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# Bone-anchored maxillary protraction (BAMP): A review

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## Abstract

**INTRODUCTION:** Protraction therapy for maxillary deficiency in the treatment of skeletal class III malocclusion involves the use of facemask. Conventionally facemask has been anchored to the maxillary dentition, which is responsible for some of the counter-productive effects of facemask therapy including backward and downward rotation of the chin, increase in the lower anterior facial height, proclination of maxillary incisors, retroclination of mandibular incisors apart from mesialization of maxillary molars with extrusion and decreased overbite.

**AIM:** The aim of this article is to highlight the nuances of Bone-Anchored Maxillary Protraction (BAMP) including a literature review, which is comprehensive and narrative and comparing the different techniques involved such as type 1 BAMP versus type 2 BAMP and BAMP versus facemask.

**MATERIALS AND METHODS:** A computerized search was performed in electronic databases such as PubMed, PubMed Central, Cochrane, Embase, DOAJ, and Google scholar using key words such as “bone-anchored maxillary protraction” and “BAMP.” The search was confined to articles in English published till March 2021. Forty-seven case-controlled, cross-sectional, retrospective and prospective studies, as well as systematic reviews and meta-analysis were included in this article, which were limited to human subjects. A hand search of the reference lists of the included articles was also carried out to include missed out articles.

**CONCLUSION:** To overcome these drawbacks, BAMP was introduced, which causes both maxillary protraction, restraint of mandibular growth with minimal dentoalveolar changes. BAMP is used widely nowadays in the treatment of skeletal class III malocclusion.

## Keywords:

BAMP, bone anchored maxillary protraction, class III, facemask, malocclusion

## Introduction

Skeletal class III malocclusion, which is caused due to maxillary retrusion or mandibular protrusion or a combination of both, has a prevalence as high as 4%–14% in certain Asian populations and 1–3% in whites.<sup>[1,2]</sup> It poses a treatment challenge to the orthodontist due to differential growth of the mandible, which progressively worsens with age.<sup>[3]</sup> Due to this, resolving the skeletal discrepancy with a fixed appliance is not helpful. This extends the treatment duration

and the concomitant problems associated with a long span of treatment.<sup>[4]</sup>

Two-phase therapy in the correction of skeletal class III malocclusion entails an initial phase of correction of the skeletal discrepancy using orthopedic appliances, which is followed by fixed orthodontic mechanotherapy. Facemask, an orthopedic appliance used for such a correction utilizes the dentition for force transmission that can cause counter-productive effects on it such as retroclination of lower incisors, proclination of upper incisors, and mesial movement of upper molars with extrusion.<sup>[5]</sup> Also, it causes clockwise rotation of the mandible, increase in the

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dimension of the lower facial third, correction of overjet, and open bite with improvement in the profile in cases of overclosure.

Alternatively, to overcome these effects seen with conventionally used facemasks, they have been used in conjunction with skeletally anchored miniplates to apply forces directly to the maxillo-facial complex (type 1 BAMP). A novel intraoral treatment technique with its ensuing protocol for the correction of skeletal class III malocclusion was developed by De Clerk *et al.* constituting intraoral class III elastics applied from the maxillary infra-zygomatic miniplates to the mandibular symphysis miniplates for 24 hours a day (type 2 BAMP) and a comparative evaluation of both the protocols (i.e. type 1 and type 2) was carried out by Elnagar *et al.*<sup>[6]</sup> In cases where dentoalveolar compensations can be detrimental, bone anchored maxillary protraction (BAMP) is preferred, as it overcomes the effects of conventional dentition anchored facemask therapy and derives anchorage from the bone and not the dentition.<sup>[7-9]</sup>

BAMP as a procedure has been used often over the years in the treatment of Class III malocclusion. Understanding the nuances involved with the procedure will equip the clinician with knowledge so as to apply it in routine clinical practice. Literature summarizing the therapy comprehensively is scarce. Hence, here we review the BAMP therapy under the following headings, namely, rationale, application protocols, procedure for placement, activation and removal followed by retention, short-term and long-term effects, success rate, complications with failures including its application in cleft patients and in conjunction with Temporary Anchorage devices (TADs) and Rapid Maxillary Expansion (RME).

## Materials and Methods

A computerized search was performed in electronic databases such as PubMed, PubMed Central, Cochrane, Embase, DOAJ and Google scholar using keywords such as "bone-anchored maxillary protraction" and "BAMP." The search was confined to articles in English published till March 2021. Case-controlled studies, cross-sectional, retrospective and prospective studies, as well as systematic reviews and meta-analysis were included. The 47 studies included were limited to human subjects. Studies with both type 1 and type 2 BAMP intervention in both cleft and non-cleft subjects were included with all outcomes. Case reports, opinions, letters to editorials, and abstracts were excluded. To find additional relevant articles that might have been missed in the electronic search, a hand search of the reference lists of the included articles was carried out.

## Results

### Rationale

BAMP is best done during the late mixed/early permanent dentition because of maturation of maxillary bone and eruption of the mandibular canine.<sup>[10-13]</sup> As accuracy of bone density is best with Cone Beam Computed Tomography/Computed Tomography, it should be undertaken to evaluate the bone density in the area of miniplate insertion.<sup>[14]</sup>

### Protocols

The two major types of BAMP therapy are:

- Type 1: It involves the installation of two miniplates at the infrazygomatic crest and the use of a facemask for protraction.
- Type 2: It involves the installation of two miniplates each at the infrazygomatic crest and the mandibular symphysis and use of Class III intermaxillary elastics for protraction.

### Procedure of placement

Type 1 BAMP Therapy [Figure 1]:

In BAMP, titanium miniplates (e.g., Multipurpose Implant; Tasarimmed, Istanbul, Turkey) are used as skeletal anchorage devices. Mucosal incisions are made in the labial sulcus bilaterally between lateral incisor and canine. The muscles and periosteum should be incised, exposing the lateral nasal wall and aperture piriformis. Contoured miniplates are placed on the lateral nasal wall and their extension into the oral cavity is bent into a hook for engaging elastics. Three screws are to be placed for stabilization of the miniplates. After approximately 7-10 days of soft-tissue healing, orthopedic forces are applied.<sup>[15]</sup>

An alternate method involves the installation of two miniplates at the infrazygomatic crest bilaterally and

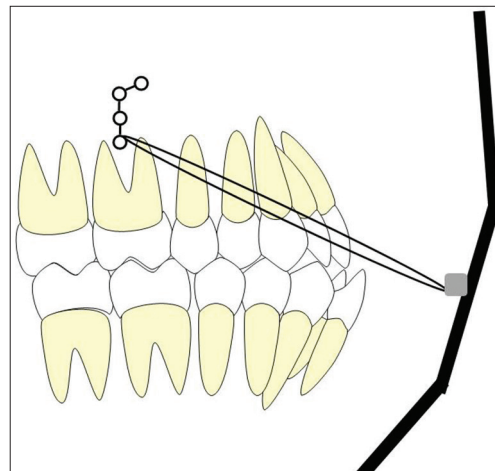


Figure 1: Type 1 BAMP Therapy

the use of a facemask. In this type, patients receive two surgical miniplates with one placed at each zygomatic buttress area. The incision is made in the buccal vestibule below the zygomatic buttress area under local anaesthesia. A mucoperiosteal flap is elevated and the surface of the cortical bone is exposed. Surgical miniplates are adapted and bent free hand using a bird-beak orthodontic plier according to the anatomy of the zygomatic buttress, in a curvilinear pattern and in accordance to the shape of the zygomatic buttress area. They are fixed with three self-tapping bone screws per side (2 mm diameter, 6 mm length). Then the incisions are sutured exposing the end of the miniplates over the keratinized attached gingiva near the canine to prevent gingival irritation and to control the vector of elastic traction. The end holes of the miniplates are cut to create a hook for elastics.<sup>[16]</sup>

#### Type 2 BAMP Therapy [Figure 2]:

Type 2 BAMP therapy involves the installation of four miniplates; two each in the maxilla and the mandible. Patients receive two surgical miniplates at the right and left zygomatic buttress area. An incision is made in the buccal vestibule below the zygomatic buttress under local or general anesthesia. The mucoperiosteal flap is elevated and the underlying surface of the cortical bone is exposed. Pre-drilling with 1.6 mm diameter bur is to be followed by fixing the miniplates to the bone. Surgical miniplates are adapted and bent free hand using a bird-beak orthodontic plier according to the anatomy of the zygomatic buttress and in accordance with the shape of the zygomatic buttress area. They are fixed with 2–3 self-tapping bone screws per side (2.3 mm diameter, 5 mm length). The incisions are then sutured exposing the end of the miniplates over the keratinized attached gingiva near the canine to prevent gingival irritation and to control the vector of elastic traction.<sup>[12]</sup>

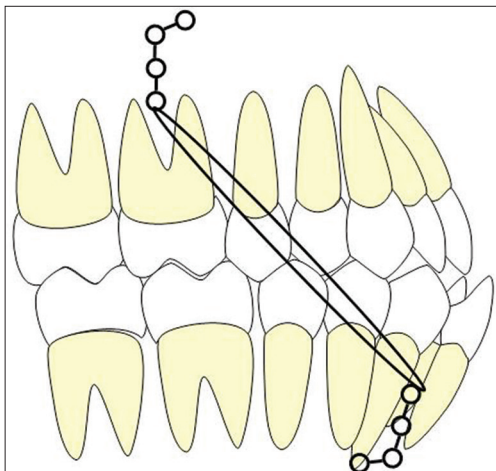


Figure 2: Type 2 BAMP Therapy

#### Activation

In type 1 BAMP therapy, after allowing the soft tissues to heal for 3 weeks, heavy orthopedic forces are applied. Extraoral elastics from the miniplates to the facemask applying 400–500 g of force per side are directed 30° downwards and forward to the maxillary occlusal plane. The patients are asked to wear the elastics for 14–16 hours continuously and replace them once each day. A removable maxillary biteplate covering the posterior occlusal surfaces is placed to eliminate occlusal interferences in the incisor region until correction of the anterior crossbite is obtained.<sup>[16]</sup>

In type 2 BAMP therapy, the miniplates are loaded similarly, 3 weeks after the surgery. Class III elastics apply an initial force of about 150 g on each side initially, which is increased to 200 g after 1 month of traction and to 250 g after 3 months. The patients are asked to wear the elastics for 24 hours a day, replacing them daily. After 2–3 months of inter-maxillary traction, a removable bite plate is inserted in the upper arch to eliminate occlusal interference in the incisor region until correction of the anterior crossbite is obtained.<sup>[13]</sup> The surgeons' and patients' experiences and problems with the plates were described by De Clerck *et al.* In one case, elastic wear was commenced after 1 month and in the other 2 cases after 2 months. Moderate continuous traction by the virtue of elastic wear was found to produce favourable results in all the three cases. Unlike orthognathic surgery which is performed at the completion of the growth phase, in BAMP, the patient's appearance does not worsen through the growth years thereby providing a psychological benefit as well.<sup>[12]</sup>

#### Removal

After 7–12 months of orthopedic traction, the bite plate is removed. The traction should be maintained for a total period of 12–16 months.<sup>[12]</sup>

#### Retention

During the follow-up period after the active treatment, the patients should be asked to wear the elastics at night for retention until the growth is complete. Miniplates remain in the patient's mouth till growth completion as it does not interfere in growth.<sup>[12]</sup>

#### Rationale for the differing force levels in type 1 and type 2 BAMP

Type 1 BAMP employs forces in the range of 400–500 g which are applied for 14–16 hours a day, whereas Type 2 BAMP forces in the range of 200–250 g per side are applied for 24 hours a day. Similar rates of maxillary protraction have been observed in the two protocols followed. However, the force of magnitude and duration of elastic wear differs between the two types of BAMP because heavy interrupted forces are applied in type 1

BAMP in contrast to the moderate continuous traction applied in type 2 BAMP.<sup>[6]</sup>

### Short-term effects

#### Skeletal

#### Maxillary component

BAMP is a contemporary counterpart of conventionally used maxillary protraction procedures. It acts mainly on the maxilla to bodily displace it forward in the sagittal direction. The amount of such a displacement is on an average 4.87 mm and 5.81 mm in type 1 and type 2 BAMP, respectively.<sup>[6]</sup>

In comparison with other methods of maxillary protraction such as RME with Facemask (RME/FM), type 2 BAMP leads to a greater forward displacement of point A, zygoma, and the orbit.<sup>[16]</sup> About 3.7 mm of forward movement of maxilla was noted in type 2 BAMP, whereas only 2.6 mm of maxillary protraction was seen in the RME/FM group.<sup>[17]</sup> De Clerck *et al.*<sup>[13]</sup> reported 4 mm of forward movement of point A, 2 mm of forward movement of orbitale, 3 mm of forward movement of point PTM, and clockwise rotation of the maxilla. These findings were corroborated by Bacetti and co-workers who also found significant and pronounced horizontal deformation of maxilla in type 2 BAMP therapy.<sup>[18]</sup>

Skeletally anchored maxillary protraction and dentally anchored maxillary protraction produced similar changes in the overjet. However, the skeletal component of such a change exceeded that produced by dentally anchored maxillary protraction by 1 cm and horizontal movement of point A by 3 mm was noted in the former.<sup>[19]</sup>

#### Mandibular component

Both type 1 and type 2 BAMP therapy affects the forward growth of the mandible. A restraining effect on point B and Pogonion with -2 mm mandibular advancement and counter-clockwise movement of the mandible is seen in type 2 BAMP.<sup>[13]</sup> In comparison with type 1 BAMP, a greater backward displacement of mandible, decreased mandibular plane angle occurs in type 2 BAMP.<sup>[6]</sup> Intraoral skeletally anchored maxillary protraction also occasionally leads to a transient or a permanent dysfunction of the temporomandibular joint owing to the effect of class III elastics, which seats the condyle into the retro-discal tissues.<sup>[19]</sup> Heymann *et al.*<sup>[11]</sup> have reported on the resorptive remodelling of the condyle owing to BAMP therapy.

#### Maxillo-mandibular component

The maxillo-mandibular difference in the amount of change between type 2 BAMP therapy and RME with facemask is -5.7 mm.<sup>[13]</sup> Also, lower anterior facial height significantly increases in type 1 BAMP with facemask in comparison with type 2 BAMP.<sup>[6]</sup>

#### Suture

BAMP effects the circum-maxillary sutures and this distraction of the sutures is important for protraction of the maxilla. Greater maxillary protraction occurs in stage A and stage B (according to classification given by Angelieri *et al.*<sup>[20]</sup>) of zygomaticomaxillary suture calcification either by BAMP or facemask and RME combination.<sup>[16]</sup>

#### Fossa

BAMP therapy leads to seating of the condyles posteriorly within the glenoid fossa. Apposition at the anterior eminence of the glenoid fossa that correlates with posterior displacement of anterior surface of condyle is seen after type 2 BAMP. Also, resorption of the posterior wall of the articular eminence of the TMJ correlates with posterior displacement of posterior surface of condyle. A displacement of 2.7 mm was seen in posterior border of ramus.<sup>[21]</sup>

#### Dentoalveolar effect

The dentoalveolar changes seen with BAMP therapy also contribute to the correction of the underlying skeletal discrepancy. De Clerk and co-workers found an improvement of overjet by 3.8 mm, molar relation by -4.8 mm, bite deepening of 1.5 mm, and mandibular incisor proclination of 1.7° with type 2 BAMP when compared with untreated cases.<sup>[2]</sup> Lower incisor retroclination occurred in type 1 BAMP therapy, whereas slight proclination of the lower incisor was observed in type 2 BAMP therapy.<sup>[6]</sup>

Incisor mandibular plane angle increases in type 2 BAMP and decreases in type 1 BAMP.<sup>[22]</sup> However, no significant changes occurred in the intermolar width of the maxilla and mandible or maxillary arch width in either type 1 or type 2 BAMP therapy. Mandibular arch depth decreases in skeletally anchored facemask and untreated cases.<sup>[23]</sup>

#### Soft tissue

Soft tissue changes in skeletally anchored facemask (Type 1 BAMP) and conventional facemask significantly differs only in vertical dimension.<sup>[7]</sup> Both type 1 and type 2 BAMP techniques of therapy significantly improve the soft tissue profile favorably which in effect leads to an improvement of the concave profile. The upper lip, cheeks, and mid-face display a significant positive sagittal displacement in both type 1 and type 2 BAMP in comparison with untreated controls. Soft tissue growth in the lower lip and chin area is more restrained in horizontal and vertical direction in type 1 BAMP group when compared with type 2 BAMP.<sup>[24]</sup>

De Clerk and co-workers showed a 4-mm improvement in maxillary soft tissue variable and 1.7–2.6 mm

improvement in mandibular soft tissue variable in type 2 BAMP when compared with untreated cases.<sup>[13]</sup>

### Airway

Extra-oral tooth borne protraction devices are effective and promote skeletal changes in younger children up to 10 years. Forward movement of maxilla and the ensuing clockwise rotation of mandible after maxillary protraction therapy favorably alters the upper airway.<sup>[25]</sup> A comparative study between type 2 BAMP therapy and untreated class III controls demonstrated an increase in the airway volume by 1499.64 mm<sup>3</sup>. Additionally, the most constricted area of airway increased by 15.44 mm<sup>3</sup> when compared to the control group.<sup>[22]</sup>

2D data show increase in the length of the boundary between the naso-pharynx to the oro-pharynx with BAMP in comparison to controls. It also potentially improves obstructive sleep apnea in patients with maxillary retrusion through an enlargement of the nasopharyngeal airway. Redirection of mandibular growth however, did not show any significant changes on the hypopharyngeal airway space.<sup>[26]</sup>

Type 1 BAMP and tooth-borne facemask, both causing maxillary protraction, demonstrate an enhancement in the pharyngeal airway space. However, the magnitude of this change is higher in type 1 BAMP compared to facemask alone.<sup>[27]</sup>

Expansion of the constricted maxilla also improves the airway constriction. RME and Alternate Rapid Maxillary Expansion and Contraction (Alt-RAMEC) are used frequently to expand the constricted maxillary arch. Type 1 BAMP (with Petit type facemask) however, causes a greater increase in the nasopharyngeal and oropharyngeal airway dimensions in comparison to the Alt RAMEC and RME procedures. Total pharyngeal airway area increases more in the BAMP group followed by the Alt-RAMEC and RME groups.<sup>[28]</sup>

### Follow-up studies on BAMP

Follow-up studies on BAMP have been described in Table 1.<sup>[22,29-34]</sup>

### Success rate

Efficacy of skeletally anchored maxillary protraction has been found to be superior to dental anchored maxillary protraction. Also, intra-oral skeletally anchored maxillary protraction (type 2 BAMP) was found to be more effective rather than extra-oral skeletally anchored protraction (type 1 BAMP) due to an improvement in patient compliance.<sup>[19]</sup>

Pre-surgical counselling along with sedation or short general anesthesia appears to be better accepted by patients. The success rate in terms of stability of the

miniplate is 97%. Initial retention of the osteosynthesis screws is by mechanical means dictated by the thickness and density of the external cortical bone and is decreased in growing children compared to adults. It is not recommended to use these plates below the age of 11 years because of increased risk of poor bone quality. Failures are noted predominantly in the upper jaw compared to the lower jaw.

Success rate in summary can be related to the following factors:

1. Pre-surgical counselling of the patient.
2. Minimally invasive surgery with decreased patient morbidity and adequate postsurgical instructions.
3. A good follow-up regimen by the orthodontist.<sup>[35]</sup>

### Post surgical care

Elocom cream (Mometasonefuroate 1 mg) application to the lips, local anesthesia (Xylocaine, 1% adrenaline) for vasoconstriction along with application of Exacyl (transexamic acid) decreases postsurgical swelling and patient morbidity. Rinsing with salt water is imperative to avoid infection. Application of wax to the miniplates avoids irritation of the soft tissues.<sup>[22]</sup>

### Complication with failures

Most miniplate failure occurs in younger patients.<sup>[10]</sup> A study by Van Hevele showed 93.6% success rate of miniplates. Failure of the miniplates is 6 times higher in maxilla, more often in younger boys but not girls. The chances of failure are lesser when post-operative antibiotic is given and the neck of miniplate is placed in the attached gingiva. Self-drilling screws have significantly fewer failures.<sup>[36]</sup>

### BAMP in cleft patients

Patients exhibiting Goslon's index score between 3 and 5 can be treated using BAMP therapy.<sup>[37]</sup> Treatment outcomes in cleft patients are less optimal due to the presence of scar tissue.<sup>[14]</sup> Failure of miniplates is most commonly seen in cleft area compared to the non-cleft area.<sup>[14]</sup> BAMP should be performed after alveolar bone grafting since the load of the applied inter-maxillary traction is not found to compromise the status of the secondary alveolar bone graft.<sup>[38-40]</sup> In case of failure of the miniplates, the location should be changed to the lateral nasal wall adjacent to nasal cavity.<sup>[41]</sup> Expansion with RME may be performed only when needed and not for the purpose of enhancing the protraction protocol.<sup>[37]</sup>

Type 1 BAMP therapy in cleft cases have shown changes in the SNA angle by 0.5–4.2° whereas in type 2 BAMP a change of 1.2–1.7° can be observed. The ANB angle in type 1 BAMP exhibited a change of 0.6–3° whereas in type 2 BAMP therapy the change was 1–3.5°. A forward movement of the zygoma by 1.1 mm and

**Table 1: Follow-up studies on effects of BAMP**<sup>[22,29-34]</sup>

Author, Year	Sample	Follow-up duration	Structure studied	Aim	Findings
Nguyen, 2014 <sup>[29]</sup>	25 patients, mean age of 11.10±1.1 years	1 year	Mandible	To measure amount of skeletal changes a year after BAMP in growing children (aged 9-13 years)	Posterior chin displacement (0.45 mm); decrease in gonial angle; posterior ramal distalization; distal condylar displacement in three patterns namely, downwards and backwards, straight backwards and upwards and backwards.
Nguyen, 2020 <sup>[30]</sup>		9-12 months	Maxilla Mandible Lower incisors	To assess effects of BAMP of the skeletal and dental structures	5.2 mm of maxillary protraction was noted without counter-clockwise rotation. Restricted from forward movement by 0.6 mm compared to untreated matched controls who showed an anterior growth of 2.2 mm. Proclination by 2° noted.
Cevdanes, 2010 <sup>[31]</sup>	BAMP-21, FM/RME-34, mean age of 11 years 10 months	12 months	Maxilla Mandible Mandibular Incisors	To compare the effects of BAMP with facemask given with rapid maxillary expansion (FM/RME)	Greater orthopedic protraction with higher displacement of A- Vert T (2.3 mm) and A- Condylion (2.9 mm) in BAMP group. Restraint of 0.6 mm in BAMP group and 1.2 mm in FM/RME group. Reduction in mandibular plane angle in BAMP group by 1.2° whereas opening by 2.3° was noted in the FM/RME group. Distal displacement of the ramus along with closure of the mandible lead to “swing back” of the mandible in the BAMP group whereas downward and backward rotation was noted in the FM/RME group. BAMP caused decompensation with 1.9° of proclination whereas FM/RME caused a retroclination by 4.3°.
C. Ağlarci, 2016 <sup>[32]</sup>	59 patients; mean age, 11.75±1.23 years, controls, 11.21±1.32 years	9 months	Maxillary incisors Mandibular Incisors Occlusal plane Maxilla Mandible	Effects of BAMP on the dental and skeletal structures in comparison to Facemask therapy	Protrusion was twice in the facemask group than that of skeletal anchorage group. Retroclined in facemask group and proclined in the skeletal anchorage group. Steeptened more in the facemask than the skeletal anchorage group. Increase in sagittal advancement of point A and ANS in the skeletal anchorage group was greater in comparison to the facemask group. Downward and clockwise rotation higher in the facemask group.
Lagravère, 2010 <sup>[33]</sup>	62 patients, age range of 10-14 years	12 months	Soft tissue	To assess the 3D soft tissue changes in growing Class III patients	Significant positive sagittal displacement in the upper lips, cheeks, and mid face noted. Significant negative sagittal changes in the chin and lower lip thereby showing their restrained growth, which was more evident in the BAMP group rather than the bone anchored facemask group.
Cornelis, 2021 <sup>[22]</sup>	28 studies; 3 52 patients	1.9 years	Skeletal	To assess the skeletal and dental changes produced by BAMP therapy	Type 1 and type 2 BAMP showed similar changes in ANB correction (4.2 degrees for type 1, 3.5 degrees for type 2). Witts correction of 5.1 mm was also similar in the two groups. Type 2 BAMP was found to produce a lower incisor proclination of 1.3 degrees whereas type 1 produced a retroclination of 4 degrees compared to untreated controls.
Steegman, 2021 <sup>[34]</sup>	19 cleft patients, 17 controls	1.5-3.5 years	Skeletal	To evaluate the skeletal changes in growing class III cleft patients 3.5 years after therapy	Point A showed an anterior displacement of 2.7±0.9 mm from T <sub>0</sub> -T <sub>2</sub> . Zygoma showed a displacement of 3.8±1.2 mm. Point B showed no significant displacement from T <sub>0</sub> -T <sub>2</sub> . ANB showed an improvement of 3.3°. Changes between T <sub>0</sub> -T <sub>1</sub> and T <sub>1</sub> -T <sub>2</sub> showed no significant difference indicating maintenance of the results in the first 1.5 years. Also, continuous orthopedic effects were noted in the following 2 years.

outward movement of 0.7 mm was seen after BAMP treatment.<sup>[14]</sup>

In patients with unilateral cleft lip and palate, the alveolar bone graft displayed no detrimental effects after BAMP therapy despite heavy forces of the intermaxillary elastics.<sup>[42]</sup>

A prospective control study of BAMP in cleft patients found that point A moved sagittally forward by 1.5 mm, point B by 0.8 mm, and Pogonion by 0.7 mm.

Two-thirds of the patient treated and studied had an improved lip projection, whereas the other one-third had an unchanged/worsened appearance.<sup>[41]</sup> Maxillary protraction with BAMP in cleft patients was similar and symmetrical in both the cleft and non-cleft sides.<sup>[43]</sup>

### BAMP with TADs

Nowadays, BAMP is also being used in conjunction with TADs. The various types of TADs anchored maxillary protraction include TADs on the buttress of the zygomatic bone, TADs for intraoral force traction, TADs

on the lateral wall of the nose, and TADs on the palate. Palatal plates are also now available instead of TADs.<sup>[44]</sup>

TAD-assisted rapid palatal expander and facemask is used with 380 g of traction per side for 12–14 hours per day. It is found to be a viable alternative to conventionally used facemask with rapid palatal expansion as an increased forward movement of maxillary molar and incisor, downward movement of maxilla, and clockwise rotation of mandible is seen compared to the latter.<sup>[45]</sup>

TAD-anchored protraction of the maxilla causes larger advancement compared to dentally anchored maxillary protraction appliances. Side effects of dentally anchored protraction such as mandibular rotation, maxillary incisor proclination, and maxillary molar extrusion are also comparatively lesser with TADs.<sup>[46]</sup>

### BAMP with or without RME

The amount of maxillary protraction was not found to be altered by preceding the BAMP procedure with RME. A study reported 3.17 mm and 3.37 mm of protraction in the non-expansion and expansion groups, respectively. However, a clockwise rotation of the palatal plane (1.6 degrees) was found in the group where BAMP was carried out without maxillary expansion.<sup>[37]</sup>

As BAMP applies an orthopedic force to the skeleton directly, the need to disarticulate the sutures so as to prevent anchorage loss is obviated. Also, the continuously applied direct force was sufficient to disarticulate the sutures around the maxilla. Hence, expansion should be performed only when deemed essential and not for enhancing the protraction therapy.<sup>[6,11,12,13,21,31,47]</sup>

## Conclusions

The technique of BAMP has evolved over the years and it has proven to be a useful therapeutic modality when a greater skeletal change is desired. Further research will help overcome some of the constraints faced clinically.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

## References

- Ishii H, Morita S, Takeuchi Y. Treatment effect of combined maxillary protraction and chin cap appliance in severe skeletal Class III cases. *Am J Orthod Dentofac Orthop* 1987;92:304-12.
- Allwright WC, Burndred WH. A survey of handicapping dentofacial anomalies among Chinese in Hong Kong. *Int Dent J* 1964;14:505-19.
- Cordasco G, Matarese G, Rustico L, Fastuca S, Caprioglio A, Lindauer SJ. Efficacy of orthopedic treatment with protraction facemask on skeletal Class III malocclusion: A systematic review and meta-analysis. *Orthod Craniofac Res* 2014;17:133-43.
- Pinskaya YB, Hsieh TJ, Roberts WE, Hartsfield JK. Comprehensive clinical evaluation as an outcome assessment for a graduate orthodontics program. *Am J Orthod Dentofac Orthop* 2004;126:533-43.
- Lin Y, Guo R, Hou L, Fu Z, Li W. Stability of maxillary protraction therapy in children with Class III malocclusion: A systematic review and meta-analysis. *Clin Oral Investig* 2018;22:2639-52.
- Elnagar MH, Elshourbagy E, Ghobashy S, Khedr M, Evans CA. Comparative evaluation of 2 skeletally anchored maxillary protraction protocols. *Am J Orthod Dentofac Orthop* 2016;150:751-62.
- Tripathi T, Rai P, Singh N, Kalra S. A comparative evaluation of skeletal, dental, and soft tissue changes with skeletal anchored and conventional facemask protraction therapy. *J Orthod Sci* 2016;5:92-9.
- Sar C, Arman-Ozcirpici A, Uckan S, Yazici AC. Comparative evaluation of maxillary protraction with or without skeletal anchorage. *Am J Orthod Dentofac Orthop* 2011;139:636-49.
- Cha BK, Ngan PW. Skeletal anchorage for orthopedic correction of growing Class III patients. *Semin Orthod* 2011;17:124-37.
- Cornelis MA, Scheffler NR, Mahy P, Siciliano S, De Clerck HJ, Tulloch JF. Modified miniplates for temporary skeletal anchorage in orthodontics: Placement and removal surgeries. *J Oral Maxillofac Surg* 2008;66:1439-45.
- Heymann GC, Cevidanes L, Cornelis M, De Clerck HJ, Tulloch JC. Three-dimensional analysis of maxillary protraction with intermaxillary elastics to miniplates. *Am J Orthod Dentofac Orthop* 2010;137:274-84.
- De Clerck HJ, Cornelis MA, Cevidanes LH, Heymann GC, Tulloch CJ. Orthopedic traction of the maxilla with miniplates: A new perspective for treatment of midface deficiency. *J Oral Maxillofac Surg* 2009;67:2123-9.
- De Clerck H, Cevidanes L, Baccetti T. Dentofacial effects of bone-anchored maxillary protraction: A controlled study of consecutively treated Class III patients. *Am J Orthod Dentofac Orthop* 2010;138:577-81.
- Ahn H, Kim SJ, Baek SH. Miniplate-anchored maxillary protraction in adolescent patients with cleft lip and palate: A literature review of study design, type and protocol, and treatment outcomes. *Orthod Craniofac Res* 201;24(Suppl 1):21-30.
- Kircelli BH, Pektas ZÖ. Midfacial protraction with skeletally anchored face mask therapy: A novel approach and preliminary results. *Am J Orthod Dentofac Orthop* 2008;133:440-9.
- Angelieri F, Ruellas AC, Yatabe MS, Cevidanes LHS, Franchi L, Toyama-Hino C. Zygomaticomaxillary suture maturation: Part II-The influence of sutural maturation on the response to maxillary protraction. *Orthod Craniofac Res* 2017;20:252-63.
- Hino CT, Cevidanes LH, Nguyen TT, De Clerck HJ, Franchi L, McNamara JA Jr. Three-dimensional analysis of maxillary changes associated with facemask and rapid maxillary expansion compared with bone anchored maxillary protraction. *Am J Orthod Dentofac Orthop* 2013;144:705-14.
- Baccetti T, De Clerck HJ, Cevidanes LH, Franchi L. Morphometric analysis of treatment effects of bone-anchored maxillary protraction in growing Class III patients. *Eur J Orthod* 2011;33:121-5.
- Major MP, Wong JK, Saltaji H, Major PW, Flores-Mir C. Skeletal anchored maxillary protraction for midface deficiency in children and early adolescents with Class III malocclusion: A systematic review and meta-analysis. *J World Fed Orthod* 2012;1:e47-54.
- Angelieri F, Franchi L, Cevidanes LHS, Hino CT, Nguyen T, McNamara JA Jr. Zygomaticomaxillary suture maturation: A predictor of maxillary protraction? Part I - A classification method. *Orthod Craniofac Res* 2017;20:85-94.
- De Clerck H, Nguyen T, de Paula LK, Cevidanes L.

- Three-dimensional assessment of mandibular and glenoid fossa changes after bone-anchored Class III intermaxillary traction. *Am J Orthod Dentofac Orthop* 2012;142:25-31.
22. Cornelis MA, Tepedino M, Riis NV, Niu X, Cattaneo PM. Treatment effect of bone-anchored maxillary protraction in growing patients compared to controls: A systematic review with meta-analysis. *Eur J Orthod* 2021;43:51-68.
  23. Elnagar MH, Elshourbagy E, Ghobashy S, Khedr M, Evans CA. Dentoalveolar and arch dimension changes in patients treated with miniplate-anchored maxillary protraction. *Am J Orthod Dentofac Orthop* 2017;151:1092-106.
  24. Elnagar MH, Elshourbagy E, Ghobashy S, Khedr M, Kusnoto B, Evans CA. Three-dimensional assessment of soft tissue changes associated with bone-anchored maxillary protraction protocols. *Am J Orthod Dentofac Orthop* 2017;152:336-47.
  25. Hiyama S, Suda N, Ishii-Suzuki M, Tsuiki S, Ogawa M, Suzuki S. Effects of maxillary protraction on craniofacial structures and upper-airway dimension. *Angle Orthod* 2002;72:43-7.
  26. Quo S, Lo LF, Guilleminault C. Maxillary protraction to treat pediatric obstructive sleep apnea and maxillary retrusion: A preliminary report. *Sleep Med* 2019;60:60-8.
  27. Seo WG, Han SJ. Comparison of the effects on the pharyngeal airway space of maxillary protraction appliances according to the methods of anchorage. *Maxillofac Plast Reconstr Surg* 2017;39:3.
  28. Kale B, Buyukcavus MH. Determining the short-term effects of different maxillary protraction methods on pharyngeal airway dimensions. *Orthod Craniofac Res* 2021;24:543-52.
  29. Nguyen T, Cevidanes L, Paniagua B, Zhu H, Koerich L, De Clerck H. Use of shape correspondence analysis to quantify skeletal changes associated with bone-anchored Class III correction. *Angle Orthod* 2014;84:329-36.
  30. Nguyen T. Dentofacial orthopedics for class III corrections with bone-anchored maxillary protraction. *In Temporary Anchorage Devices in Clinical Orthodontics*, Jae Hyun Park (editor). John Wiley and Sons Inc., New Jersey, U.S.A. 2020, pp. 185-90.
  31. Cevidanes L, Baccetti T, Franchi L. Comparison of two protocols for maxillary protraction: Bone anchors versus face mask with rapid maxillary expansion. *Angle Orthod* 2010;80:799-806.
  32. Ağlarıcı C, Esenlik E, Fındık Y. Comparison of short-term effects between face mask and skeletal anchorage therapy with intermaxillary elastics in patients with maxillary retrognathia. *Eur J Orthod* 2016;38:313-23.
  33. Lagravère MO, Carey J, Heo G, Toogood RW, Major PW. Transverse, vertical, and anteroposterior changes from bone-anchored maxillary expansion vs traditional rapid maxillary expansion: A randomized clinical trial. *Am J Orthod Dentofac Orthop* 2010;137:304.e1-12.
  34. Steegman RM, Meulekamp AF, Dieters A, Jansma J, van der Meer WJ, Ren Y. Skeletal changes in growing cleft patients with class III malocclusion treated with bone anchored maxillary protraction- A 3.5-year follow-Up. *J Clin Med* 2021;10:750.
  35. De Clerck EE, Swennen GR. Success rate of miniplate anchorage for bone anchored maxillary protraction. *Angle Orthod* 2011;81:1010-3.
  36. Van Hevele J, Nout E, Claeys T, Meyns J, Scheerlinck J, Politis C. Bone-anchored maxillary protraction to correct a class III skeletal relationship: A multicenter retrospective analysis of 218 patients. *J Craniomaxillofac Surg* 2018;46:1800-6.
  37. Elabbassy EH, Sabet NE, Hassan IT, Elghoul DH, Elkassaby MA. Bone-anchored maxillary protraction in patients with unilateral cleft lip and palate: Is maxillary expansion mandatory? *Angle Orthod* 2020;90:539-47.
  38. Gomes OS, Carvalho RM, Faco R, Yatabe M, Ozawa TO, De Clerck H, et al. Influence of bone-anchored maxillary protraction on secondary alveolar bone graft status in unilateral complete cleft lip and palate. *Am J Orthod Dentofac Orthop* 2020;158:731-7.
  39. Yang IH, Chang YI, Kim TW. Effects of cleft type, facemask anchorage, and alveolar bone graft on maxillary protraction: A three-dimensional finite element analysis. *Cleft Palate Craniofac J* 2012;49:221-9.
  40. Stangherlin Gomes O, Carvalho RM, Faco R, Yatabe M, Ozawa TO, De Clerck H. Influence of bone-anchored maxillary protraction on secondary alveolar bone graft status in unilateral complete cleft lip and palate. *Am J Orthod Dentofac Orthop* 2020;158:731-7.
  41. Ren Y, Steegman R, Dieters A, Jansma J, Stamatakis H. Bone-anchored maxillary protraction in patients with unilateral complete cleft lip and palate and Class III malocclusion. *Clin Oral Invest* 2019;23:2429-41.
  42. Lee NK, Baek SH. Stress and displacement between maxillary protraction with miniplates placed at the infrazygomatic crest and the lateral nasal wall: A 3-dimensional finite element analysis. *Am J Orthod Dentofac Orthop* 2012;141:345-51.
  43. Yatabe M, Garib DG, Faco RAS, de Clerck H, Janson G, Nguyen T. Bone-anchored maxillary protraction therapy in patients with unilateral complete cleft lip and palate: 3-dimensional assessment of maxillary effects. *Am J Orthod Dentofac Orthop* 2017;152:327-35.
  44. Kook YA, Bayome M, Park JH. New approach of maxillary protraction using modified C-palatal plates in Class III patients. *Korean J Orthod* 2015;45:209-14.
  45. Ngan P, Wilmes B, Drescher D, Martin C, Weaver B, Gunel E. Comparison of two maxillary protraction protocols: Tooth-borne versus bone-anchored protraction facemask treatment. *Prog Orthod* 2015;16:1-11.
  46. Feng X, Li J, Li Y, Zhao Z, Zhao S, Wang J. Effectiveness of TAD-anchored maxillary protraction in late mixed dentition: A systematic review. *Angle Orthod* 2012;82:1107-14.
  47. Nguyen T, Cevidanes L, Cornelis MA, Heymann G, De Paula LK, De Clerck H. Three-dimensional assessment of maxillary changes associated with bone anchored maxillary protraction. *Am J Orthod Dentofac Orthop* 2011;140:790-8.