can be effective in treating patients with severe high angle Class III malocclusion, which is considered extremely problematic in orthodontics because controlling the vertical dimension is a difficult challenge during expansion and protraction treatment protocol. Combining MSE and FM can provide a critically needed solution to this century-old unsolved problem.

Case Study 1 (MSE for Mature patients)

Figure 5 illustrates a 17 year- and 8 month-old female patient with a narrow maxilla and retrognathic mandible.

Treatment Plan

Non-surgical maxillary expansion and surgical mandibular BSSO advancement procedures were planned. MSE was used for non-surgical expansion prior to the surgical mandibular advancement. An MSE was connected to the bands on maxillary first molars with the supporting arms. Four micro-implants, two on each side of the mid-palatal suture, were used to securely place MSE against the palatal vault. The supporting arms and molar bands were used merely as a guide to position the appliance against palate during the implant placement and as a stabilizer during the expansion. The entire expansion and protraction forces were delivered to maxillary skeletal complex through the implants, not to the molars. The expansion screw was activated approximately 0.4 mm per day until the diastema appeared and 0.2 mm per day thereafter (Figure 6).

Results:

The CBCT images clearly demonstrate skeletal expansion, and the expansion is not limited to the inferior aspect of the nasal cavity but extending up to the nasal bone (Figure 7). The space in the between the two halves of the maxilla is uniform in width, indicating a parallel expansion with MSE. Disarticulation of various sutures are visible. Figures 8 and 9 illustrate two more mature patients (20 years and 6 months; 54 years and 2 months) with MSE treatment.

CONCLUSION

MSE can effectively cause midfacial expansion and loosen premaxillary structures, even in mature patients.

Case Study 2 (MSE and FM Growth Modification)

Figure 10 illustrate an 11 year-old female patient presented with a skeletal and dental Class III malocclusion (SNA: 80.4, SNB: 83.2, ANB: -2.8°, Wits: -15.4 mm), concave facial profile, bimaxillary protrusion, proclined maxillary incisors, incompetent lips, and slight mentalis strain. The mandibular plane angles were larger than the norm.

Treatment Plan

The initial Phase I orthopedic treatment using MSE and FM was followed by a Phase II orthodontic treatment.

Phase I Orthopedic Treatment:

A MSE was customized with bands on the first molars, and FM hooks were soldered to the molars bilaterally (Figure 11). Four micro-implants were used to securely place MSE against the palatal vault. The entire expansion and protraction forces were delivered to maxillary skeletal complex through the implants. The expansion screw was activated approximately 0.6 mm per week for 6 weeks, and FM was worn 12-14 hours per day with 500 g of force on each side.

Results:

Significant facial changes were observed after 10 months of treatment with MSE and FM (Figure 12). The paranasal area became fuller as facial profile became more convex. The radiographic images confirmed significant orthopedic correction with significantly more anterior position of the maxilla after a 10-month period. Cephalometric measurements and superimposition revealed considerable skeletal correction: increase of SNA and ANB angles both by 7 degrees, and decrease of Wits value by 14 mm. The conventional FM therapy generally causes forward flaring of the incisors; however, with MSE and FM, previously proclined maxillary incisor decompensated as the skeletal relationship became harmonious. With the orthopedic Phase I treatment, a Class III bimaxillary protrusive patient transformed to a Class I bimaxillary protrusive patient. There were no changes in the mandibular plane angle, and the vertical dimension was kept stable.

Phase II Orthodontic Treatment:

After the orthopedic Phase I treatment, facial convexity was achieved, but the patient still had a pronounced lip protrusion (Figure 12). Extraction of four bicuspid and non-extraction treatment options were considered, and the non-extraction approach was chosen. After banding and bonding of mandibular dentition, micro-implants were places between second and first molars bilaterally for En-Masse retraction of mandibular dentition (Figure 13a,b). After achieving the ideal mandibular incisor position, the same procedure was performed in the maxillary arch in order to achieve a Class I dental relationship (Figure 13c,d).

Results:

A straight facial profile was created without lip protrusion after 28 months of orthodontic Phase II treatment (Figure 14). The mentalis strain was also eliminated by distally driving the maxillary and mandibular dentition. During this phase of the treatment, the skeletal correction achieved during the Phase I treatment remained stable. Both maxilla and mandible grew significantly but the SNA and ANB angles did not change.

CONCLUSION

By combining MSE and FM, it is possible to enhance the growth of the maxilla in the antero-posterior direction without dental side effects, and the existing dental compensations can be reversed, while controlling the vertical dimension. The magnitude and speed of skeletal correction were much greater compared to the conventional approach. This means the timing of growth modification treatment can be much later than the conventional approach. Figures 15 and 16 illustrate patients who received MSE and FM treatment at a later than usual age for conventional FM treatments but achieved great results.

Case Study 3 (MSE and FM for Mature patients)

Figure 17 is a 24 year- and 6 month-old patient with significant skeletal disharmony. MSE was applied for non-surgical expansion and FM for distraction like protraction of loosened maxilla. The preliminary result illustrates significant forward movement of the mid-face including maxilla and zygoma (Figure 18). When MSE is successfully applied, all perimaxillary sutures are affected because its expansion force extends to distant areas both posteriorly and superiorly due to its unique features: posterior placement and bi-cortical engagement (Figure 17). When heavy protraction force is applied to already loosened maxillary complex, the forward movement of maxilla is possible (Figure 19). This type of movement seems to be different than the growth modification, described above. It is much slower and required heavier force; a protraction force of 1 Kg per side was used in this case.

SUMMARY POINTS

- The conventional growth modification of Class III patients includes an orthopedic correction utilizing a facemask (FM) and rapid palatal expander (RPE). Some improvements in skeletal relationship were observed, but a significant amount of unwanted dental side effects (excessive anterior flaring of the maxillary incisors as well as buccal tipping and extrusion of the maxillary molars, causing the increase in lower face height especially in high angle cases) is common.
- By incorporating the micro-implants into a RPE, the expansion force can be directed to bone; and micro-implant assisted rapid palatal expander (MARPE) can aid in reducing the above side effects. However, numerous MARPE designs and activation protocols yield varying results, often in contradiction each other.
- Maxillary Skeletal Expander (MSE) is a unique MARPE, with posterior force loading and bi-cortical engagements of implants, and the expansion force is concentrated near the suture according to the FEM study. This approach reduces bone bending and dental tipping, and aids in disarticulating the perimaxillary sutures connecting the maxilla to the skull.
- MSE can effectively cause non-surgical mid-facial expansion in mature patients, disarticulating all sutures associated with maxillary complex.
- By applying FM force directly to MSE, unwanted dental movements can be eliminated. Additionally, the preexisting dental compensation (proclining maxillary incisors and retrocling mandibular incisors) reverses as the skeletal relationship improves.

- When this approach is used for growing patients, a large amount of skeletal correction can be achieved rapidly, indicating that orthopedic treatment time can be later than that of the traditional FM therapy.
- When this approach is used for patients with high mandibular plane angles, vertical dimensions can be controlled.
- When heavy protraction force is applied to MSE after a successful skeletal expansion in mature patients, a distraction-like protraction of midface is possible. This finding can provide a novel non-surgical treatment approach for mature Class III patients.

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Figure legends for Moon articles in Seminars in Orthodontics

Figure 1

Maxillary Skeletal Expander: Jack screw body with four holes (1.8 mm in diameter and 2 mm deep) and four soft supporting arms, soldered to first molar bands

Figure 2

Mid Facial Expansion with MSE: Superimposition of the CBCT images, before (white) and after (green) the MSE expansion

Figure 3

FEM Illustration of MSE: Strain before (a and c) and after (b and d) MSE expansion

Figure 4

FEM Illustration of MSE with FM

Figure 5

17 Year- and 8 month-old female patient with narrow maxilla and retrognathic mandible

Figure 6

17 Year- and 8 month-old female patient, before (a and c) and after (b and d) MSE treatment

Figure 7

CBCT Images of 17 Year- and 8 month-old female patient, before (a) and after (b) MSE treatment

Figure 8

20 Year- and 6 month-old male patient, before (a and c) and after (b and d) MSE treatment

Figures 9

54 Year- and 2 month-old male patient, before (a and c) and after (b and d) MSE treatment

Figure 10

11 year-old female patient before MSE and FM with SNA: 80.4, SNB: 83.2, ANB: -2.8°, Wits: -15.4 mm

Figure 11

Phase I Orhtopedic Treatment: MSE with soldered FM hooks

Figure 12

11 year- ad 10 month-old female patient after MSE and FM for 10 months with SNA: 87.4, SNB: 82.8, ANB: 4.6°, Wits: -1.3 mm

Figure 13

Phase II Orthodontic Treatment: the En-Masse retraction of mandibular dentition (a and b) followed by the En-Masse retraction of mandibular dentition (c and d), utilizing buccal micro-implants

Figure 14

Completion of Phase II Treatment (28 months): 14 years- and 2 month-old female patient

Figure 15

MSE and FM Therapy on 12 Year- and 3 Month-Old Patient

Figure 16

MSE and FM Therapy on 10 Year- and 3 Month-Old Patient

Figure 17

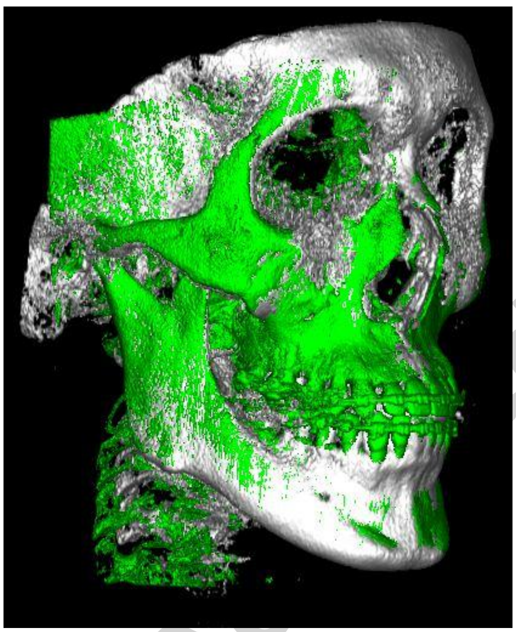
24 year- and 6 month-old patient with significant skeletal disharmony treated with MSE and FM (white: before treatment; blue: after treatment)

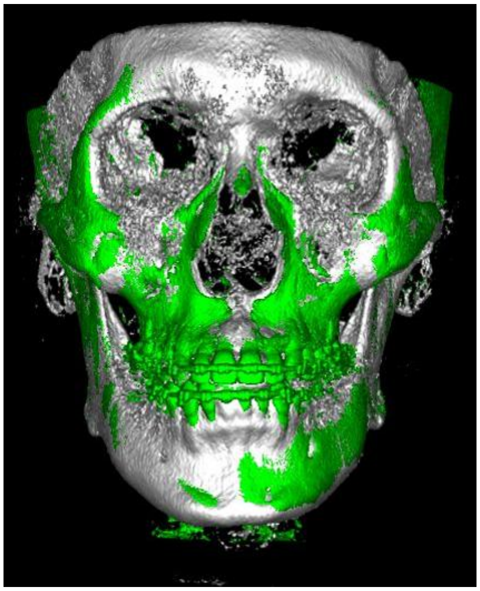
Figure 18

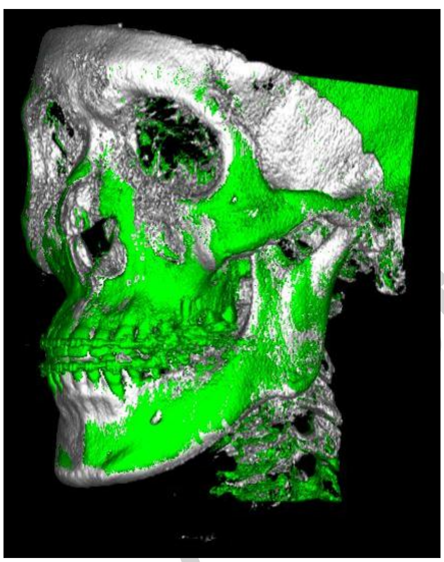
3D Superimposition: before (white) and after (blue) MSE and FM treatment.

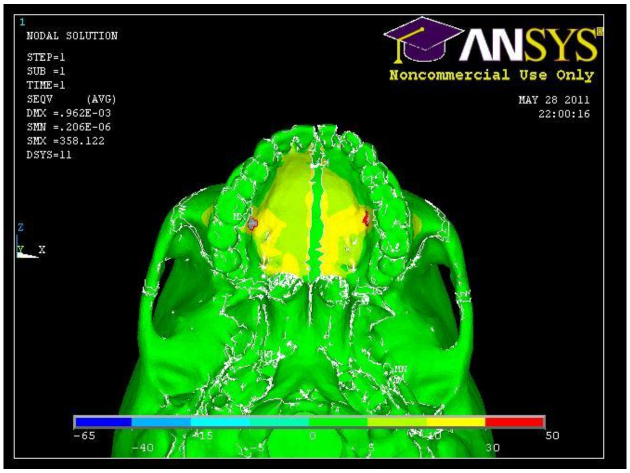
Figure 19

2D Superimposition: before (white) and after (blue) MSE and FM treatment.





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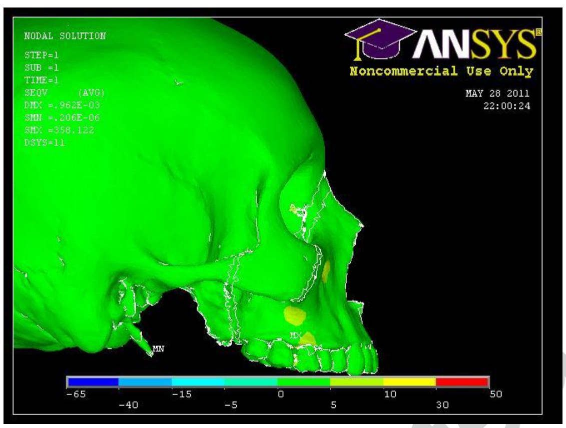
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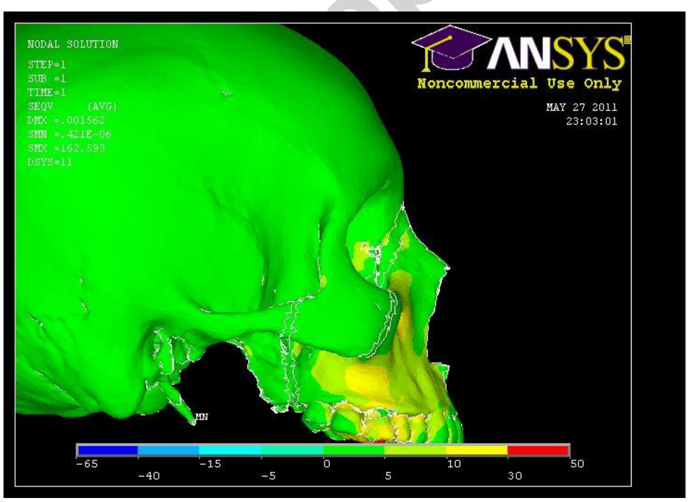
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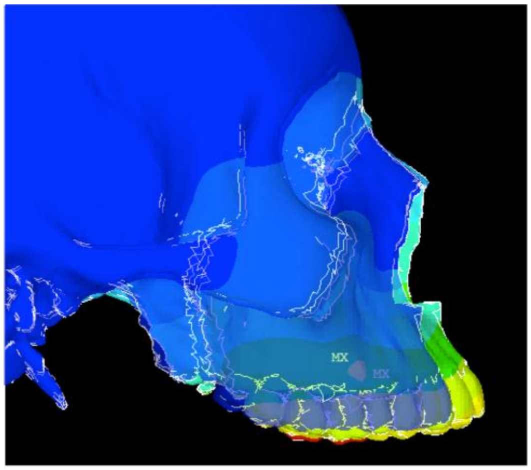
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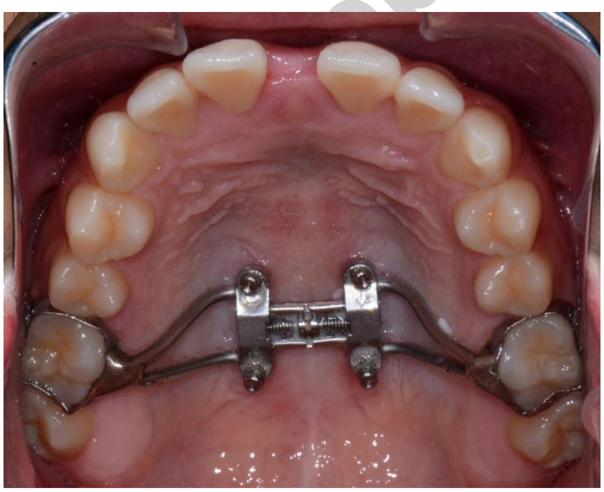

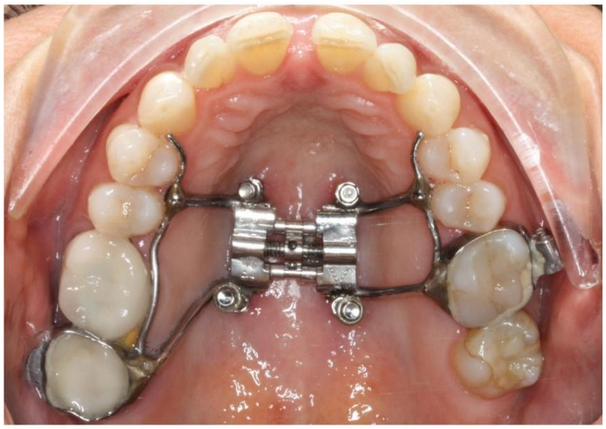

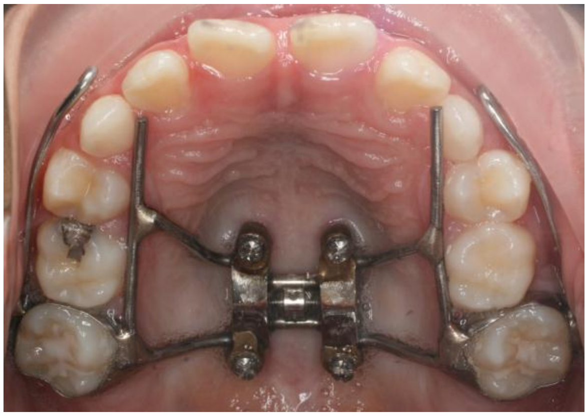

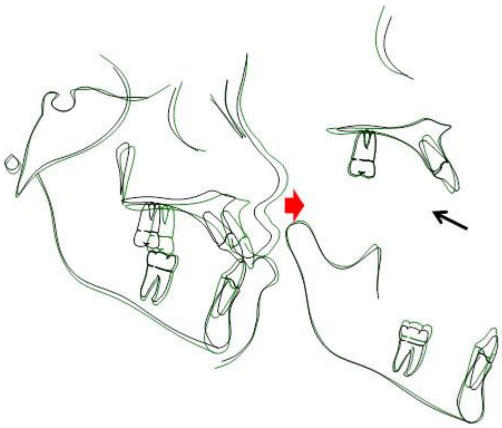

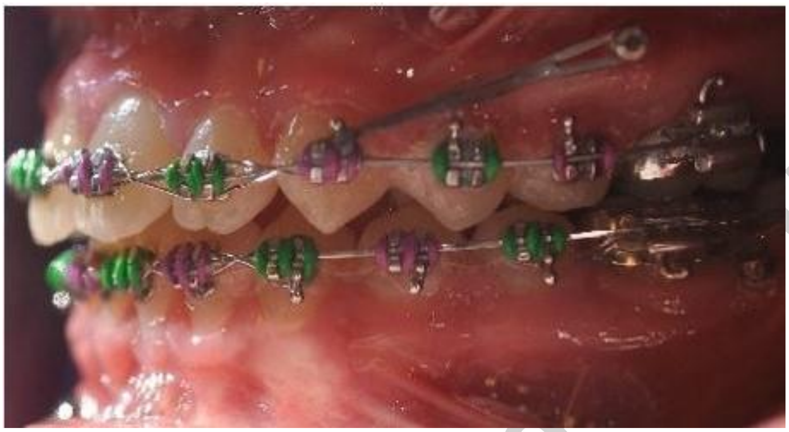

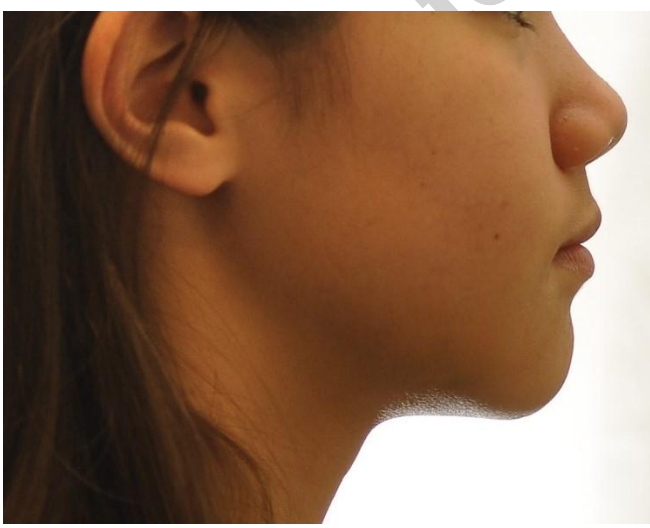

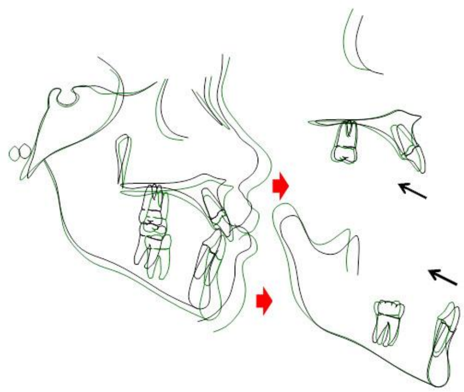

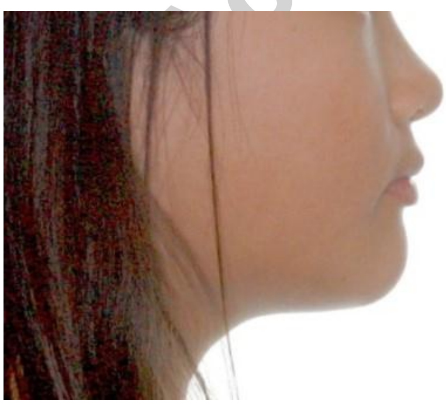


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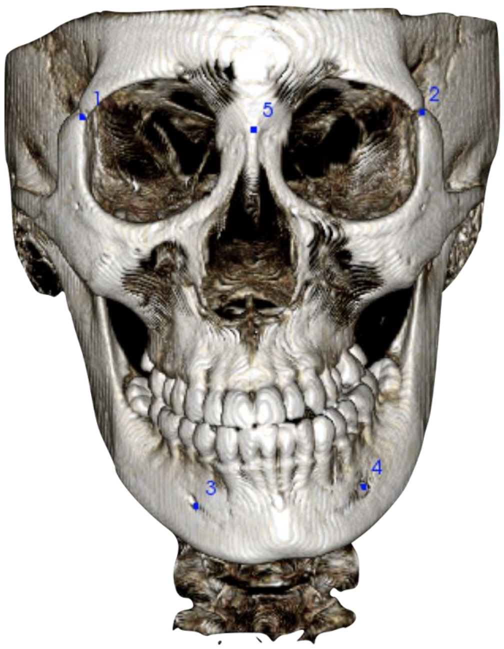
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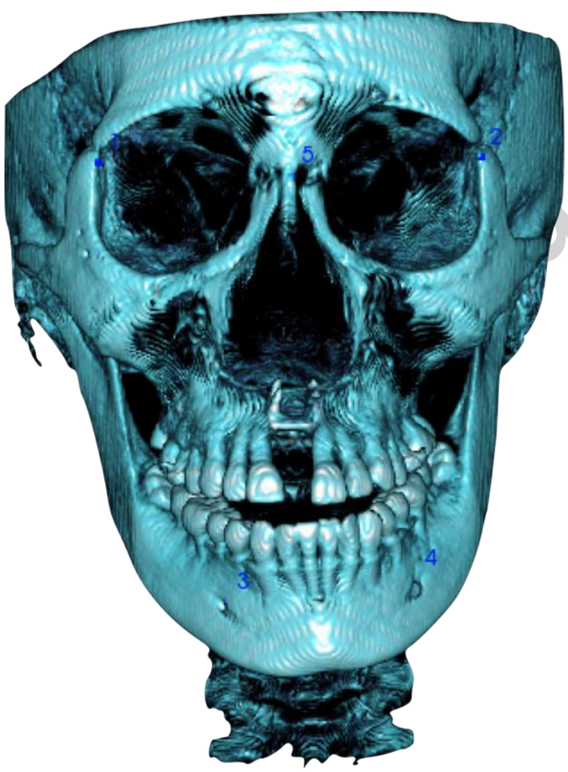
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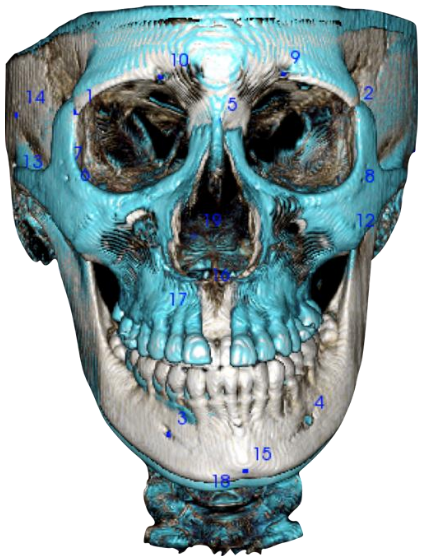
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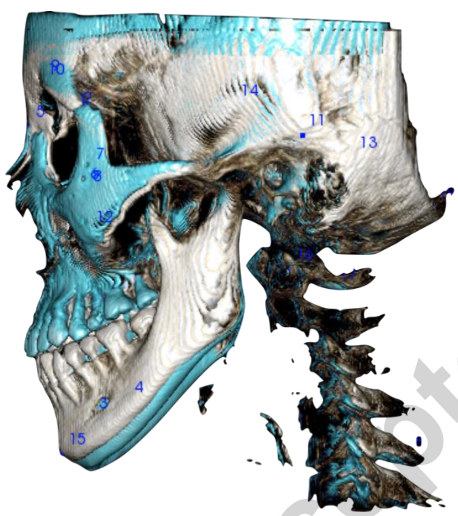
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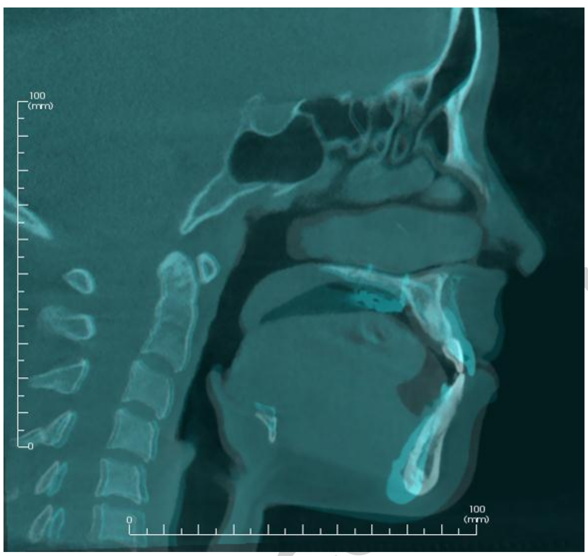
100
(mm)
0
120
(mm)



100
(mm)
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0
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