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Clinical Effectiveness of Miniscrew Anchorage for Maxillary Protraction: An Outcome Evaluation

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ABSTRACT

In recent years, various bone-anchored maxillary protraction (BAMP) methods have been developed to treat developing Class III. The most important factor influencing the success of bone anchorage in orthodontics is mini-implant stability. This prospective study was conducted to assess the success rate of miniscrew anchorage for MAMP in patients with developing maxillary retrusion. In this study, twenty patients with maxillary hypoplasia without clefts or craniofacial abnormalities (11.4 ± 1.3 years; range, 9.5-13.2 years) were enrolled. A hybrid hyrax expander with miniscrew support was given to each participant, and it was activated for nine weeks using the Alt-RAMEC protocol. Each case included a miniscrew-anchored mandibular bar that served as an attachment for 200 g full-time Class III elastics. When a positive overjet was achieved, maxillary protraction was stopped. The same operator installed 80 mini-screws in total (40 maxilla and 40 mandible). Fisher's exact test was used to analyze the miniscrew success rate for gender and insertion site at the 5% level of significance. In every instance, maxillary protraction was accomplished in 12.2 ± 2.1 months. Gender and insertion place did not significantly correlate with miniscrew failure ($P > 0.05$). The mandibular interradicular screws had an 87.5% success rate, while the palatal screws had a 97.5% success rate. Miniscrew skeletal anchoring works well for BAMP. Mandibular interradicular screws were less successful than palatal mini-screws, however, the difference was not statistically significant.

Keywords: Class III, Maxillary protraction, Mini-implant, Success rate

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Introduction

For many years, growing patients with maxillary hypoplasia were treated with facemask therapy [1] while used with tooth-borne intraoral appliances, the protraction facemask has several drawbacks, including dentoalveolar compensations, clockwise and anticlockwise mandibular and maxillary rotation, and noncompliance, particularly while leading an active lifestyle [2-6]. Several bone-anchored protraction procedures using class III elastics were developed to address these side effects, such as bone-anchored maxillary protraction (BAMP) using microplates and hybrid hyrax (HH) mentoplasty combination [7, 8]. Following flap elevation, the surgeon must implant the aforementioned plates while under general anesthesia. Under local anesthesia, orthodontists can easily install the tiny crew implants. Miniscrew anchored maxillary protraction (MAMP), a modified BAMP that substitutes mini-screws for mini plates, was given in several papers [9-12]. Although the success rate of mini-screws in MAMP has not yet been examined, these reports demonstrated encouraging results. To assess the success rate of miniscrew anchorage for MAMP in patients with developing maxillary retrusion, this prospective study was conducted.

Materials and Methods

Twenty patients were recruited for this study from the postgraduate clinic of orthodontics, Faculty of Dentistry, Mansoura University, Egypt. The mean age of patients was 11.4 ± 1.3 years (range, 9.5-13.2 years). Ten male (mean age, 11.6 ± 1.3 years; range, 9.7-13.2 years) and 10 female patients (mean age, 11.2 ± 1.2 years; range, 9.5-13 years) were included. The success rate was used as a parameter for sample size calculation by using the two proportions Z-test. Based on a previous study, the difference between the two proportions was determined as 27.8% [13]. The power analysis revealed that 33 mini-implants per group were needed to detect clinically meaningful differences between the groups at a power of 90% and a significance level of 0.05. The sample size was estimated by G*Power (Version 3.1.9.4; Kiel University, Germany). Accordingly, a total of 80 mini-implants (40 per group) which were inserted in 20 patients, were evaluated in the study.

The inclusion criteria were; growing Class III patients with maxillary hypoplasia erupted mandibular canines and no clefts or craniofacial anomalies. Written consents were signed by the parents before patient inclusion.

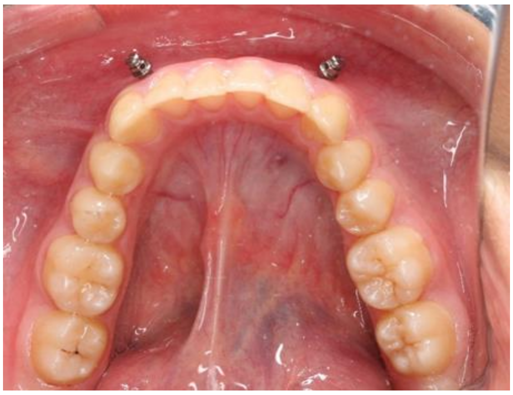
In the maxillary arch, 2 paramedian palatal mini-screws (8 mm length,1.8 mm diameter, 3 M ESPE Dental Products, St. Paul, MN, USA) were inserted distal to the 3rd palatine rugae and 3 to 5 mm lateral to the mid palatine raphe according to the protocol described by Wilmes *et al.* and Becker *et al.* **(Figure 1a)** [14, 15]. The O-caps were used over the screws acting as transfer caps and attachments for the HH. A silicon impression was recorded for the upper arch with the caps in place. Then the HH was fabricated on the dental model and welded to the caps on the transfer analogs. Posterior bite blocks were added to the HH to avoid any occlusal interference during protraction. Buccal hooks on the molar bands were used as attachments for elastics. The HH was cemented 3 weeks after mini-screw insertion using a Blue band (SIA Orthodontic Manufacturer, Rocca d' Evandro, Italy) **(Figure 2)**. Nine weeks of alternate rapid maxillary expansions and constrictions (Alt-RAMEC), with an activation protocol of 2 quarter turns every 12 h, were initiated.

In the 7th week of Alt-RAMEC, 2 inter radicular screws (8 mm length, 1.5 mm diameter, 2mm transmucosal, Morelli, S.B, Brasil) were inserted at the mucogingival level between the mandibular canine and lateral incisor with 20-30 degrees to the occlusal plane apically **(Figure 1b)** [10]. The screws were transferred to the model using a silicon impression for the lower arch. A custom-made bar was fabricated to fit perfectly over the screws with 2 hooks above the screws for elastic attachment. The bar was cemented with the Blue band.

All the mini-screws were inserted by the same operator (AK) under local anesthetic. All patients were instructed to rinse with chlorhexidine HCL (125 mg/100 ml) mouthwash and after meals for 2 weeks. Paracetamol (500 mg/12 h) was prescribed for 2 days. Chlorhexidine gluconate (0.1%) containing toothpaste was used daily till the end of treatment.

After 2 weeks, intermaxillary class III elastics (Ortho Organizers, CA, USA) running from the maxillary hooks to the bar, were used on both sides for 24 hours a day **(Figure 3)**. The patients were instructed to change the elastics every 12 hours. The initial force was 100 g per side. It was increased to 200 g per side after one month and kept at that level till the end of treatment. The mean follow-up period was 12.2 ± 2.1 months (range, 9-16 months).

a)



b)

Figure 1. a) Palatal paramedian mini-implants; b) Lower inter radicular mini-implants.

Figure 2. Hybrid Hyrax expander, anchored on 2 paramedian palatal mini-implants.

Figure 3. Miniscrew anchored maxillary protraction, intermaxillary elastics running from hybrid hyrax to the miniscrew supported mandibular bar.

Statistical analysis

SPSS® for Windows version 23.0 (IBM Corp., Armonk, NY, USA) was used for all statistical analyses. The normal distribution of the metrical parameters was tested using the Kolmogorov-Smirnov (K-S) test. The success rates of mini-screws were examined using the following parameters: 1) location of insertion; 2) gender of the patient. Fisher's exact test for non-parametric data was used to compare nominal variables. The threshold for statistical significance was $P < 0.05$.

Results and Discussion

IBM Corp., Armonk, NY, USA's SPSS® for Windows version 23.0 was used for all statistical analyses. The metrical parameters were tested for normality using the Kolmogorov-Smirnov (K-S) test. About miniscrew success rates, the following parameters were examined: 1) Patient gender, and 2) Insertion place. For non-parametric data, Fisher's exact test was used to compare nominal variables. At $P < 0.05$, statistical significance was established.

A male patient reported pain in one palatal insertion site after nine weeks, and when the device was removed, the associated screw fell away. Four weeks later, it was put back in a more lateral position.

All patients reported lower lip and tongue irritation following the screw insertion session before device delivery. This was resolved by applying soft wax to the screw's head.

With great patient acceptability, the mini-screws offer superior skeletal anchoring. In recent years, various reports on miniscrew failure and success rates have been published [16-20]. Only the impact of constant loading on the stability of mini-screws was examined, though. Intermaxillary elastics do not provide a constant or consistent force throughout time. Because of the many mandibular movements involved in chewing, swallowing, and speaking, the force varies in duration, direction, and amount. The success rate according to sex and insertion site is presented in **Table 1**.

Table 1. Success rate according to sex and insertion site.

Variable		Stable *n* (%)	Failed *n* (%)	**P* value
Sex (n = 80)	Male (n = 40)	36 (90%)	4 (10%)	0.675
	Female (n = 40)	38 (95%)	2 (5%)	
Site (n = 80)	Maxilla (n = 40)	39 (97.5%)	1 (2.5%)	0.201
	Mandible (n = 40)	35 (87.5%)	5 (12.5%)	

Fisher's exact test, *$P < 0.05$

To the best of our knowledge, no research has been done on the success rate of miniscrew anchorage for maxillary protraction using a hybrid hyrax-intermaxillary elastics combination in growing patients. In contrast to the current study's finding of 97.5%, a clinical trial including 48 screws indicated a miniscrew success rate with a MAMP of 79.2% in the maxilla [11]. This is explained by the variations in the loading protocol and insertion sites. In our investigation, the authors employed buccal interradicular sites rather than palate paramedian sites. According to reports, the anterior palatal screws had a greater success rate (98.9%) than the interradicular screws (71.1%) [13]. In contrast to our protocol's indirect loading through the hybrid hyrax, the protraction forces were applied directly to the screws. The mandibular success rate (87.5%) matched our findings. The connecting bar's increased surface area of the two screws could be the cause [21].

It has been demonstrated that indirect loading is more successful than direct use [22]. Unlike indirect loading in the maxilla, elastic forces directly loaded the mandibular screws. But with greater success, the palatal screws were given a greater Alt-RAMEC expansion force. The current investigation used the moderate loading forces that were recommended for high success [23].

The screw's diameter and length have an impact on its success [20]. Our study's use of various screw types and sizes, but not length, is a limitation. Because the mandible has a limited interradicular insertion site, screws with a lower diameter were selected. Nonetheless, it is anticipated that the 1.6 mm screw will fail less frequently than the 1.8 mm screw [20]. Due to the screws' identical length, bicortical insertion—which was advised for increased stability—was not examined in this study. The mechanical retention of the mini-screws in the external cortical bone is the primary determinant of the initial stability. Consequently, the screw's initial stability is determined by the thickness and density of this bone, which is thinner in growing patients than in adult individuals [24]. Although the density was not examined, it most likely played a role in the screws' failure in our investigation.

All in all, careful observation of oral hygiene, gingival status, miniscrew mobility, and elastic forces are essential for successful treatment.

Conclusion

- Miniscrew anchorage is successful for bone-anchored maxillary protraction.
- The palatal paramedian mini-screws offered a higher survival rate of 97.5%.
- Splinting the 2 mandibular screws resulted in a success rate of 87.5%.

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Conflict of interest: None

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Ethics statement: The study protocol was approved by IRB (code no. A16260219).

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