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## The Faces of War

Few physical injuries are as devastating as trauma to the face. In the blink of an eye, the person is permanently disfigured. Unprotected by the helmet, the soldier's face is vulnerable to such injuries. Battlefield facial wounds are often characterised by severe loss of facial structures including jaws and teeth. This extent of facial destruction is less common with civilian trauma, creating a challenge for oral and dental surgeons.

Most wounded faces are ghastly to look at and are complex puzzles which oral and dental surgeons have to solve quickly with lives hanging in the balance. The wars in Iraq and Afghanistan have led to surgical advances in the treatment of facial wounds. Military oral and dental surgeons deployed to these combat zones have made key strides in treating disfiguring facial injuries suffered by soldiers and civilians. A review article on craniomaxillofacial battle injuries is published in this issue of *SDJ*.

We thank all who have submitted manuscripts to the *SDJ* as well as our editors and reviewers for their hard work. *SDJ* continues to receive more submissions that it could publish. We are committed to producing a high standard journal for our SDA members.

**Dr. Tan Peng Hui**  
Editor-in-Chief

# Craniofacial Battle Injuries: Injury Patterns, Conventional Treatment Limitations and Direction of Future Research

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## Abstract

This study analyses the US Army Joint Theatre Trauma Registry database for craniofacial (CMF) battle injuries (BI) experienced by US Service Members in Iraq/Afghanistan conflict to describe type, distribution and mechanism of injury.

**Methods and materials:** Joint Theatre Trauma Registry was queried from 19 October 2001 to 12 December 2007 for CMF BI entered in the database using ICD-9 codes; the data was compiled for BI soldiers.

**Results:** We have identified 7770 BI. About 26% had CMF BI. There were 4783 CMF BI among the 2014 BI (2.4 injuries per soldier). Majority of CMF BI were male (98%). Average age was 26 years. CMF BI by branch of service was Army 72%, Marines 24%, Navy 2% and Air Force 1%. Penetrating soft tissue injuries and fractures were 58% and 27%, respectively; 76% of fractures were open and 24% of soft tissue injuries were noted as complicated. Frequency of facial fractures was mandible 36%, maxilla/zygoma 19%, nose 14%, and orbit 11%. Remaining 20% not otherwise specified. Primary mechanism of injury was explosive devices (84%).

**Conclusions:** Twenty-six per cent of all BI were to CMF area. CMF BI account for a disproportionate number of injuries observed in Iraq and Afghanistan compared with the previous American Wars. Mechanism of CMF BI involves explosive devices 84%. [*Singapore Dent J* 2010;31(1):1–8]

**Key Word:** craniofacial battle injury

Craniofacial (CMF) injuries on the current battlefields of Iraq and Afghanistan are predominantly penetrating in nature and characterized by a combination of complex lacerations and open fractures, and injuries complicated by tissue avulsions and burns. Recent epidemiological studies demonstrate an increased frequency of

CMF battle injuries (BI) in the current Iraq and Afghanistan conflicts compared with the previous American Wars of the past century with the head and neck region suffering BI in World War II (21.0%), Korean War (21.4%), Vietnam War (16.0%) and Iraq and Afghanistan War (30.0%).<sup>1</sup> Recent advances in body armour and cranial vault protection have led to the increase in the percentage of head and neck casualties that survive initial torso injuries to present for treatment of uniquely devastating CMF injuries.<sup>2</sup>

In a recent study the Joint Theatre Trauma Registry (JTTR) database for CMF BI experienced by US Service Members in the current Iraq and

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Afghanistan conflict to describe the type, distribution and mechanism of injury has been analysed. The JTTR is a military health care database of all US Service Members injured and treated at any medical facility throughout the evacuation system and spanning all military services at all levels of care. The database was started at the beginning of military operations in Afghanistan, on 19 October 2001; diagnostic patient information is continuously entered in the database by trained data retrieval specialists from paper and electronic medical charts. The JTTR was queried from 19 October 2001 to 12 December 2007 for CMF BI, excluding burns, intracranial, intraocular and ear injuries, entered in the JTTR using ICD-9 codes specific to CMF injury. The data was then compiled for each battle injured Service Member. Excluded from the study were injured Service Members who were returned to duty within 72 hours (Tables 1–3 and Figure 1).

During the 6-year period studied, there were 7770 battle injured US Service Members. About 26% (2014/7770) had CMF BI. There were 4783 CMF BI among the 2014 battle injured US Service Members (2.4 injuries per Service Member with a range of 1–8). The majority of the CMF US Service Members were male (98%) versus female (2%). The average age was 26 years, with a range of 18–57 years. CMF BI by branch of service was Army 72%, Marines 24%, Navy 2% and Air Force 1%.

Penetrating soft tissue injuries and fractures were the majority of CMF BI: 58% and 27%, respectively; 24% of the soft tissue injuries were noted as complicated and 76% of the fractures were open. Among the facial fractures, the mandible was most frequently involved 36%, followed by the maxilla and zygoma 19%, nasal 14% and orbit 11%. The remaining 20% were listed as not otherwise specified facial fractures. The primary mechanism of injury to the CMF region was

explosive devices (84%), which was much higher than previous wars.<sup>3</sup>

Gunshot wounds (GSW) accounted for 8% of CMF BI; this statistics undoubtedly reflects the enemy’s weapon of choice of explosive devices and the lethality of a GSW to the head and neck.

**Table 2.** Types of CMF BI

CMF wound	Number	%
Simple open or penetrating soft tissue	2128	44
Complicated versus open or penetrating soft tissue	660	14
Total soft tissue	2788	58
Fractures	1280	27
Abrasions	231	5
Dental	204	4
Contusions	111	2
Dislocations	6	<1
Skull	15	<1
Unknown	148	3

Source: *J Oral Maxillofac Surg* 2010;68:3–7.

**Table 3.** Mechanism of injury distribution of combat-related CMF injuries

Mechanism of injury	Number of injuries	%
Explosive	4061	84
GSW	400	8
Motor vehicle accident	77	2
Other/not documented	81	2
Fragment/shrapnel	43	1
Helicopter/plane crash	40	1
Miscellaneous*	55	1

**Table 1.** Distribution of wounds by body region (in %)

	Body surface area	World War II	Korea War	Vietnam War	OIF/OEF
Head and neck	12	21.0	21.4	16.0	30.0
Thorax	16	13.9	9.9	13.4	5.9
Abdomen	11	8.0	8.4	9.4	9.4
Extremities	61	58.0	60.2	61.1	54.5

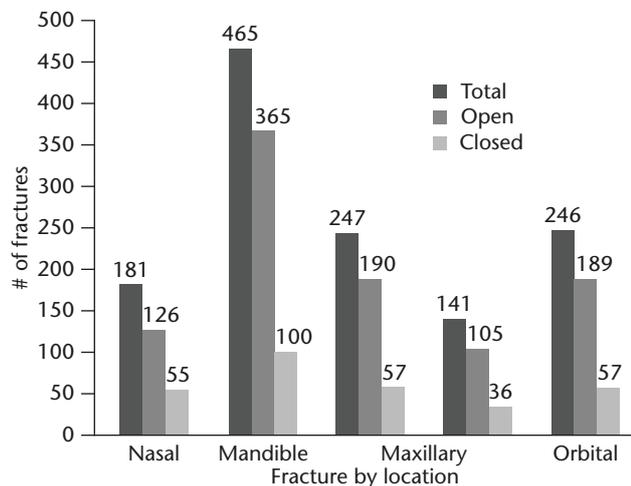
In the Battle of Mogadishu, 36% of GSW to the head and neck were fatal, which is consistent with Vietnam casualty statistics. In a study of that battle, it was noted Kevlar helmets did not protect the cranium from projectiles entering through the face. It was further postulated that the unprotected face was specifically targeted by the enemy in an urban battlefield.

Burns account for 5% of all evacuated casualties with 77% of combat burns to the face; explosive devices were the principle cause of face burns at 86%.<sup>4</sup>

Given the above statistics, a pattern of severe CMF BI emerge as characterized by loss or partial loss of central facial features, notably portions of the jaws, lips, cheeks and nose. If the penetrating trauma is from a nearby explosion, second- and

third-degree burns complicate the injury by damaging skin adjacent to the area of tissue loss, making local flaps and tissue transfers difficult or impossible. Thermal injuries also destroy cartilaginous portions of the ears and noses, and lead to lid ectropion, microstomia and extra-articular ankylosis. This combination of open soft tissue wounds, burns, avulsions and compound fractures, conditions seldom seen with civilian trauma, creates a challenge for military maxillo-facial surgeons (Figures 2–5).

A significantly injured US Service Member is resuscitated and stabilized in the combat theatre and then transferred to the Regional Army Medical Center in Germany. Serial and conservative debridement followed by facial fracture stabilization occurs throughout the evacuation process.<sup>5,6</sup> Within a week of injury in most cases, and within 24–48 hours for burn cases, the Service Member is transferred to Walter Reed or



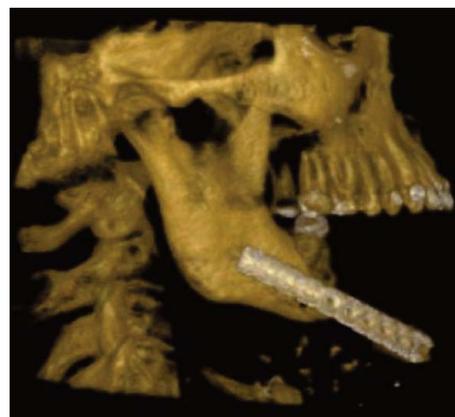
**Figure 1.** Distribution of Combat-Related Craniomaxillofacial Fractures in Operation Iraqi Freedom and Operation Enduring Freedom from October 2001 through December 2007. Source: *J Oral Maxillofac Surg* 2010;68:3–7.



**Figure 3.** Lefort 2 fracture and bilateral comminuted mandibular body fracture.



**Figure 2.** 40% upper lip and 85% lower lip avulsion.



**Figure 4.** Mandibular avulsion.



**Figure 5.** Severe facial burns with penetrating orbito-frontal wound.



**Figure 6.** External pin fixation to temporarily stabilize fracture.

Brooke Army Medical Center. Polytrauma requires the coordination of specialists in several fields. Oral and maxillofacial surgeons share the case load of maxillofacial trauma with otolaryngologists; in cases of severe face injuries, collaboration between oral and maxillofacial surgery, otolaryngology and plastic surgery is the rule.

Complex CMF injuries caused by explosions are addressed by stabilizing the facial skeleton in the same fashion as blunt trauma patients unless the overlying skin is burned or avulsed. In cases of severe soft tissue compromise, external fixation and intermaxillary fixation is necessary until serial debridement, flaps and grafts can close the integument. Re-establishment of gross facial dimensions, occlusion and facial projection guide treatment at this phase (Figures 6 and 7). Comminuted fractures deemed non-repairable are debrided and bone replaced with primary grafts in the upper face, midface and condylar areas,



**Figure 7.** Stereolithography generated resin model used to simulate fracture repair in situ. Bone plates bent to model are sterilized and used intraoperatively to reconstruct comminuted mandible.

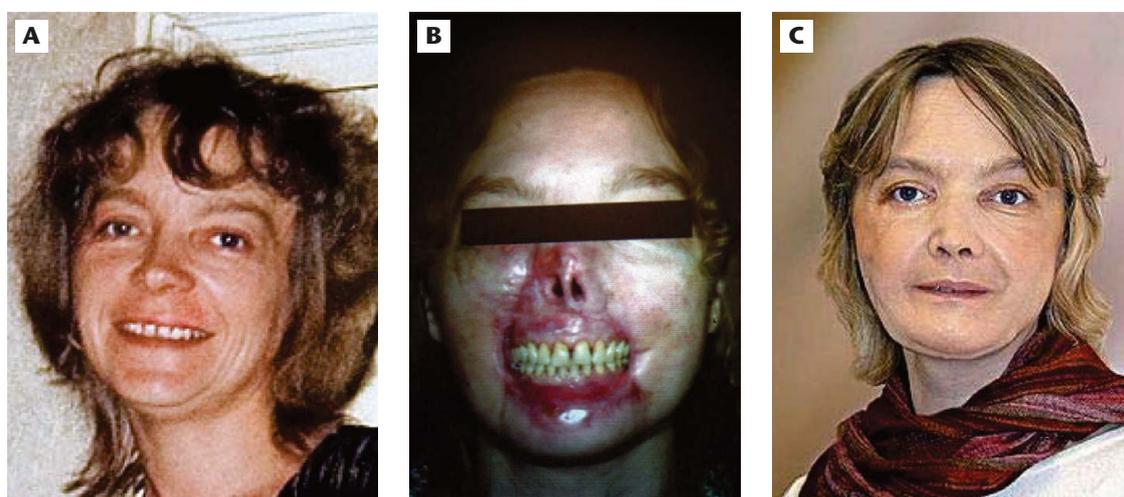
provided soft tissue coverage is possible; primary bone grafts to repair continuity defects of the mandibular body are avoided until the zone of soft tissue injury is demarcated, debrided and reconstructed with robust flaps.<sup>7</sup>

Once the existing facial skeleton is reconstructed and wounds closed, re-evaluation of avulsed and damaged facial features is performed. Treatment options to replace avulsed and damaged features are basically the same options used by reconstructive surgeons for decades: autogenous flaps with attendant donor site morbidity and acceptance of treatment limitations in cases of severe tissue loss or burns. Significant loss of lip structure creates a difficult deformity to reconstruct, especially if lip loss of greater than 67% occurs, or there is significant involvement of the opposing lip (Figure 8). To avoid severe microstomia, regional or distant tissue transfers to close the wound are performed, but these reconstructions seldom provide acceptable appearance or function.<sup>8</sup>

In November 2005, a team of surgeons in Amiens, France led by Drs Dubernard and Devauchelle performed the first face allotransplantation to reconstruct a young woman's entire lower face, to include the nasal tip, lips and chin. The face transplant successfully replaced the missing tissues with 'like' tissue from a brain-dead, beating heart donor. ABO blood type and major histocompatibility antigens were matched, as well as skin colour, gender and age. During the first 18 months after surgery, the patient



**Figure 8.** Avulsed lips defy all known techniques to reconstruct form and function. Same case after multiple surgeries, to include bilateral cervicofacial advancement rotation flaps and anteriorly based ventral tongue flap shown here. Final result after five procedures: patient still has significant lip incompetence and microstomia.

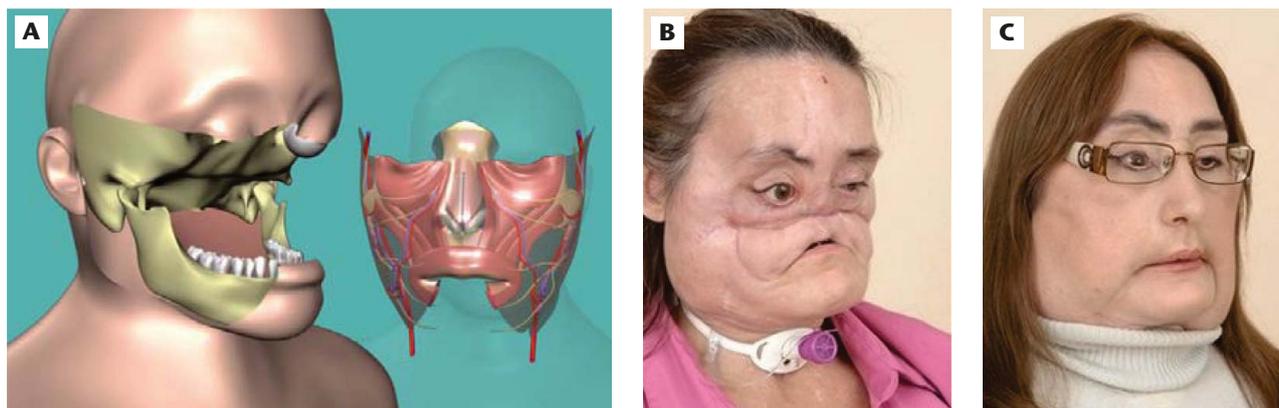


**Figure 9.** World's first face transplant in November 2005. Pre-injury condition, 6 month condition after dog bite avulsed lips and nasal tip, and 3-year postoperative condition after face allotransplantation. Source: Dr. Jean-Michel Dubernard.

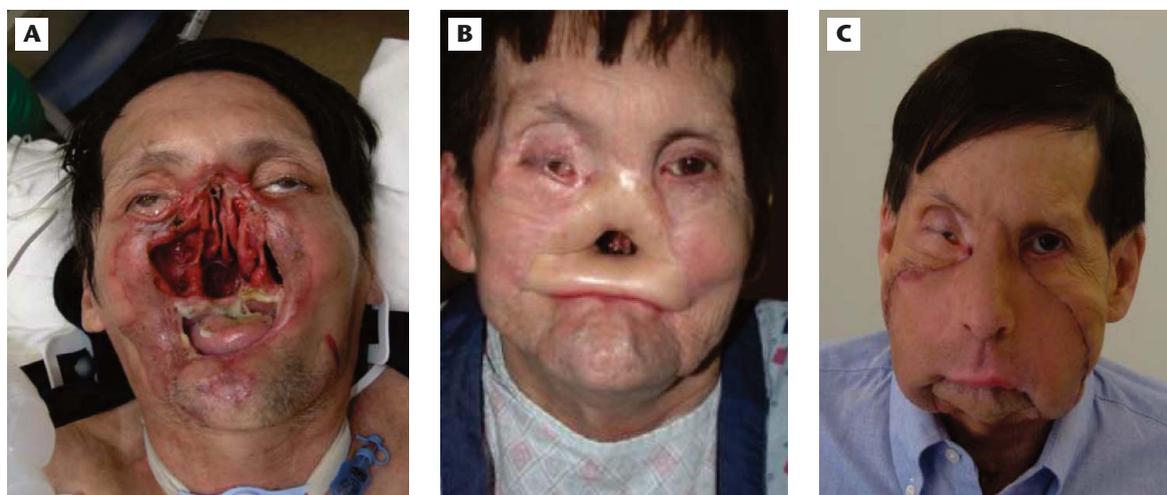
had two acute rejection episodes requiring hospitalization and high doses of corticosteroids. Post-transplant cytomegalovirus (CMV) and fungal infections also required interventions. Four years later, the patient is stable with no signs of rejection, the replaced tissue appears normal and well-integrated, and partial sensory/motor function has returned to the lips (Figure 9).

At present, seven other cases of face allotransplantation have been performed with the past five performed since December 2008: a rural Chinese farmer mauled by a bear with partial midface avulsion was reconstructed by Dr Shuzhong Guo, Xijing, China. A patient with severe facial neurofibromatosis was treated by Dr Lantieri, Paris, France. A young woman with midface avulsion

from a shotgun blast was treated at Cleveland Clinic under the direction of Dr Siemionow with replacement of the nose, lower eyelids, cheeks, upper lip and all the underlying bone supporting these facial features, to include the maxilla with nine teeth (Figure 10). Two more patients were treated by Dr Lantieri: a midface reconstruction after a shotgun blast and a severely burned patient who underwent resurfacing of the entire face with a vascularized flap that included the nose, ears, eyelids, forehead and scalp. This burn patient also underwent bilateral hand transplantation during the same operation. Midface reconstruction after severe burns to the face with reconstructive allotransplantation was performed by Dr Pomahac of Bingham and Women's



**Figure 10.** Illustration of surgical plan to replace entire midface, including palate with 9 teeth. Preoperative condition shown after 18 conventional procedures to reconstruct midface and 3 month postoperative condition after face allotransplantation by Cleveland Clinic group lead by Dr Maria Siemienow. Source: Dr Maria Siemienow by Cleveland Clinic group.



**Figure 11.** Condition after debridement of a severely burned (electrocuted) midface. After multiple conventional procedures the patient has no resemblance of a midface. Three months after allotransplantation performed by Dr Pomahac, Harvard Medical School. Source: Dr Pomahac, Harvard Medical School.

Hospital in Boston (Figure 11). Lastly, Dr Carados, Madrid, Spain performed allotransplantation in August 2009 to replace the mandible and tongue on a patient with severe radiation necrosis.

All these patients treated with allotransplantation previously had unacceptable results following conventional treatment. All patients were treated with immunosuppression to prevent rejection. The Chinese patient died after returning to his rural home and discontinuing immunosuppressant therapy. The burn patient with face and bilateral hand transplants developed multidrug-resistant infection and died within a month of the surgery. All the other patients are reportedly progressing well after surgery, although

follow-up is less than 12 months for the majority of patients.

Experience over the past 10 years in allotransplantation of hands and faces worldwide have proven that the reconstructive technique is possible with current microvascular procedures and high levels of immunosuppression. Despite an engraftment success rate of over 90%,<sup>9</sup> long-term success and effects of lifelong immunosuppression are unknown. Additionally, acute flap failure due to vein thrombosis is expected to occur at a rate of 6–10%.<sup>10</sup> This complication would be catastrophic following face allotransplantation; therefore, ‘rescue’ procedures must be considered preoperatively. Currently, research

in the field of reconstructive allotransplantation is focused on modulating the immune system utilizing fewer drugs, with a trend towards tacrolimus monotherapy. Induction of immunotolerance, considered the 'holy grail' by transplant specialists, would eliminate immunosuppressants entirely.<sup>11</sup>

Application of allotransplantation to reconstruct facial defects currently appears suitable for only the most severe cases of facial defects. As researchers develop predictable protocols to modulate the immune system, allotransplantation to repair composite facial defects or resurface facial burns will undoubtedly become more acceptable. The recent Cleveland Clinic face allotransplant case was a young woman with a near-total midface avulsion, dependent on a tracheotomy and feeding tube. This patient underwent multiple conventional surgeries, all predictably futile, before finally becoming a transplant candidate. Although not fully researched and appreciated, the burden of disease in patients with severe face defects must be significant, which is the most compelling argument in favour of face allotransplantation.<sup>12,13</sup> Dr Maria Siemionow, Head Surgeon of Cleveland Clinic's Face Transplant Team, said it well: 'You need a face, to face the world.'

The limited pool of brain-dead, beating heart donors, issues with immunosuppression and a lifetime expense of about \$1,000,000 for each patient receiving an allotransplant will spur science to develop the regenerated face. Already, a trachea 'construct' has been successfully developed and transplanted into a patient without the need for immunosuppression. As 'constructs' of composite tissue are developed, scientists will focus on the face, a highly vascularized, accessible body part of high value, as their target for reconstruction. Indeed, it is well within the realm of possibilities to develop a vascularized soft tissue composite tissue autograft in the next 10–15 years using growth factors and mesenchymal stem cells to re-vitalize and re-populate an extracellular matrix from a donated face, a face depleted of antigenic proteins. Tissue engineered bone and cartilaginous ear and nose constructs can be added to this regenerated soft tissue autograft. Regeneration of nerves and muscles would be the last challenge to achieve the fully regenerated face.

Arguably, there exist a significant number of injured Service Members who might qualify as candidates for face composite tissue allotransplantation, but the associated risks of the current levels of lifetime immunosuppression dampens enthusiasm for that technology. Regenerative medicine ultimately promises to provide 'like' subunits of functional autogenous tissue to not only reconstruct CMF battle defects, but facial defects from all causes. The surgical professions involved in face reconstruction now have the opportunity to define specific research requirements and lead the future of regenerative medicine.

### Conflict of Interest

The opinions or assertions contained herein are the private views of the authors and should not be construed as official or reflecting the views of the Department of Defense or the US Government; the authors are employees of the US Government.

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# Ectodermal Dysplasia Treated With One-Step Surgical Rehabilitation: A Case Report

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## Abstract

Ectodermal dysplasia (ED) comprises a large heterogeneous group of inherited disorders that are characterized by primary defects in the skin, hair, nails, eccrine glands and teeth. The most characteristic findings are the reduced number of teeth. All rehabilitative programmes involve proper evaluation of skeletal relationships. Prosthetic-implantological treatment at the end of bony growth can be used. In this article a case of ED treated with Le Fort I for maxillary advancement, femur homografts, implants' insertion and immediate loading is described. In December 2007, a 38-year-old female was referred to the Maxillofacial Department of Galeazzi Hospital (Milan, Italy) who had a diagnosis of ED. Twelve implants were inserted in one-step surgical procedure. No implant was lost and all are stable. The occlusion is stable after 15 months of follow-up. The results indicate that the one-step oral rehabilitation can be performed in adults who are affected by ED. Also, this significantly reduces the time of oral and facial rehabilitation. [*Singapore Dent J* 2010;31(1):9–14]

**Key Words:** bone, remodelling, resorption, ridge, alveolar, fixture

## Introduction

Ectodermal dysplasia (ED) comprises a large heterogeneous group of inherited disorders that are characterized by primary defects during the development of two or more tissues that are derived from embryonic ectoderm. The tissues primarily involved are the skin, hair, nails, eccrine glands and teeth.<sup>1</sup>

This condition is classified into two major types:

1. Hypohidrotic, in which the sweat glands are absent or significantly decreased.
2. Hidrotic, in which the sweat glands are normal.

Hypohidrotic ED is the more severe form and it affects males more than females. It is associated with sensitivity to heat and frequent high fevers.<sup>2</sup> Clinical recognition varies, based on the severity of symptoms and associated complications, from birth to childhood. However, the diagnostic tool is typical clinical physiognomy.<sup>3</sup> Men with ED have an easily recognizable face, also referred to as an 'old man' face. The forehead appears square, with frontal bossing, and there is a prominent supra-orbital ridge. The nose has a depressed nasal bridge and is called a 'saddle nose'. The midface is depressed and hypoplastic, giving it a 'dished-in' appearance. The cheekbones are high and broad, although they appear flat and depressed as well.

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The chin may be pointed and the lips are exerted and protuberant.<sup>4</sup> Some infants have a premature look with scaling of the skin. This can also form a clue to the diagnosis: the number of sweat glands is reduced and both scalp and body hairs are sparse, with lack of eyebrows and eyelashes.<sup>3,4</sup> These remarkable variabilities in facial dimensions and harmony found in patients with ED probably correspond to different kinds of dysplasia, with different expression of the associated genes.<sup>5</sup>

The most characteristic finding in man is the reduced number and abnormal shape of the teeth. The dental findings of ED range from complete anodontia to hypodontia of the primary or permanent teeth with or without cleft lip and palate. The delay in teething is often the first step in the diagnosis. However, if teeth are present, they may be tapered, malformed and/or widely spaced. Congenital absence of the teeth is more frequent in the lower jaw and affects the growth of the jawbones, leading to a lack of alveolar bone in both height and width.<sup>3,6</sup>

Early dental treatment of patients with ED is necessary, because it affords the child the opportunity to develop normal forms of speech, chewing, swallowing and normal facial support. It also improved the temporo-mandibular joint function and self-esteem.<sup>7</sup> The course of the treatment is to restore the function and the aesthetics of the teeth, normalize the vertical dimension and support the facial soft tissues.<sup>8</sup> All rehabilitative programmes involve proper evaluation of skeletal relationships, which will eventually be corrected using the appropriate orthodontic techniques. The use of a total or partial removable prosthesis or overdentures is often the initial treatment of choice.<sup>1</sup> However, prosthetic-implantological treatment at the end of bony growth must be implemented, with the possibility of restoring *ad integrum* the patient's masticatory function and aesthetics.<sup>9</sup>

In this article case of ED treated with Le Fort I for maxillary advancement, femur homografts, implants' insertion and immediate loading is described.

## Materials and Methods

A 38-year-old female was referred to the Maxillofacial Department of Galeazzi Hospital (Milan,



Figure 1. Frontal view of the occlusion.



Figure 2. Pre-surgical panoramic radiograph.

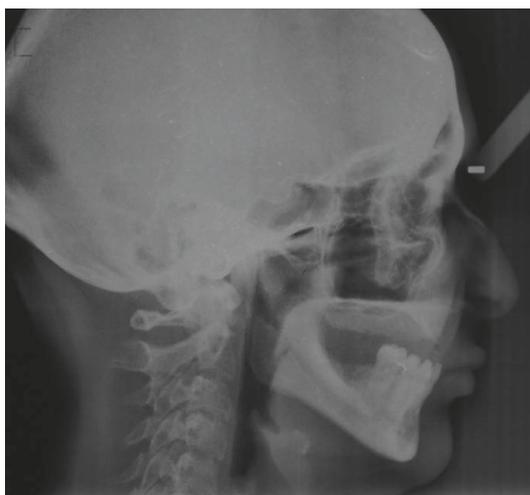
Italy) who had a diagnosis of ED in December 2007. Informed written consent approved by the local Ethics Committee was obtained from the patient for using her data for research purpose.

The patient was neither a smoker nor a drinker, and she is a nurse. She had no previous major operation in the head or neck region.

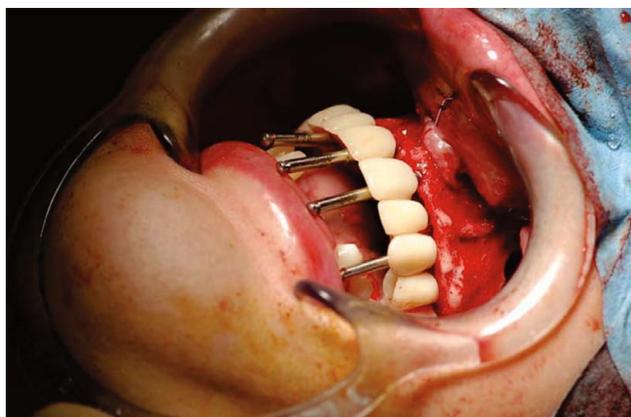
Examination of the oral cavity showed the presence of two lateral incisors, two canines, one right premolar and one molar in the mandible (Figure 1). Faces and skin annex were typical for ED, and the clinical history was suggestive for a hidrotic ED (with no high-fever episode).

Ortopantomography and lateral telerradiography (Figures 2 and 3) were performed as along with impressions and custom model splint for maxilla reposition.

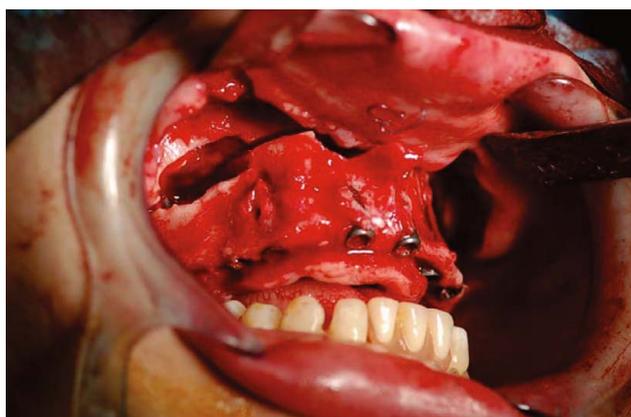
An operation was planned to insert implants in the upper and lower jaws (Figure 4): after placement of the surgical guide, a mucotomy was performed, the bone drilled and implants inserted (Neoss S.r.l., Milan, Italy). The implant platform was positioned at alveolar crest level. Then, a maxillary advancement by means a Le Fort I osteotomy (Figure 5), temporary intermaxillary fixation



**Figure 3.** Pre-surgical teleradiography.



**Figure 4.** Implant inserted by means a customized provisional prosthesis.

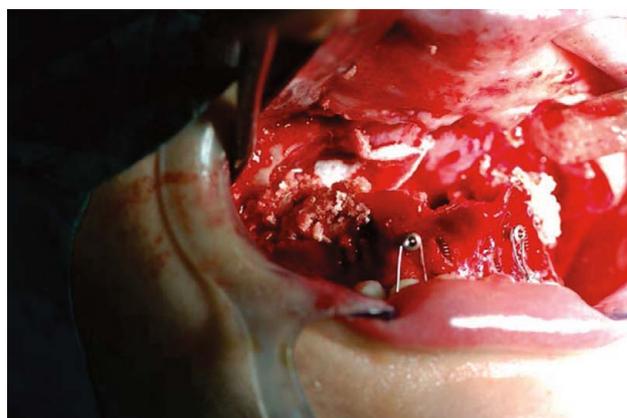


**Figure 5.** Le Fort I osteotomy.

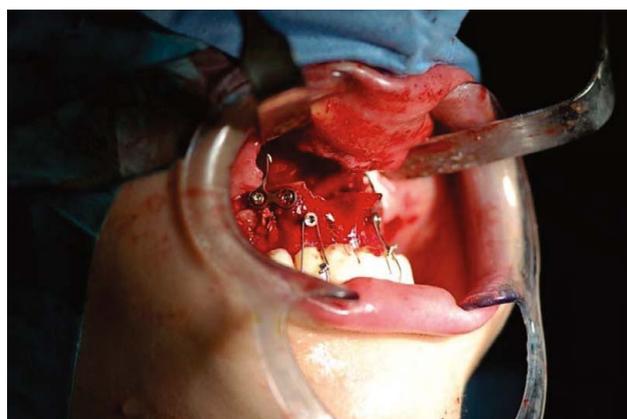
(Figure 6), femur homografts (banked from living donors, Bone Bank of Orthopedic Institute Gaetano Pini, Milan, Italy) inserted in the osteotomic gaps (Figure 7), and internal rigid fixation was performed (Figure 8). The provisional restoration immediately



**Figure 6.** The temporary intermaxillary rigid fixation.



**Figure 7.** The maxillary gaps filled with homografts.



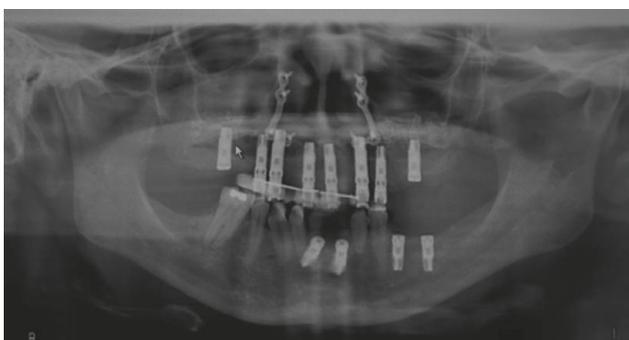
**Figure 8.** Paranasal plates used for internal rigid fixation.

delivered, and after 8 weeks the final restoration was done.

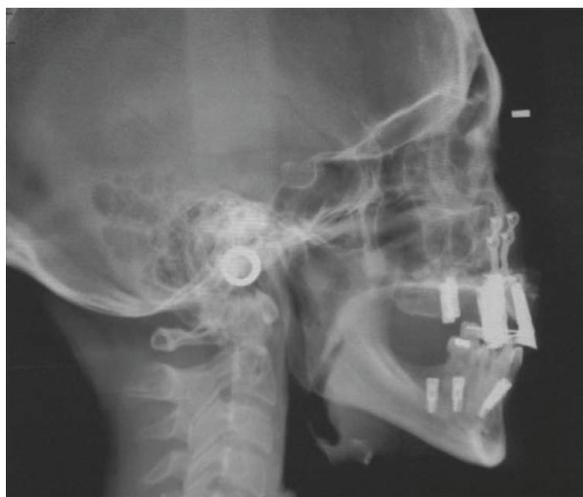
The immediate postoperative clinical (Figure 9) and radiological controls (Figures 10 and 11) demonstrated a successful outcome. The 15 months follow-up demonstrated the stability of the result (Figures 12–14).



**Figure 9.** *The occlusion at the end of the operation.*



**Figure 10.** *The immediate post-surgical panoramic radiograph.*



**Figure 11.** *The immediate post-surgical teleradiography.*

## Results

There were a total of 12 fixtures. Informed written consent approved by the local Ethics Committee was obtained from patient to use her data for research purposes. The mean follow-up after

implant insertion is 15 months: six implants were immediately loaded and six (two upper molars and four inserted in the mandible) are still not prosthodontized (because of economic problem of the patient). The mean post-loading follow-up is 7.5 months.

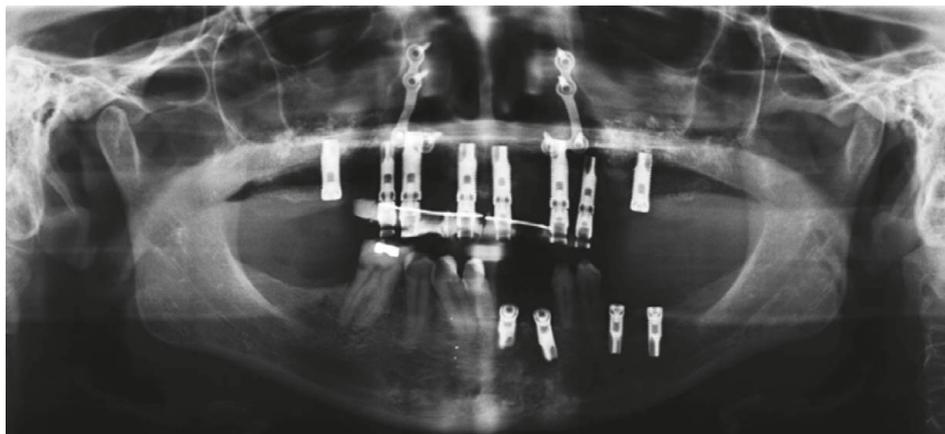
A total of 12 implants (Neoss S.r.l., Milan, Italy) were inserted: eight into the maxilla and four into the mandible. Two measures of fixture length and diameter 11.5 and 13 mm and 3.5 and 4.0 mm, respectively, were used. Implants were inserted to replace four incisors, two cuspids, three premolars and three molars. The gap of maxillary osteotomy was filled with femur graft, whereas no graft was placed in the mandible. Six of the eight fixtures inserted in the upper jaw were immediately loaded.

No implant was lost, and all are stable.

## Discussion

Dental implants have become an accepted treatment modality for ageing patients with either completely or partially edentulous arches.<sup>10</sup> However, in partially edentulous children who have ED, multiple implant placement is not possible because of the ongoing development of the jaws and insufficient bone. In addition, the bone height and width will not be sufficient for implant insertion without advanced surgical approaches.<sup>11</sup> In patients not treated with ED, craniofacial deviations from the norm increased with increasing age<sup>12</sup> with a tendency towards a Class III pattern with anterior growth rotation.<sup>3</sup> Cephalometric analysis and anthropometry studies are able to show reduced facial dimensions, decreased lower facial height and variable pattern in facial widths. The maxilla is relatively more retruded than the mandible, and the nasal alar width and mouth width are significantly smaller.<sup>13</sup> In the mandible, sufficient bone may be available only at the mid-symphysial area, where one implant could provide stability for the mandibular denture.<sup>14</sup> However, the maxilla of totally edentulous patients frequently requires bone grafting procedures or Le Fort I and grafting<sup>15</sup> before implant insertion because this may affect their retention and stability.

Orthognathic surgical procedures are the treatment of choice in ED patients who exhibit maxillary and/or mandibular skeletal deficiency.<sup>16</sup> It has



**Figure 12.** The 15 months follow-up panoramic radiograph.



**Figure 13.** The 15 months follow-up teleradiography.



**Figure 14.** The 15 months follow-up frontal view of the occlusion.

been postulated that the Le Fort I osteotomy that restores normal maxillomandibular relationship might restimulate maxillary growth.<sup>17,18</sup> First, the jaws must be positioned correctly in relation to

each other and the cranium by means of orthognathic surgery; only then implant placement with autogenous or heterologous bone grafts can be attempted.<sup>19</sup>

Although these surgical procedures can be performed in most ED patients, removable dentures are usually the only viable treatment alternative when the expenses and morbidity of the surgical procedures are taken into account.<sup>20</sup>

In the present study we describe a case of ED treated with simultaneous implant placement, Le Fort I advancement, grafting of maxillary gaps and provisional immediate rehabilitation of the upper jaw. Although implants were inserted also in the mandible, these lasts are still not prosthetized due to the economic condition of the patient. The mandible is bearing removable dentures.

## Conclusion

The one-step oral rehabilitation is stable in terms of occlusion and implant outcome after 15 months follow-up. This procedure can be performed in adults. It significantly reduces the time of oral and facial rehabilitation without compromise with the medium-term clinical outcome.

## Acknowledgements

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cliniche della medicina rigenerativa, Unità Operativa n. 14.

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# Effect of Ageing Towards Location and Visibility of Mental Foramen on Panoramic Radiographs

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## Abstract

Mental foramen is an opening of the mental canal onto the lateral surface of the mandible. In this pilot radiographical study, in Malay population the effects of ageing towards the location and visibility of the mental foramen were determined. Most of the mental foramina were found to be located inferior to the apex of the second premolar. Non-visibility of the foramen was greatly increased in patients aged 50 years and above (Pearson Chi-square;  $p=0.00$ ). This finding may provide a guide to dental surgeries in Malay patients of different age groups. [*Singapore Dent J* 2010;31(1):15–19]

**Key Words:** mental foramen, radiograph, ageing

## Introduction

Mental foramen is a funnel-shaped opening of the mental canal onto the lateral surface of the mandible.<sup>1</sup> The mental nerve that exits this foramen provides sensation to the ipsilateral mucosa around the premolar regions as well as the mandibular lip and chin. Any injury to this nerve may result in various degrees of paraesthesia to the mandibular lip of the same side. Proper knowledge of the accurate location of the mental foramen is of great clinical significance, especially when performing dentoalveolar surgery in this anatomical region.

Many anatomical and radiographical studies have been conducted for determining the position of the mental foramen. However, these studies have focused mainly on Caucasian populations,<sup>1–5</sup> and their findings may not be applicable to the Asian populations. The few studies undertaken on Asian populations reported that the most common location for the mental foramen is in the line of

the second premolar.<sup>6–12</sup> This is in contrast with the reports of mental foramen being located in between the first and the second premolars of the Caucasian populations. Therefore, these race-based studies are important, as they provide a guide on the possible location of mental foramen while treating patients of different races.

Fishel et al<sup>5</sup> studied the vertical position of the mental foramen in relation to the apex of the second premolar. They found that about 60% were located superior to the level of the apex of the second premolar. Their result was in contrast with that reported by Phillips et al<sup>3</sup> who found that the most common position was below the apex of the second premolar.

The location of the mental foramen has been reported to move upwards closer to the alveolar crest in elder edentulous patients due to bone resorption.<sup>13</sup> However, no studies have looked into the effects of ageing towards its location and visibility on panoramic radiographs of fully dentate patients.

The purpose of this study was to determine the radiographical location of the mental foramen in a group of Malay subjects. The effect of ageing on the location and visibility of the mental foramen on dental panoramic radiographs was also studied. The null hypothesis is that age does not affect the

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location and visibility of the mental foramen on panoramic radiographs of fully dentate patients.

## Materials and Methods

### Materials

One hundred and twenty panoramic radiographs of Malay patients of four different age groups of each gender, taken between 2003 and 2005, were obtained from the Dental Faculty, University of Malaya. The age groups were categorized as 20–29, 30–39, 40–49 and 50 years and above.

All panoramic radiographs were taken using Planmeca® (Planmeca, Helsinki, Finland) and Siemen Orthophos® (Sirona, Bensheim, Germany). The magnification factors reported by the manufacturers were 1.2 and 1.25, respectively.<sup>14,15</sup> The radiographs were chosen by two investigators according to the following criteria:

- 1 High quality with respect to geometric accuracy and contrast of the image.
- 2 Radiographs in which the mandibular teeth (between 36 and 46) were missing, had deep caries, endodontic treatment or multiple restorations were excluded because of possible associated periapical pathology.
- 3 Radiographs must be free from any radiolucent or radio-opaque lesion in the mandible. There should be no evidence of jaw fracture around the mental foramen region.
- 4 Radiographs with supernumeraries and unerupted teeth were excluded because the impacted/unerupted teeth might obscure the appearance of mental foramen.
- 5 Radiographs should be devoid of any radiographical exposure or processing artefacts.
- 6 Radiographs were excluded if the mandibular canines were missing, because of the possibility of mesial premolar drift.
- 7 Radiographs were excluded in which the maxillary premolars were missing, because of the possibility of over-eruption of the mandibular premolars.

### Methods

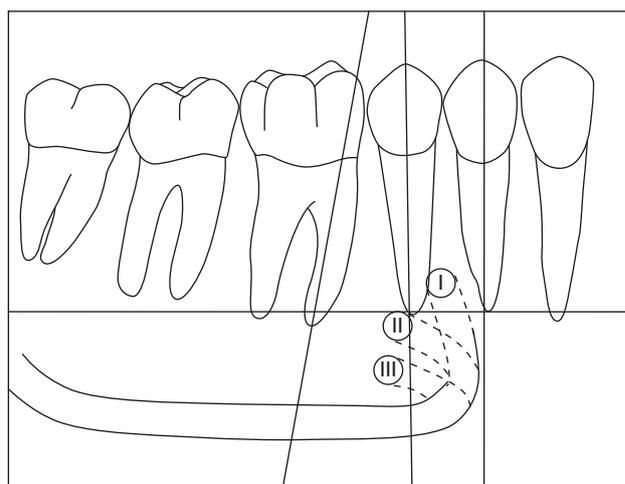
#### Locating mental foramen

The radiographs were placed on a well-illuminated radiographical view box (0400 Series Countertop/Wall-Mount Universal Viewers #67-0442, Dentsply,

USA). A line following the inferior contour of the mandible and a second line passing through the apices of the premolars and the first molar were drawn on a tracing paper. Observations were then made for determining the presence (or the absence) of the mental foramen on the radiographs. If present, the relationship of the mental foramen to the second premolar was recorded. The vertical position of the mental foramen is categorized as inferior, superior or at the level of the apex of the second premolar, according to the protocol used by Fishel et al<sup>5</sup> (Figure 1).

### Results

A total of 97 radiographs that fulfilled the selection criteria were examined. The breakdown of the number of subjects according to different age groups is shown in Table 1. Fewer radiographs



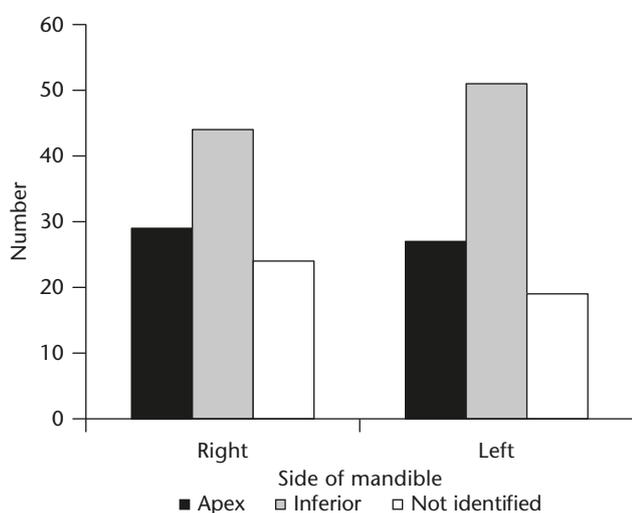
**Figure 1.** Schematic illustration showing the method employed to determine the location of mental foramen (I=superior to the level of apex; II=apical level; III=inferior to the level of apex).

**Table 1.** Breakdown of the number of subjects included according to various age groups

Age group (in years)	Number of subjects/radiographs [sites]
20–29	31 [62 sites]
30–39	24 [48 sites]
40–49	22 [44 sites]
≥50	20 [40 sites]
Total	97 [194 sites]

fulfilled the selection criteria as the age of subjects increased as a result of increasing incidence of edentulism.

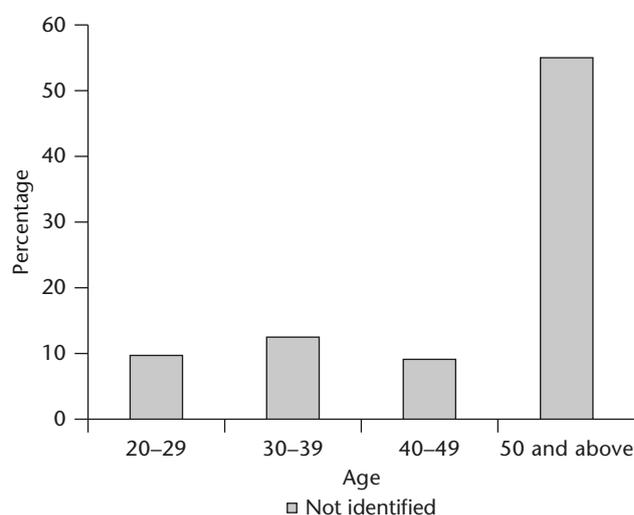
Figure 2 shows the overall distribution of the mental foramen. The mental foramen was more pronounced on the left (80.4%; 78 sites) than the right side (75.3%; 73 sites) of the mandible. The mental foramina were mainly located inferior to the apical level of the second premolar on both sides of the mandible (left=52.6% and right=45.4%) (see Figure 2). No mental foramen was found to be superior to the level of the apex. It was noted that the distribution of location and visibility of the mental foramen were not symmetrical between the left and right side of the mandible.



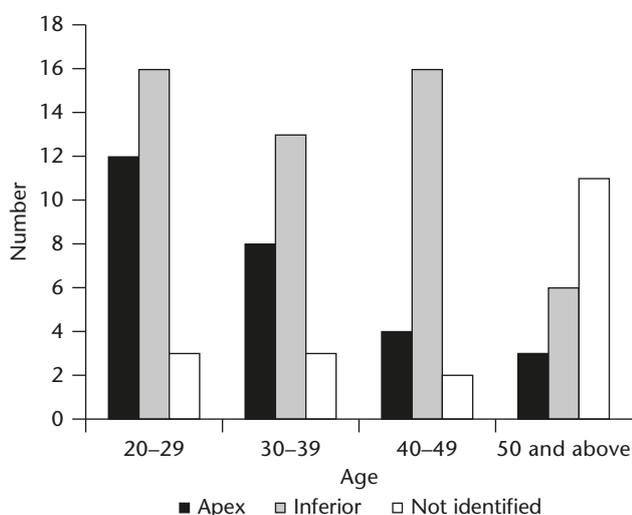
**Figure 2.** Distribution of mental foramen on the right and left mandible.

Figures 3–6 show the distribution of the location and visibility of the mental foramen according to different age groups. It is noted that the most common location was inferior to the apical level of the second premolar, regardless of the age of the subjects.

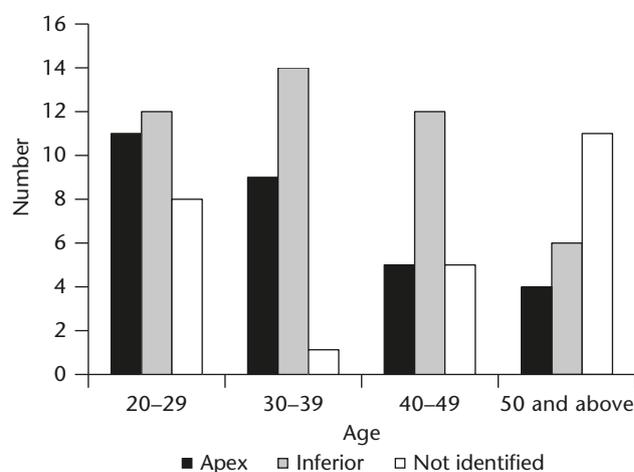
On the left mandible, the pattern of distribution and non-visibility of mental foramen was as follows: 52.6% inferior to the second premolar, 27.8% at the apex of the second premolar and 19.6% not visible (Figure 3). The non-visibility of the mental foramen varied between 9.7% (in the age group of 20–29 years) to 55% (in those aged 50 years and above) (Figure 4). The general pattern was an increase in the percentage of non-visibility



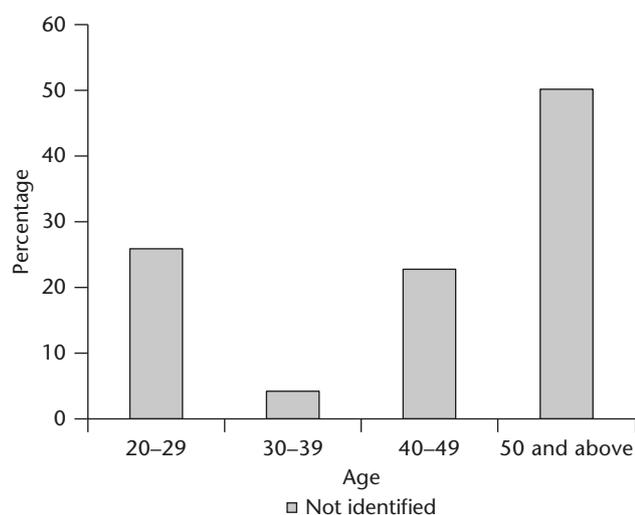
**Figure 4.** Percentage of non-identified mental foramen on the left mandible.



**Figure 3.** Distribution of mental foramen on left mandible according to various age groups.



**Figure 5.** Distribution of mental foramen on right mandible according to various age groups.



**Figure 6.** Percentage of non-identified mental foramen on the right mandible.

of the mental foramen when age increased, apart from the 3.40% drop seen between the age group of 30–39 and 40–49 years.

The distribution of the location of the mental foramen on the right mandible did not differ from that of the left mandible (Figure 5), with most (45.4%) mental foramina located inferior to the apical level of the second premolar. This was followed by 29.9% at the apex of the second premolar and 24.7% not visible.

The right mandible, however, did not register the pattern of increased non-visibility of the mental foramen with an increase in age as seen on the left side of the jaw (Figure 6). Instead, the right mandible registered a higher percentage of non-visible mental foramen for the age group of 20–29 (25.8%) and 40–49 (22.7%) years, as opposed to the left side (9.7% and 9.1%, respectively) for the respective age group.

The non-visibility of the mental foramen on panoramic radiograph was 19.6% on the left mandible and 24.7% on the right side. One obvious finding was that the visibility of the mental foramen was reduced to at least half (left = 55% and right = 50%), when the patients became 50 years and above. This difference was statistically significant (Pearson Chi-square;  $p=0.00$ ).

## Discussion

Accurate presurgical localization of the mental foramen is one of the critical factors that ensures

successful dentoalveolar surgeries and prevents neurosensory disturbances from happening. Panoramic radiography is widely used by many clinicians for this purpose, as it provides a reasonably good image of the mental foramina.<sup>16</sup> Its disadvantages included: image distortion, variable magnification of images ranging between 20% and 30%,<sup>17</sup> and invisibility in the facio-lingual dimension.<sup>18</sup> The location of the mental foramen also varies due to certain factors such as the presence of pathologies in the jaw, the technique of radiograph taking, age and the integrity of the dental arch.<sup>13</sup>

The current study shows that the most common position of the mental foramen was below the apex of the second premolar. This is similar to that reported by Phillips et al,<sup>3</sup> but is in contrast with that reported by Fishel et al.<sup>5</sup> The difference found between this study and that reported by Fishel et al<sup>5</sup> may be related to the differences in positioning of the jaw when taking radiographs.<sup>19</sup>

Depending on the sites, a non-visibility of the mental foramen that involved 19.6% panoramic radiographs on the left mandible and 24.7% on the right side was observed. This is higher than the 14% of severe limitation; i.e. to non-visualization in the region of clinical interests based on a grading of visibility, reported.<sup>16</sup> It has been reported that the lack of identification of the mental foramen was attributed to the inability to distinguish it from the trabeculae pattern and poor radiograph quality.<sup>19</sup>

Bone undergoes various quantitative and qualitative changes with age. Bone remodelling appears to be slower with ageing, and there is a marked increase in cortical porosity and the percentage of Haversian canals showing resorption after 50 years of age.<sup>20</sup> As a result, the marrow space enlarges and disordered trabeculae are often seen, hence affecting the identification of the mental foramen.<sup>21</sup> This may explain why the percentage of non-visibility of the mental foramen was more prominent and statistically significant in subjects aged 50 years and above.

Due to the high number of subjects (radiographs) excluded, the authors were unable to perform more statistical analysis, apart from a Chi-square test between the visibility of the mental foramen and age 50 and above.

It is important to note that although only a limited number of radiographs were examined

in this study, the implication of this finding must not be ignored. The findings of this pilot study suggest that the location of the mental foramen remains constant with changes in age. However, the mental foramen becomes more difficult to locate with the increase in age, especially in patients above 50 years of age. As a result, panoramic radiographs may not be sufficient for presurgical assessment in older patients and may need to be supplemented with a CT scan.

## Conclusion

In conclusion, most of the mental foramina were found to be located inferior to the apical level of the second premolar. However, non-visibility of the foramen is greatly increased in patients aged 50 years and above.

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# Outpatient Endoscopic Removal of Gutta-Percha From the Maxillary Sinus Using a Sublabial Antroscopy: A Rare Entity

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## Abstract

Any foreign body in the paranasal sinuses can cause chronic complications. It is therefore important to remove these foreign bodies meticulously. Various approaches are available to accomplish this. This article is a case report of a patient who had gutta-percha as a foreign body in left maxillary sinus, after a gutta-percha point had been used to trace a sinus to confirm that it was an oroantral fistula. Traditional surgical approaches to the maxillary sinus require invasive techniques, such as radical antrostomy and the Caldwell–Luc approach. These may result in further complications and morbidity. The gutta-percha point in this case report was removed endoscopically in an otolaryngology clinic with local anaesthesia using a sublabial antroscopy. There is only one case reported in the dental literature regarding the endoscopically-assisted technique for removal of displaced gutta-percha using the sublabial antroscopy approach (Yura S, Ohga N, Ooi K, Izumiyama Y. Procedure of endoscopic removal of a gutta-percha point in maxillary sinus mucosa by ultrathin arthroscope. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2004;104:e58–60). [*Singapore Dent J* 2010;31(1):20–25]

**Key Words:** gutta-percha, maxillary sinus, endoscopic removal, sublabial antroscopy, local anaesthesia

## Introduction

One of the common complications of retained foreign bodies in the paranasal sinuses is chronic maxillary sinusitis. One study found that this condition is present in 14–24% of the cases.<sup>9</sup> Other sources of chronic sinusitis include chronic rhinosinusitis resistant to medical therapy, previous history of odontogenic infections, namely endodontic and periodontal surgeries and dental abscesses.<sup>1</sup> Odontogenic infections on the other hand has been reported to be the responsible

cause in 10–12% of cases of maxillary sinusitis.<sup>1</sup> It is usually due to the disruption of Schneiderian membrane by an infected tooth, trauma and dental implants.<sup>1</sup> Another chronic sinusitis source has been related to the appearance of fungal elements within the paranasal sinuses. These sources of infection should be considered in the differential diagnosis when attending to a patient who presents with symptoms of chronic unilateral maxillary sinusitis. The organisms commonly isolated from patients of sinusitis with an odontogenic cause (SOC) differ from those without SOC. The bacteria isolated from patients of SOC are a combination of aerobes and anaerobes, although there is a predominance of anaerobes. In a review of 28 patients, Brook et al<sup>1</sup> found a significant presence of anaerobes isolated from SOC regardless of its acute or chronic onset. Although there were many studies that had proven the presence of anaerobes,

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Ramadan<sup>8</sup> in 1995 proved this differently: in this particular study, *Staphylococcus* species were the major aerobes found. Bacteria commonly isolated from sinusitis without an odontogenic cause include *Streptococcus pneumoniae*, *Haemophilus influenzae* and *Moraxella catarrhalis*, but these are absent in SOC regardless of the onset.<sup>1</sup> The predominant anaerobes in SOC are anaerobic streptococci, Gram-negative bacilli and Enterobacteriaceae. In a study of 76 patients, it was reported that anaerobes and aerobes were isolated in 7.6% and 76.3% of cases respectively.<sup>9</sup> The favourable conditions of poor oxygen tension and a lowered pH on the inflamed sinus mucosa are the pathophysiological factors behind the enhanced growth of these anaerobes.<sup>1</sup> Long-standing retained foreign bodies in the paranasal sinuses have resulted in complications, such as chronic sinusitis, cutaneous fistula, rhinolith formation, lead poisoning (when the foreign body is of the element lead), meningitis and chronic pain.<sup>5</sup> Various surgical techniques can be performed to remove the odontogenic aetiology of inflammation and infection such as direct curettage of the antrum through an existing fistula or an enlarged buccal window.<sup>3</sup> On the other hand, involvement of other sites of paranasal sinuses namely ethmoid and sphenoidal sinus may require different approaches. A report in the literature shows that foreign bodies lodged in different parts of the paranasal sinuses such as those due to airgun projectiles were removed successfully using the Caldwell–Luc and external ethmoidectomy approaches.<sup>5</sup> A foreign body lodged in the frontal sinus region however posts a greater challenge. The choice of the surgical method, whether an endoscopic or an external approach with trephination was to be performed, is dependent on the location where the foreign body is impacting.<sup>5</sup> The purpose of this article is to highlight the advantages of the minimally invasive endoscopic sublabial antroscopy approach, performed under local anaesthesia, compared to the traditional and more invasive technique using the Caldwell–Luc approach, which is performed under general anaesthesia.

## Case Report

A 54-year-old male presented to the otorhinolaryngology clinic complaining of fullness of his

left maxillary region of about 2-week duration. He gave a history of a long persistent periapical abscess with chronic unilateral maxillary sinusitis. He was otherwise healthy with no known medical history. He also gave a history of an extraction of his second upper molar tooth about 2 months before. The diagnosis of an oroantral fistula was confirmed by the attending dentist with the use of a gutta-percha point\* to trace the sinus during radiography. Unfortunately, the gutta-percha accidentally got pushed into the left maxillary sinus during the procedure. An orthopantomogram and a plain Waters' (occipito-mental) view radiograph of his left maxillary sinus were suggested (Figure 1). A displaced gutta-percha point was identified and lodged in the antero-lateral part of the left maxillary sinus antrum. The patient was referred to an otorhinolaryngologist for an endoscopic assessment. Endoscopic transantral removal of the gutta-percha was scheduled under local anaesthesia in the clinic setting. Three vials of 2% Mepivacaine with adrenaline (44 mg and 22 µg, Scandonest, Septodont) were given, and a sublabial antroscopy was performed by a 1.5-cm sublabial incision in the canine fossa. A 5-mm diameter trochar (Karl Storz) was positioned superior and lateral to the root of the left maxillary canine and then gently rotated for penetrating into the maxillary sinus cavity. Rigid endoscopes (Karl Storz) 4 mm in diameter with optical viewing angles of 0°, 30° and 70° were utilized to visualize the maxillary sinus antrum. The displaced gutta-percha point was seen in the left maxillary sinus near the oroantral fistula (Figure 2), at the antero-lateral part of the antrum. It was then grasped with a straight Weil–Blakesley forceps (Figure 3) and withdrawn through the sublabial antroscopy (Figure 4). The dimensions of the gutta-percha were 1 mm width by 3.8 mm in length as seen in the radiograph. Subsequently, an advanced buccal flap was created to close the buccal antroscopy opening. With the aid of the angled endoscope (30° and 70°), a thorough inspection of the entire maxillary antrum was performed to look for the possibility of remnants of the gutta-percha. There were no residual foreign body or gross oedema noted. Vicryl 3/0 (Ethicon, Johnson and Johnson, Belgium) interrupted sutures were then applied to secure the buccal flap. The patient was prescribed Amoxycilin

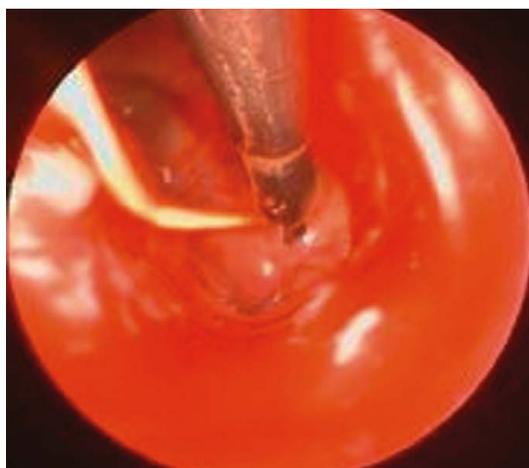
\*The gutta-percha used was within its expiry period.



**Figure 1.** A displaced gutta percha in the left maxillary sinus on an orthopantomogram.



**Figure 2.** A 30 degrees endoscopic view showing the displaced gutta percha encroaching the oro-antral fistula.



**Figure 3.** A 70 degrees endoscopic view showing the displaced gutta percha being gently grasped with a straight Blakesley forceps.



**Figure 4.** A zero degree endoscopic view of the removed gutta percha from the left maxillary sinus.



**Figure 5.** Water's view showing a displaced gutta percha in the left maxillary sinus.

and Clavulanate Potassium (Augmentin, Glaxo Smith Kline) tablets 625 mg twice daily, Celecoxib (Celebrex, Pfizer) tablets 200 mg daily and Chlorhexidine mouthwash 0.2% (Steriline, Malaysia) thrice daily for ten days. Postoperative recovery was unremarkable. At the 2-week follow-up, no evidence of oedema or exudation was detected endoscopically, nor were there any signs or symptoms suggestive of foreign body remaining in the sinus cavity. The buccal advancement flap closure healed well. Patient was well with no complaints upon review 9 months after surgery.

## **Discussion**

Recent literature review has revealed that chronic rhinosinusitis affects 31 million Americans annually and has a significant impact on the quality of life. Based on the current American Academy of Otorhinolaryngology, Head and Neck Surgery Guidelines, this condition is defined as a group of disorders characterized by the inflammation of the mucosa of the nose and paranasal sinuses of at least 12 consecutive weeks.<sup>7</sup> The clinical features of chronic rhinosinusitis comprise of cardinal symptoms: mucopurulent discharge, nasal obstruction, facial pain, hyposmia with clinical findings of purulent mucopus, polypoidal changes and mucosal abnormalities of middle meatus. Studies have also shown strong association of asthma in 25–50% of patients with chronic sinusitis.<sup>7</sup>

The causes of odontogenic pain can be due to an exposed dental pulp, a preexisting dental infection extending into the bone around the apex of a tooth root or periodontal disease. In the cases of odontogenic infections and foreign bodies leading to sinusitis, patients may present with dental pain, headache and anterior maxillary tenderness, the symptoms typical of sinusitis. To differentiate the sinusitis with or without odontogenic causes, a good history, thorough clinical examination which includes both anterior rhinoscopy and nasal endoscopy supplemented with radiographical imaging are required. Preexisting oroantral communication, history of past sinusitis disease, allergic rhinitis and also history of foreign body being displaced into the sinus cavity should alert the clinician of the possibility of sinusitis with an odontogenic cause. Swelling and erythema of buccal soft tissue and vestibule should also prompt

the attending clinician of an odontogenic source of infection. The various contributing factors to rhinosinusitis are listed in Table 1. Foreign bodies dislodged in the paranasal sinus acts as irritants, which leads to subsequent inflammation of the mucosa of the sinus and chronic sinusitis.

Panoramic radiographs can be used to look for the presence of pneumatization, pseudocyst, identification of displaced roots and foreign-body localization. Computerized tomography is the gold standard for clinical imaging, especially in pinpointing the exact location of foreign bodies; with careful examination of bone and soft tissues, it can be obtained in thin slices and multiple views including axial and coronal cuts.

The treatment for chronic rhinosinusitis can be divided into medical and surgical. Medical treatment includes prescribing antibiotics, topical and systemic decongestants and control of allergies. Refractory cases that failed medical therapy are subjected to endoscopic sinus surgery. For foreign-body-related sinusitis and odontogenic sinusitis, the mainstay of treatment is eradication of the sources of infection, such as removal of a persistent oroantral fistula, controlling periodontal disease, treating periapical disease and removal of the displaced foreign bodies like the gutta-percha highlighted in this case report together with prescribing a 3–4-week course of antimicrobial therapy. For fungal sinusitis, the treatment is more tedious. Frequent surgical debridement supplemented with long-term systemic and topical antifungal treatment is recommended.

All foreign bodies in the paranasal sinuses should be meticulously removed as they can cause interruption in the mucociliary clearance resulting in chronic sinus infection.<sup>4</sup> Conservative management of SOC may inadvertently lead to sequelae such as chronic sinusitis, fistula or rhinolith formation and fungal infection, which can remotely become cancerous.<sup>3,5</sup> Upon review of the literature, we could identify only one case report of endoscopic removal of gutta-percha from the maxillary sinus through the buccal window.<sup>2</sup> Different materials can be used to trace the sinus tract such as gutta-percha, silver point and lacrimal probe. Probing with a gutta-percha point is a common method in identifying oroantral fistulas as reported here. The accidental displacement of a gutta-percha point into the maxillary sinus is one of the complications encountered during the clinical

**Table 1.** Factors contributing to chronic rhinosinusitis\*

Extrinsic causes
<ol style="list-style-type: none"> <li>1. Infectious (viral, bacterial, fungal and parasitic)</li> <li>2. Non-infectious/inflammation                             <ol style="list-style-type: none"> <li>a. Allergic – IgE mediated</li> <li>b. Non-IgE-mediated hypersensitivities</li> <li>c. Pharmacological</li> <li>d. Irritants</li> </ol> </li> <li>3. Disruption of normal ventilation or mucociliary drainage                             <ol style="list-style-type: none"> <li>a. Surgery</li> <li>b. Infection</li> <li>c. Trauma</li> </ol> </li> </ol>
Intrinsic causes
<ol style="list-style-type: none"> <li>1. Genetic                             <ol style="list-style-type: none"> <li>a. Mucociliary abnormality (e.g. cystic fibrosis and primary ciliary dyskinesia)</li> <li>b. Structural</li> <li>c. Immunodeficiency</li> </ol> </li> <li>2. Acquired                             <ol style="list-style-type: none"> <li>a. Aspirin hypersensitivity associated with asthma and nasal polyps</li> <li>b. Autonomic dysregulation</li> <li>c. Hormonal (e.g. rhinitis in pregnancy and hypothyroidism)</li> <li>d. Structural (e.g. neoplasms, retention cysts and antrochoanal polyp)</li> <li>e. Autoimmune or idiopathic (e.g. sarcoidosis, Wegener’s granulomatosis, pemphigoid and systemic lupus erythematosus, SLE)</li> </ol> </li> </ol>

\*ANOVA; OSF = oral submucous fibrosis;  $f = 18.39$ ;  $p = 0.001$  (HS);  $\eta^2 = 0.12$ .

practice.<sup>2</sup> In Japan, Shinya et al reported a similar technique using the ultrathin arthroscope.<sup>2</sup> This case report highlights the endoscopic transantral technique using a sublabial antroscopy, which is a safe and minimally invasive method that preserves the integrity of the sinus lining. Furthermore, it allows better visualization of the sinus cavity.<sup>5</sup> Another advantage of this technique is that it can be performed under local anaesthesia in an office setting with minimal bone removal in comparison to those classically performed under general anaesthesia, as various medical conditions might render patients unsuitable to undergo general anaesthesia not to mention the attending risks accompanying such a procedure. Use of local anaesthesia will not only reduce the postsurgical morbidity of the patient, but also allows the patient to be discharged on day the procedure is performed.

Previously, the classical approach was open surgical techniques through the canine fossa

(Caldwell–Luc approach) and was a general agreed method for the removal of foreign bodies in the maxillary sinus.<sup>3,5</sup> The disadvantages of this technique are unnecessary removal of sinus mucosa, radical bone removal, greater blood loss, longer operating time and hospitalization with more post-operative pain as compared to the endoscopic sublabial antroscopy.<sup>3</sup> For management of SOC with presence of oroantral fistula, some centres perform an external approach: Caldwell–Luc with exploration of the affected sinus with simultaneous closure of the oroantral fistula. An approach for removal of a dental implant displaced into the maxillary sinus was reported by Jeong et al.<sup>4</sup> The implant was removed using the transnasal endoscopic removal method using a middle meatal antrostomy that is part of the anterior functional endoscopic sinus surgery (FESS) procedure whereby the natural maxillary ostium is widened for better mucociliary clearance. FESS is a safe, effective and physiological method in terms

of restoring the ostium patency and natural sinus clearance, and the technique can be used to retrieve foreign bodies, if it were to be lodged more medially and in close proximity to the maxillary ostium. The sublabial antroscopy was planned based on the position of the gutta-percha being in the non-dependent antero-lateral part of the maxillary antrum. Although reports have stated that there are certain limitations in the viewing angle of endoscopes,<sup>4</sup> we did not encounter this problem, as endoscopes of various viewing angles were available (30°, wide 45° and 70° angles). The limitation of this technique arises when there is gross oedema within the sinus cavity where the swelling hampers the view in some cases. However, the presence of oedema does not render endoscopes entirely useless, as adequate antibiotics and steroids can be administered preoperatively to reduce the swelling prior to the endoscopic procedure.

## Conclusion

Sinusitis of odontogenic cause differs in pathophysiology, microbiology and management from sinusitis of other causes. An effort should be made to identify the source of persistent chronic sinusitis especially those refractory to optimal medical therapy. A foreign body in the maxillary sinus should be suspected and looked for, and any dental disease if found should be treated accordingly. Failure to identify a foreign body in the sinus may lead to further complications. Although historically, the most common approach is none other than the traditional Caldwell–Luc procedure, the development of sinonasal endoscopy has provided us with a much less invasive technique

for the direct visualization of the internal structure of the maxillary sinus using a pinhole sublabial antroscopy.

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# Adenomatoid Odontogenic Tumour Mimicking a Periapical Cyst in Pregnant Woman

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## Abstract

Adenomatoid odontogenic tumours (AOT) are uncommon odontogenic lesions characterized histologically by duct-like structures derived from the epithelial component of the lesion and can be distinctly classified into follicular, extrafollicular and extraosseous variants (Neville BW, Damm DD, Allen CM, et al. *Adenomatoid Odontogenic Tumor. A Text Book for Oral and Maxillofacial Pathology*, 2<sup>nd</sup> edition, 621–3). Most of these tumours develop in the second or third decade of life and have a distinct predilection for women. The follicular variant accounts for 75% of reported cases (Curran AE, Miller EJ, Murrah VA. Adenomatoid odontogenic tumor presenting as periapical disease. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1997;84:557–60) and is associated with the crown of an impacted tooth, commonly the maxillary canine. We present a rare case of extrafollicular AOT mimicking a periapical cyst that originated in a woman in her first trimester of pregnancy and enlarged rapidly thereafter. The lesion was enucleated and sent for histopathology and immunohistochemistry, which revealed AOT with a cystic component with no dependence on oestrogen or progesterone for its growth. This case of AOT introduces us to the unique variation in its presentation and the difficulty in differentiation from periapical disease of inflammatory origin. [*Singapore Dent J* 2010;31(1):26–29]

**Key Words:** adenomatoid odontogenic tumour (AOT), periapical cyst, extrafollicular, gingiva, cortex, basaloid cells

A 25-year-old female patient in her second trimester of pregnancy, presented with a swelling of 3 months duration on the right side of the face. The asymptomatic swelling first originated when she was in her first trimester and gradually increased in size with occasional salty discharge intraorally in relation to the upper right lateral incisor. The patient did not give any history of prior trauma in the concerned region.

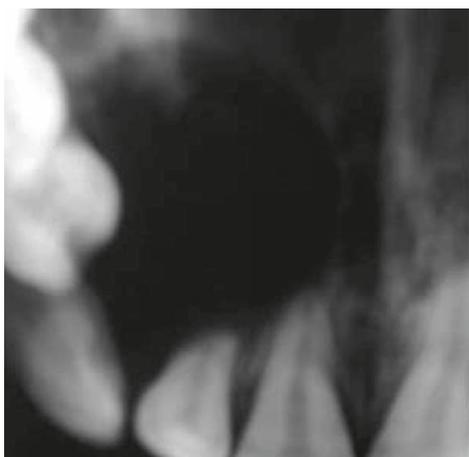
Examination revealed a firm swelling in the labial gingiva and alveolar mucosa extending from the right central incisor up to the right first

premolar with normal overlying mucosa. On percussion upper right lateral incisor and canine were grade I mobile. Occlusal radiograph showed a well-defined oval radiolucency of about 3 cm in size, apical to and between 11, 12, 13 and 14 with loss of lamina dura around the apices of 12 and 13. Dental caries was not apparent in any tooth but 12 and 13 showed negative tooth vitality (Figure 1). The roots of lateral incisor and canine were displaced with root resorption visible in the lateral incisor (Figure 2). A clinical diagnosis of a radicular cyst was established. Access opening of 12 and 13 was executed, and a calcium hydroxide dressing was given. Due to persistent wet canal of lateral incisor it was decided to obturate the lateral incisor following enucleation of the lesion in the same appointment.

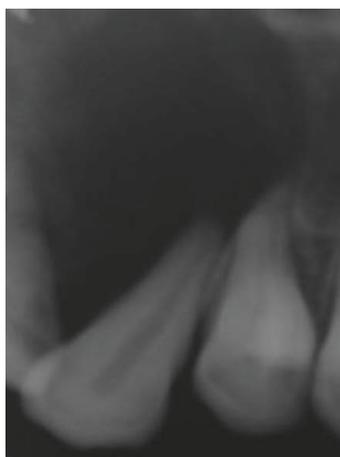
As the patient was in a stable term of pregnancy the lesion was surgically enucleated under

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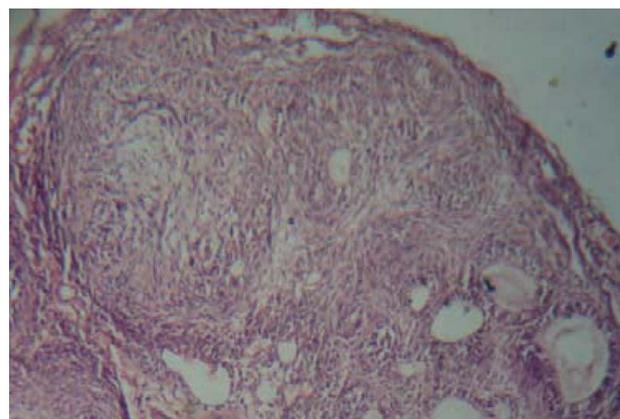


**Figure 1.** Occlusal view showing a well-defined radiolucent lesion in relation to roots of 11, 12 and 13 with root resorption in 12.

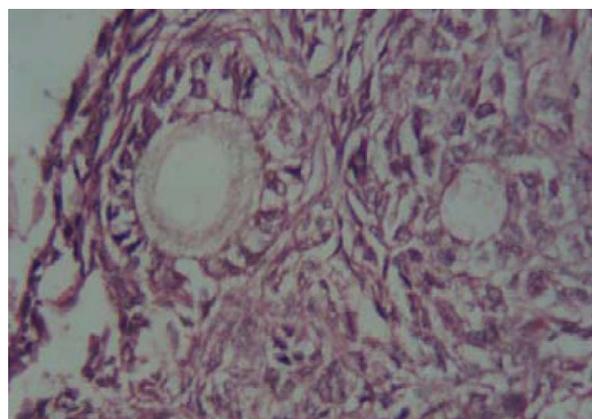


**Figure 2.** Periapical radiograph showing the same lesion in relation to roots of 13 and 14 with root displacement of 13.

local anesthesia after consent from the patient and her gynaecologist. On surgical exposure it was observed that the lesion had perforated the labial cortex over the lateral incisor and canine and was attached to the apex of the canine with extension into the maxillary sinus. The displacement of root of canine, as visible on the radiograph was evident along with root resorption of the lateral incisor. The canine was extracted along with the lesion as there was inadequate bone support after excision of the lesion. A drain was left *in situ* for irrigating the sinus that was removed after a week. The recovery was uneventful and healing was satisfactory.



**Figure 3.** Low magnification showing duct-like structures along with microcyst formation; 10x.



**Figure 4.** Nuclei of tumour cells lining duct-like structures; 40x.

### Histopathology and Immunohistochemistry

Microscopically some sections showed presence of a cystic lining component of reduced enamel epithelium continuous with a more basaloid appearing lining epithelium that became confluent with solid tumour mass. Areas of lining epithelium showed the presence of round calcified masses. The tumour proper was composed of spindle-shaped and basaloid cells arranged in solid nests in a whorl manner with some of these islands airing the presence of duct-like structures (Figures 3 and 4). The lumen of these ducts was lined by eosinophilic hyaline rings. Microcyst formation was noted in some areas (Figure 3). Pathological diagnosis was that of adenomatoid odontogenic tumour (AOT) displaying a cystic component. Immunoreactivity to oestrogen and progesterone receptor was not detected in the



**Figure 5.** No immunoreaction for oestrogen receptor in the tumour cells.



**Figure 6.** Postoperative radiograph taken 1 year later.

ameloblastoma-like cells and in the odontogenic squamous epithelium (Figure 5).

## Discussion

This case illustrates an extrafollicular variant of AOT mimicking a periapical lesion in a pregnant lady. Few clinico-radiological indicators including age<sup>1</sup>, sex<sup>3</sup> and site of the lesion<sup>4</sup> could have suggested the case was a possible extrafollicular type AOT, although this subvariant is not very common.

Typically AOT is a slow-enlarging swelling rarely accompanied by fluctuation,<sup>4</sup> but in our case the tumour showed a considerably rapid growth in 3 months. A distinct radio-opaque border of the unilocular radiolucency is typical of the radiographical manifestation of AOT, but the lack of an intact periodontal ligament and lamina dura in the involved teeth along with negative vitality in the lateral incisor and canine makes a more likely diagnosis of radicular cyst.<sup>5</sup> The radiolucency demonstrated root displacement in relation to canine with root resorption in the lateral incisor. Kim et al<sup>6</sup> in their study have shown root resorption in 53.9% cases of radicular cysts along with migration of involved teeth in 22.5% cases.

Although there is a known female predilection for AOT, in this case the lesion became clinically evident during pregnancy suggesting that oestrogen or progesterone might play some role in the development and growth of the lesion.

There has been only one reported case of AOT in a pregnant woman<sup>7</sup> where the lesion was examined immunohistochemically to find out biological behaviour of the tumour. As in their study, we also examined the oestrogen receptor expression along with progesterone receptor and did not find any immunoreactivity to either of the hormones, which shows that the growth of the lesion was not dependent on hormonal surge, secondary to pregnancy.

A considerable number of AOTs demonstrate an identifiable cystic component that makes its differentiation difficult from a radicular cyst. It is not clear whether the cystic component represents pooling of the mucoid stroma due to rupture of the thin lattice-work pattern or if the tumour developed within or adjacent to a pre-existing cyst; presumably, either could occur.<sup>8</sup>

In the present case, the lesion mimicked a large radicular cyst, as this was found associated with two non-vital teeth without any carious exposure or history of trauma with loss of lamina dura and pus discharge from the lateral incisor. It is possible that the negative vitality could be the result of pulp necrosis, secondary to rapid tumour expansion resulting in the pulp being devoid of blood supply. The root canal infection might be secondary to the tumour expansion. It is also possible that both lesions were independent of each other and happened to occur simultaneously.

Nevertheless, the favourable treatment of AOT is enucleation, and recurrence if any, is rare. This patient gave birth to a healthy baby girl 3 months

later and has been on regular follow-up for 1½ years (Figure 6).

## Conclusion

Our case reveals a clear association of the roots of the teeth both clinically and radiographically with the AOT in a pregnant lady, which has not been reported previously. It is important for both the surgeon and the endodontist to be aware of this variation, so as to be in a position to identify future cases of this entity and to resolve issues concerning its association with preexisting periapical disease of inflammatory origin, if any.

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# Management of Severe Class II Malocclusion With Sequential Fixed Functional and Orthodontic Appliances: A Case for MOrthRCSEd Examination

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## Abstract

Fixed functional appliance is an effective way of treating skeletal Class II malocclusion in children and adolescents. The following case report documented a 13-year-old boy with 15 mm overjet treated by a phase I 12-month growth modification therapy using Herbst appliance with Hyrax palatal expander and high pull headgear in a stepwise mandibular advancement protocol followed by a phase II pre-adjusted edgewise appliance therapy. It is one of the cases submitted for the Membership of Orthodontics Examination of the Royal College of Surgeons of Edinburgh. [*Singapore Dent J* 2010; 31(1):30–35]

**Key Words:** Class II malocclusion, functional appliance, Herbst appliance, growth modification

## Introduction

Based on the incisor relationship, Class II malocclusion is defined as the lower incisor edges lie posterior to the cingulum plateau of the upper incisors resulting in an increase in overjet.<sup>1</sup> The prevalence of having an overjet > 10 mm was reported to be around 0.2% in the population.<sup>2</sup>

Large overjet, especially in children and adolescents, is associated not only with an increased risk of traumatic injury to the upper front teeth

but also psychological distress which results in loss of self esteem and problems with social interaction. Among different malocclusions, Class II malocclusion was rated as the most unattractive by both orthodontists and lay people.<sup>3</sup> Albino<sup>4</sup> assets appearance is the most common reason given for seeking treatments.

Class II malocclusion can usually be corrected by either extracting two upper premolars followed by retraction of the upper front teeth (camouflage) or advancing the mandible by growth modification or orthognathic surgery. There are still controversies about how effective is growth modification for the correction of large overjet. The following case report documented a 13-year-old boy with 15 mm overjet treated by a phase I growth modification followed by a phase II preadjusted edgewise appliance therapy. It is one of the cases submitted for the Membership of Orthodontics

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Examination of the Royal College of Surgeons of Edinburgh.

## Case Presentation

### Clinical examination and diagnostic summary

A 12-year and 11-month-old Chinese boy attended our clinic complaining of sticking out upper front teeth. He had convex profile, average nasolabial angle, retrognathic mandible and retruded chin. He presented in the permanent dentition with a Class II division 1 incisor relationship on a Class II skeletal base indicated by both ANB angle (+9.5°) and Wits appraisal (+11 mm). Overjet and overbite were increased at 15 mm and 6 mm respectively. The molar and canine relationships were one full unit Class II on both sides. There was mild to moderate crowding in both arches. The upper dental midline was on while the lower dental midline was deviated to the right by 2 mm from the mid-facial axis. He also had an anterior Bolton tooth size discrepancy due to relatively wider teeth in the lower anterior segment. The oral hygiene needed to be improved (Figure 1).

### Aims of treatment

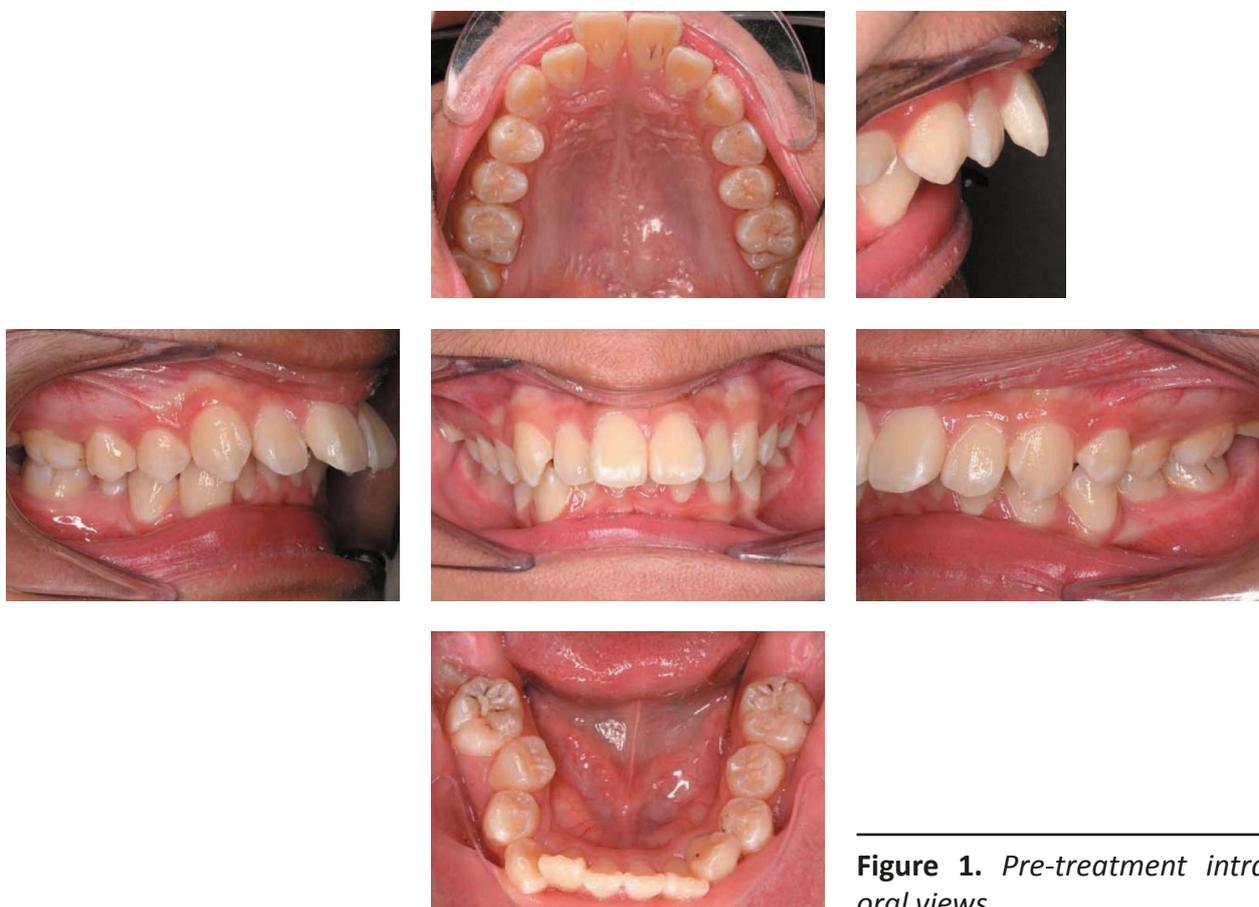
1. Improve oral hygiene
2. Enhance forward growth of the mandible to improve facial profile and jaw base relationship
3. Reduce overjet and overbite and achieve Class I incisor and buccal segment relationships
4. Relieve crowding and align teeth
5. Eliminate lip trap and improve lip competency

Orthodontic treatment comprised a phase I 12-month growth modification therapy using Herbst appliance with Hyrax palatal expander and high pull headgear in a stepwise mandibular advancement protocol and a phase II fixed pre-adjusted edgewise appliance treatment.

### Treatment progress

#### Phase I growth modification therapy

The patient was referred to a dental hygienist for oral hygiene instruction and scaling and prophylaxis. After achieving a satisfactory oral hygiene level, orthodontic treatment commenced. A cast-silver splinted Herbst appliance<sup>5</sup> was cemented



**Figure 1.** Pre-treatment intra-oral views.

with an initial mandibular advancement of 6 mm. A high pull headgear was issued 1 month later and was worn with 450g of force on each side for 12 to 14 hours per day. After 6 months, the appliance was activated by advancing the mandible for another 6 mm to achieve a reverse incisor relationship. At this stage, the Hyrax palatal expander was also activated at a rate of 0.5 mm per week for 12 weeks to achieve a palatal expansion of 6 mm (Figure 2).

**Phase II fixed appliance**

The Herbst appliance was removed after 12 months into treatment. The overjet was overcorrected to -3 mm. Crowding was relieved in the upper arch due to distalizing effect of the dentition as well as in the lower arch by proclination of the lower incisors. Both upper and lower arches were bonded

using 0.022"×0.028" slot pre-adjusted edgewise appliance with Roth's prescription and aligned with 0.014" Nickel Titanium (NiTi) wires. The archwires were subsequently changed to 0.016 NiTi and 0.017"×0.025" NiTi for further alignment and for torque control. After 6 months, 0.017"×0.025" Titanium Molybdenum Alloy (TMA) wire was then used to expand the lower buccal segments in order to create space to retrocline the lower incisors, while giving lingual root torque on lower canines at the same time to minimize risk of gingival recession. Twenty-seven months into treatment, the lower six anterior teeth were stripped to normalize the Bolton's ratio and to further retrocline the lower incisors on 0.018" stainless steel wire. 0.019"×0.025" stainless steel wires were used at the end of the treatment to coordinate the arch forms. The treatment was completed in



**Figure 2.** Headgear Herbst appliance fitted.

32 months. 0.018" twistflex fixed lingual retainers were delivered on both arches. Upper and lower Hawley's retainers were also issued as an additional protection measure against unnoticed debonding of the fixed lingual retainers.

### Treatment change

The total treatment time was 32 months. An appreciable amount of sagittal and vertical mandibular growth was observed during the treatment period. The facial profile, measured as facial convexity angle, improved 7°. Jaw base relationship improved by 2.1° and Wits appraisal value improved by 6.5 mm despite the patient still has a Class II skeletal base. The use of high pull headgear during the functional appliance stage helped restraining downward and forward maxillary growth and also prevented clockwise rotation of the maxilla which might cause backward and downward rotation of the mandible thus jeopardizing the treatment effects.

Overjet and overbite were normalized to 3 mm and 1.5 mm respectively and Class I molar, premolar and canine relationships were achieved. The improvement of the occlusal relationship was a result of mandibular skeletal and maxillary and mandibular dental changes. Class II molar correction was mainly due to an increase in mandibular length and posterior movement of the maxillary molars. Overjet correction was mainly due to an increase in mandibular length and proclination of lower incisors and posterior movement of upper incisors. According to the sagittal-occlusion analysis,<sup>6</sup> overjet improvement of 18.5 mm was due to 38% skeletal and 62% dental changes, while molar improvement was due to 47% skeletal and 53% dental changes. Patient could close his lip without difficulty at this moment despite some lip incompetence still existed. A 97.8% reduction in PAR score was achieved with the initial PAR score of 45 points reduced to 1 point post treatment. This can be categorized as greatly improved (Figures 3–6).

## Discussion

### Treatment rationale

In many respects the patient was a suitable candidate for functional appliance treatment. He presented with a moderate Class II skeletal discrepancy,

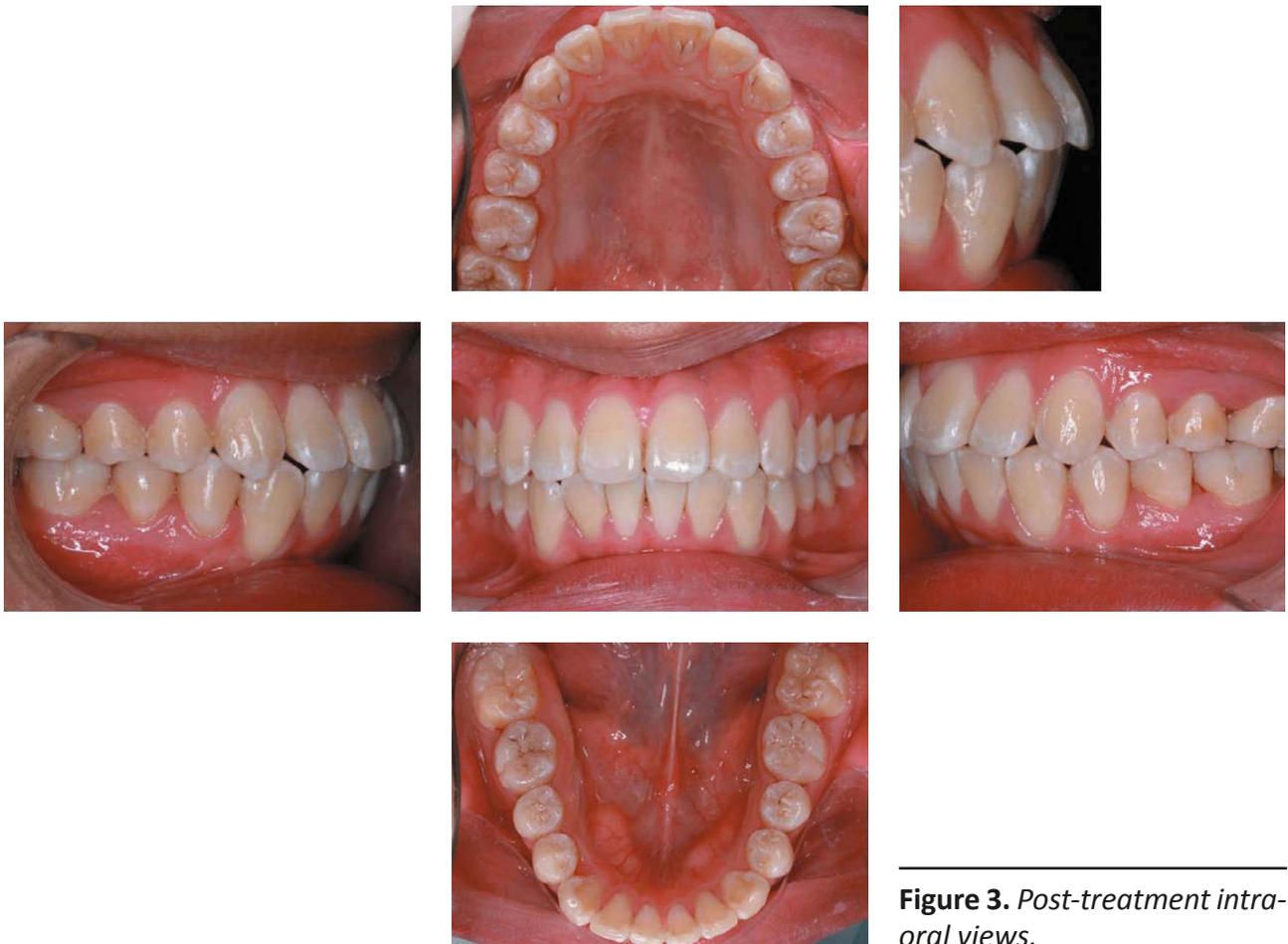
reduced lower facial height proportion, mild crowding in the upper arch and proclined upper incisors, with the lower incisors of average inclination. He was in the pubertal growth spurt period and this was the appropriate timing to modify his growth. The functional appliance was used to improve the skeletal discrepancy and to reduce the facial convexity by restraining the maxillary growth, advancing the mandible and moving the chin point forward, and correcting incisor and buccal segment relationships to Class I. As a result of the potential skeletal and dentoalveolar changes produced by the functional appliance, a more favourable soft tissue environment was created with elimination of the lip trap which tended to procline the upper incisors.

Fixed functional appliance, which was Herbst appliance in this case, was used because we could minimize any potential compliance problem<sup>7</sup> and maximize the efficiency of the treatment. Mandibular advancement every 6 months in a stepwise manner has been proved more effective in stimulating condylar growth and improving mandibular prognathism.<sup>8</sup> Herbst appliance incorporating with high-pull headgear could restrain the undesirable vertical growth of the maxilla, which in turn reduced the downward and backward rotation of the mandible which would compromise the Class II correction.<sup>9</sup>

### Two phase vs. one phase treatment

The patient was treated in 32 months, including 12 months of growth modification and 20 months of fixed appliance therapy. The main aim of the two phase orthodontic treatment was to enhance the patient's potential for favourable mandibular growth and improve his skeletal and soft tissue profile by growth modification. It was also planned to avoid over retraction of his upper incisors with respect to the incisor angulations, future nasal growth and his existing smile line. The originally convex profile could be worsened if this mild-to-moderate crowding case was treated with extraction. We were able to maintain the upper lip profile of the patient while improving the retrusive mandible by functional appliance treatment.

Lower incisors proclination is one of the major side effects of functional appliances. In this case, the lower incisors were proclined as a result of anchorage loss from the Herbst appliance and also from the fixed appliance using round wire for



**Figure 3.** Post-treatment intra-oral views.



**Figure 4.** Pre-treatment profile.

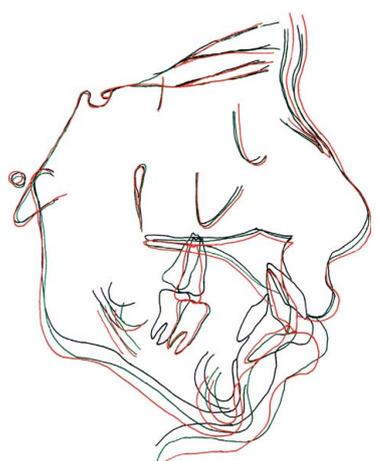


**Figure 5.** Post-treatment profile.

crowding relief. The proclination improved in the fixed appliance stage due to occlusal recovery and the teeth retroclined into the space created by rounding off the molar and premolar area. There was no gingival recession noticed at the end of treatment which was in agreement with Ruf's study<sup>10</sup> and this was because the patient was still growing and the alveolar bone followed the movement of the teeth. However, gingival recession

and root resorption might be potential risks from excessive lower incisor proclination especially in adults where growth has finished and therefore extra care has to be taken.

The prognosis for stability was good provided the patient's growth pattern was favourable and the mandible would not rotate downward and backward. Good buccal interdigitation and incisal contact also helped stabilize the occlusal stability,



— Pre-treatment  
 — Post-headgear Herbst appliance  
 — Post-treatment

**Figure 6.** Superimposition of pre-treatment, mid-treatment and post-treatment radiographs.

as well as the fixed retainers and removable retainers. Fixed retainers should be in place as long as possible as the incisors were rotated before the treatment.

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# Three-Dimensional Comparison in Palatal Forms Between Modified Presurgical Nasoalveolar Molding Plate and Hotz's Plate Applied to the Infants With Unilateral Cleft Lip and Palate

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## Abstract

The presurgical nasoalveolar molding plate appliance with stent (PNAM) extended from the palatal molding plate; to correct the nostril shape of infants with cleft lip and palate is well known. The PNAM appliance is based on the finding that a high degree of plasticity is maintained in the cartilage of infants during the first 6 weeks after birth. However, on the current PNAM protocol described by Grayson et al. the nasal stent is supposed to be an adjunct to the palatal molding plate after reducing the severity of the alveolar cleft width. We have used the modified Hotz's plate from the setup model and built up the nasal stent even before reducing the severity of the alveolar deformity. In this study we assess the effects of the modified Hotz's plate and the modified PNAM appliance for the alveolar and palatal form. The lateral deviation of the incisal point, the width of the palatal cleft, and the degree of curvature of the palatal vault were first evaluated on plaster models. The PNAM group is smaller on the lateral deviation of the incisal point than the modified Hotz's group. The decreased average width of the palatal cleft and curvature of the palate, was almost the same in both the modified Hotz's and PNAM groups. In comparison with the modified Hotz's plate, the modified PNAM appliance also improves the molding of the alveolar segments and reduces cleft width. [*Singapore Dent J* 2010;31(1):36–42]

**Key Words:** unilateral cleft lip and palate, presurgical orthopedics, presurgical nasoalveolar molding three-dimensional, morphology

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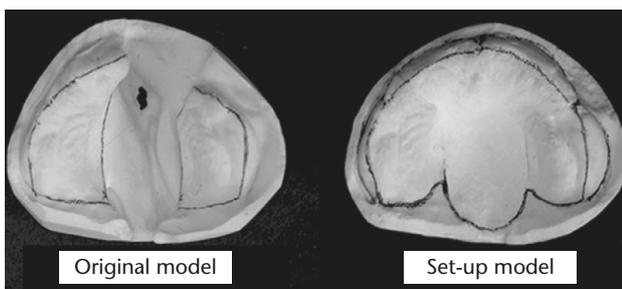
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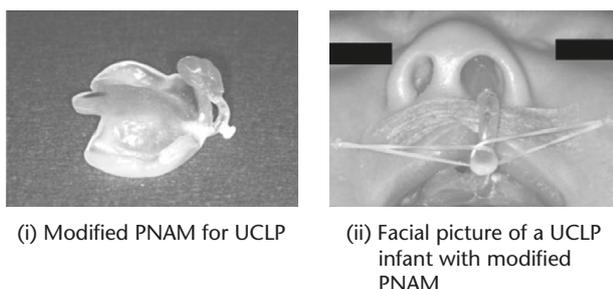
## Introduction

The presurgical nasoalveolar molding plate with stent (PNAM) extending from the palatal molding plate to correct the nostril shape is the most well known<sup>1–5</sup> appliance for the presurgical

orthopaedic treatment of infants with cleft lip and palate (CLP). The PNAM appliance is based on the finding that a high degree of plasticity is maintained in the cartilage of infants during the first 6 weeks after birth after which, there is a gradual in plasticity.<sup>1,6</sup> The 'Active Soft Tissue and Cartilage Molding Plate' therapy like the PNAM is more successful during this period. However, on the current PNAM protocol described by Grayson et al the nasal stent is supposed to be an adjunct to the palatal molding plate after reducing the severity of the alveolar cleft width.<sup>2</sup> Using the modified Hotz's plate from the idealized setup model (Figure 1), we built up nasal stents even before reducing the severity of the alveolar deformity for the palatal molding plate part of the PNAM procedure, called the modified PNAM (Figure 2). We have previously reported that this modified PNAM was effective in reducing both nasal and palate deformity.<sup>7,8</sup> We had not however compared the degree of effectiveness between both procedures. The aim of this study is to assess the effect of the palatal molding plate appliance (the modified Hotz's plate, the modified PNAM) on the alveolar and palatal form through a quantitative and three-dimensional evaluation.



**Figure 1.** An idealized set-up model.



**Figure 2.** Modified PNAM for UCLP.

## Materials and Methods

The subjects in our study were infants with unilateral CLP who were treated with the modified Hotz's plate—Hotz's group or the modified pre-surgical nasoalveolar molding plate (PNAM)—PNAM group appliance, at (i) National Center for Child Health and Development (NCCHD), (ii) St. Mary's Hospital, and (iii) Tokyo Medical and Dental University Dental Hospital (TMDU) (Table 1). Each group consisted of five infants. Treatment protocol was as in Figure 3. The changes of palatal forms in patients with CLP were evaluated quantitatively using plaster models. The plaster models were taken at the initial visit and later after the modified Hotz's or PNAM appliance was inserted. The use of these plaster models for this study was agreed to by their parents under the code of ethics of each hospital.

The width between the edges of the major and minor alveolar ridge on an alveolar cleft was measured, to assess the changes in the width of the alveolar cleft (WA) (Figure 4). The changes in the lateral deviation of the incisal point (LDI) were assessed by measuring the plaster casts as shown in Figure 5.

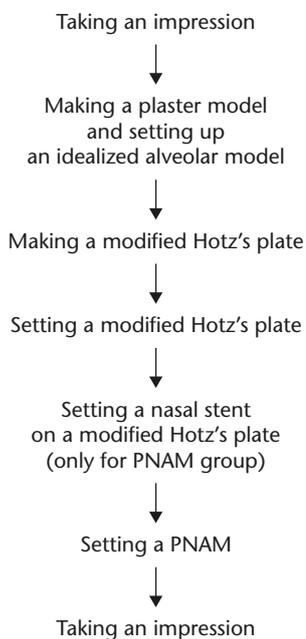
The width between the crossing points of the palatal cleft edges and the line between the maxillary tubers was measured, to assess the changes in the width of the palatal cleft (WP) (Figure 4).

The changes in the curvature of the palate (CP) were assessed by using Grating Projection Systems for Profiling (GRASP, Technoarts Lab. Co.) (Figure 6). The plaster casts were scanned by GRASP and the points along the surface of the cast converted to a three-dimensional Cartesian coordinate system. The vertical section from the right and left crossing points of a canine groove and the alveolar ridge (C(r), C(l)) to the plane passing through C(r), C(l) and the crossing point of an alveolar ridge. The line from an incisive papilla to a frenulum, was converted in the dispersion diagram. An approximated quadratic curve of this dispersion diagram of the vertical section was calculated by Excel (Microsoft Co.). The coefficient of  $x^2$  in this approximated quadratic curve was taken, to evaluate the curvature of the palate.

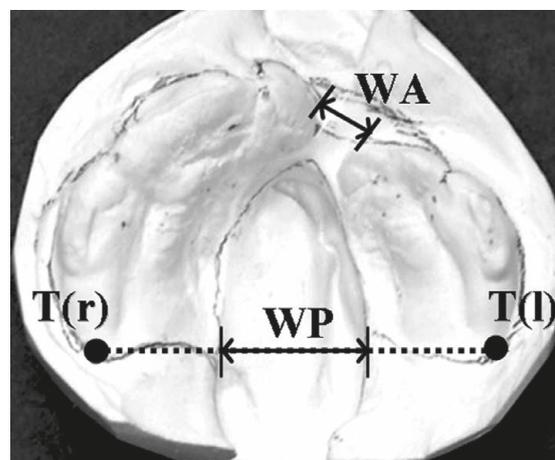
All measurements (WA, LDI, WP, and CP) each time were compared with paired *t* tests while the differences between the Hotz's and PNAM groups

**Table 1.** Breakdown of subjects

	Institute	Day of taking an impression before Hotz's/NAM appliance from BD	Day of setting a palatal plate from BD	Day of setting a stent from BD	Day of impression after Hotz's/PNAM appliance from BD
H1	NCCHD	17	29		142
H2	NCCHD	14	21		147
H3	St. Mary	4	7		161
H4	St. Mary	1	4		91
H5	St. Mary	1	6		111
Average of Hotz's group		7.4	13.4		130.4
P1	NCCHD	18	25	39	116
P2	St. Mary	6	10	34	104
P3	St. Mary	4	9	29	115
P4	St. Mary	1	6	21	183
P5	TMDU	6	13	17	130
Average of PNAM group		7	12.6	28	129.6



**Figure 3.** Treatment protocol.



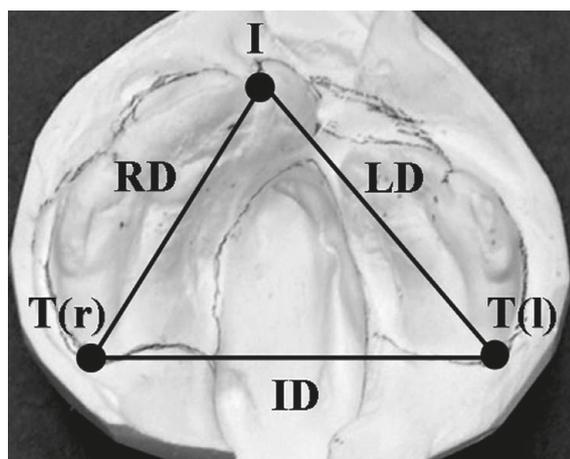
WA : The width between edges of a minor and a major segment each alveolar ridge on an alveolar cleft side.  
 WP : The width between the crossing points of palatal cleft edges and the line between the maxillary tubers (T(r,l)).

**Figure 4.** The assessment of the width of the alveolar cleft (WA) and the palatal cleft (WP).

were compared with unpaired *t* tests.  $p < 0.05$  was considered to be statistically significant.

It was decided that two comparative pictures (before and after the modified PNAM treatment)

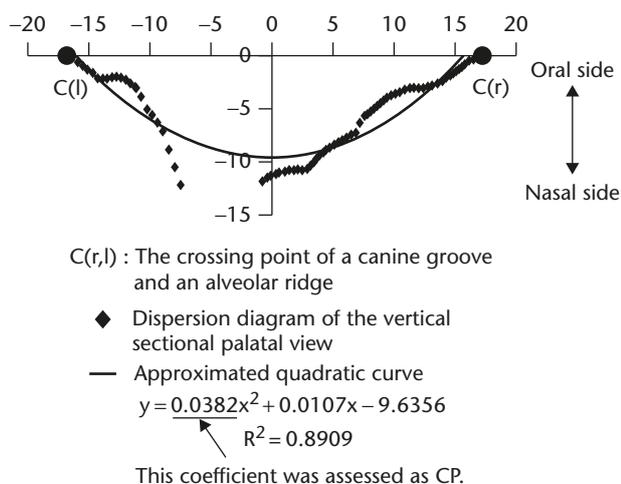
be used (Figure 7). The patients shown are only from the Tokyo Medical Dental University to allow for this comparison. Data from other hospitals is still under evaluation.



The lateral deviation of the incisal point (LDI)  
 $= |RD^2 - LD^2| / 2 ID$

- I : The crossing point of alveolar ridge and the line from incisive papilla to frenulum
- T(r,l) : The maxillary tubers
- RD : The length between I and T(r)
- LD : The length between I and T(l)
- ID : The length between T(r) and T(l)

**Figure 5.** The assessment of the lateral deviation of the incisal point (LDI).

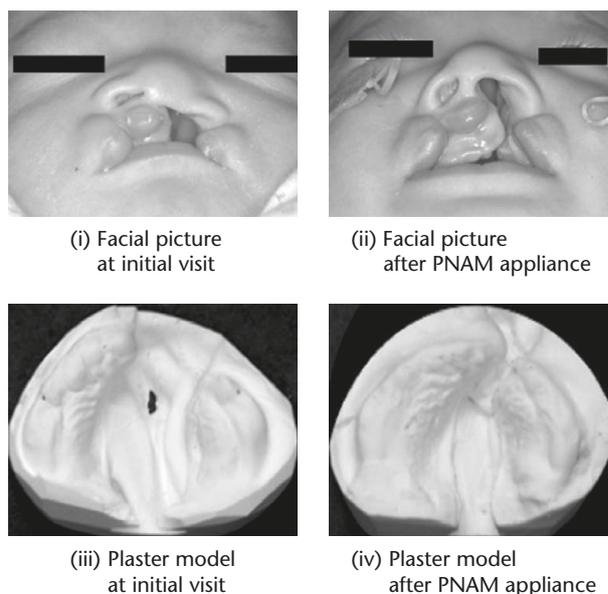


**Figure 6.** The assessment of the curvature of the palate (CP).

**Results**

The width of the alveolar cleft (WA) was decreased in all cases (Table 2, Figure 8). And there were no significant differences in the change between the Hotz's group and the PNAM group ( $p < 0.05$ ).

The lateral deviation in the incisal point (LDI) was improved in all cases (Table 3, Figure 9). There were no significant differences in the change of LDI between the Hotz's group and the PNAM group ( $p < 0.05$ ).

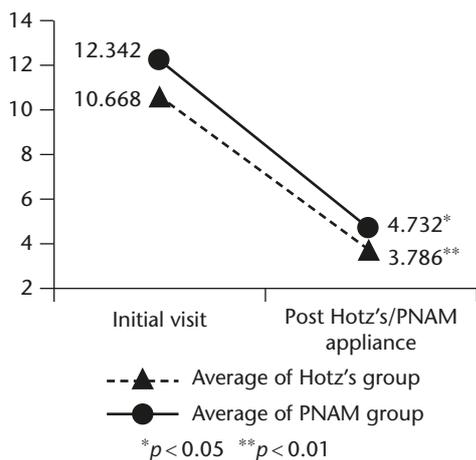


**Figure 7.** Unilateral CLP case seen in TMDU.

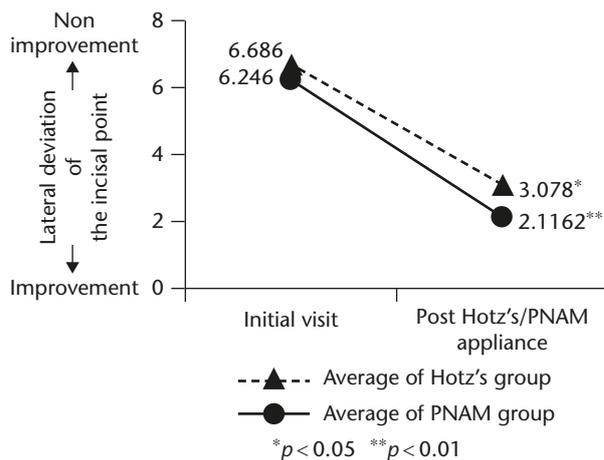
**Table 2.** Changes in the width of the alveolar cleft (WA)

	WA	
	Initial visit	Post Hotz's/ PNAM appliance
H1	8.76	1.76
H2	13.1	7.39
H3	9.65	1.75
H4	8.65	1.09
H5	13.18	6.94
Average of Hotz's group	10.668	3.786
P1	11.78	4.66
P2	12.22	5.1
P3	8.89	3.84
P4	19.43	7.65
P5	9.39	2.41
Average of PNAM group	12.342	4.732

The width of palatal cleft (WP) was also decreased in all cases (Table 4, Figure 10) and there was no significant difference between the Hotz's group and the PNAM group ( $p < 0.05$ ). The average decrease in the widths of the palatal cleft were almost the same between the Hotz's and PNAM groups (approximately 11 mm) (Figure 10).



**Figure 8.** Changes in the width of the alveolar cleft (WA).



**Figure 9.** Changes in the lateral deviation of the incisal point (LDI).

**Table 3.** Changes in the lateral deviation of the incisal point (LDI)

	LDI	
	Initial visit	Post Hotz's/ PNAM appliance
H1	4.68	1.07
H2	7.41	4.33
H3	6.74	2.65
H4	5.65	1.08
H5	8.95	6.26
Average of Hotz's group	6.686	3.078
P1	6.38	3.31
P2	7.3	4.51
P3	3.92	1.05
P4	9.86	1.56
P5	3.77	0.151
Average of PNAM group	6.246	2.1162

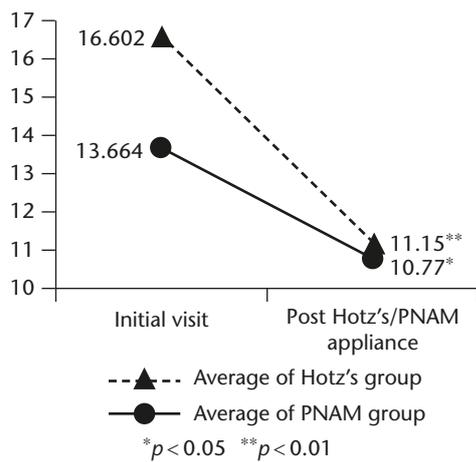
**Table 4.** Changes in the width of the palatal cleft (WP)

	WP	
	Initial visit	Post Hotz's/ PNAM appliance
H1	14.13	7.75
H2	19.51	10.98
H3	15.75	11.23
H4	14.12	9.15
H5	19.5	16.64
Average of Hotz's group	16.602	11.15
P1	11.25	9.25
P2	11.5	10.42
P3	11.65	9.99
P4	19.46	12.9
P5	14.46	11.29
Average of PNAM group	13.664	10.77

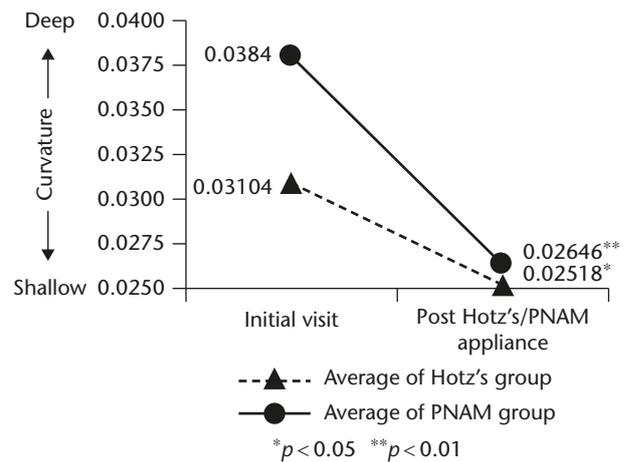
There was a decrease in the curvature of the palate (CP) in all cases (Table 5, Figure 11) and there was no significant difference in the change of CP between the Hotz's group and the PNAM group ( $p<0.05$ ). The average decrease in the curvatures of the palate were almost identical for the Hotz's and PNAM groups (approximately 0.026) (Figure 11).

**Discussion**

In both the Hotz's and PNAM groups the lateral deviation of the incisal point (LDI) was decreased in all cases (Table 3, Figure 9) as was the width of the alveolar cleft (WA) (Table 2, Figure 8). There was an improvement in the positions of the pre-maxilla segment too. These results were obtained



**Figure 10.** Changes in the width of the palatal cleft (WP).



**Figure 11.** Changes in the curvature of the palate (CP).

**Table 5.** Changes in the curvature of the palate (CP)

	CP	
	Initial visit	Post Hotz's/ PNAM appliance
H1	0.031	0.0279
H2	0.0245	0.0192
H3	0.0439	0.031
H4	0.0275	0.0243
H5	0.0283	0.0235
Average of Hotz's group	0.03104	0.02518
P1	0.0335	0.0235
P2	0.0413	0.0259
P3	0.0379	0.0301
P4	0.0383	0.0205
P5	0.041	0.0323
Average of PNAM group	0.0384	0.02646

by the early fitting of the palatal plate on the pre-surgical orthopaedic appliance guide and the anterior growth of the major and minor segments.<sup>9-11</sup> Although the PNAM appliance is disadvantageous in improving the alveolar form when compared with the Hotz's plate appliance in applying the nasoalveolar molding plates to the unilateral cleft lip and palate (CLP) cases, because of the asymmetrical pressure from the stent to the palatal plate; these results suggest that the modified

PNAM appliance could obtain better alveolar form than the modified Hotz's plate appliance in these cases.

The width of the palatal cleft (WP) and the curvature of the palate (CP) was decreased in all cases (Tables 4 and 5, Figures 10 and 11) and showed an improvement in the palatal form. These results were obtained by positioning the tongue such that the abnormal force exerted by the tongue on the palate was removed.<sup>9,11-13</sup> These results suggest that there was no significant difference in the techniques of molding the palatal form between the modified Hotz's plate and the modified PNAM for the palatal plate to improve the tongue posture.

After the Hotz's or PNAM procedure, the decreased average WP was similar (approximately 11 mm—Figure 10) as was the decreased average CP (approximately 0.026—Figure 11) in both the Hotz's and PNAM groups. These results suggest that this could be the limit of the effectiveness of this type of pre-surgical orthopaedic appliance on the palatal form.

Grayson et al described that an attempt to correct the nasal cartilage deformity present in a larger alveolar cleft defect, may result in an undesirable increase in the circumference of the lateral alar wall.<sup>2</sup> However, it seems that the nasal cartilage can be molded more easily in the first three months. The modified Hotz's plate was made from the idealized setup model and may indicate the idealized occlusal plane. We therefore expect that by using the modified Hotz's plate for the PNAM we could add and adjust the nasal

stent by imaging the idealized nasal form properly even before the alveolar cleft width reduces by less than 6 mm. On the other hand we were afraid of the negative influence from the asymmetrical pressure of the nasal stent on the palatal molding plate. On the nasal form, a favourable effect was obtained using the modified PNAM in the TMDU case (Figure 7). The modified PNAM appliance could obtain the same results as the modified Hotz's plate appliance on the alveolar and palatal form. These results suggest that the set of the nasal stent on the modified Hotz's plate before the severe alveolar deformity, did not show any negative influence on the improvement of the alveolar and palatal deformity in unilateral CLP patients.

## Conclusions

The favourable effects of treatment using the Hotz's plate and the modified PNAM on both the alveolar and palatal forms in all cases for the unilateral CLP are quantitatively confirmed. On the nasal form, the favorable effect was obtained with the modified PNAM. As such, the modified PNAM appliance would be a better appliance than the modified Hotz's appliance for the improvement of the nasal form in unilateral CLP patients. The modified Hotz's plate would be a better for setting the nasal stent early.

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