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EVALUATION OF PALATAL ANCHORAGE-SUPPORTED MAXILLARY ARCH MESIALIZATION

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Abstract

Objectives: This retrospective study compared the dental and skeletal effects of two palatal mini-screw-supported methods for maxillary arch mesialization, a Cap Splint appliance and a transpalatal arch (TPA) with NiTi closed-coil springs, in Class III camouflage patients. **Materials and Methods:** We retrospectively reviewed the records of 142 patients treated for Class III malocclusion at the Department of Orthodontics, Istanbul Okan University, between 2018 and 2025. A total of 26 patients met the inclusion criteria and were enrolled. 11 patients were treated with an acrylic Cap Splint appliance covering complete dentition supported by palatal mini-screws, and 15 were treated with NiTi closed-coil springs placed between a TPA and palatal mini-screws. 11 skeletal and dental parameters were measured on lateral cephalometric radiographs before (T0) and after (T1) treatment, using NemoStudio software (Software Nemotec, Madrid, Spain), and compared within and between the two groups. Significance was set at $p<0.05$.**Results:** 5 of the 11 measurements showed statistically significant changes in both groups. SNA increased significantly in the Cap Splint group, where ANB also increased by a mean of 1.55°; in the TPA group, ANB instead declined by 0.87°. The upper molars moved mesially by 1.36 mm in the Cap Splint group and 3.57 mm in the TPA group, avarege amount of movement was 0.17 mm and 0.44 mm per month. The upper incisors also moved labially in both groups (2.31 mm and 1.77 mm), but only the TPA group showed a significant increase in incisor proclination (5.73°), suggesting the incisors tipped labially more in this group. Overjet increased significantly in both groups (1.61 mm and 1 mm), while GoMe-SN, U6-HD, OP-SN, and overbite did not show statistically significant change. **Conclusion:** Both methods were found effective in the maxillary arch mesialization without major vertical side effects. The Cap Splint moved the whole dentition, while in the TPA method molars moved further mesially but tends to tip the upper incisors labially. Patient's age, growth stage, and the required type of tooth movement should guide treatment planning.

Keywords: Class Iii Malocclusion, Camouflage Treatment, Palatal Mini-Screw, Cap Splint, Transpalatal Arch, Maxillary Arch Mesialization, Cephalometry.

INTRODUCTION

Class III malocclusion is one of the most difficult skeletal problems to treat and retain in orthodontics. It has many causes and can involve a forward-positioned mandible, an underdeveloped maxilla, retroclined lower incisors, protruded upper incisors, or a combination of these features [1, 2].

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Treatment of Class III malocclusion is usually grouped into three approaches: growth modification, orthodontic camouflage, and orthognathic surgery. The indication depends on the patient's growth stage, how severe the skeletal or dental problem is, and the patient's esthetic expectations [3].

In growing patients with an underdeveloped maxilla, facemask can be used to move the maxilla forward. Once growth is complete, though, these orthopedic methods have limited effect, which makes treatment planning harder in adults [4]. Orthognathic surgery is often used in adults to correct skeletal problems permanently, but its invasive nature, recovery time, and cost lead many clinicians and patients to look for non-surgical options [3].

Orthodontic camouflage is one such option. It can improve both function and appearance, especially in patients with mild to moderate skeletal problems. Moving the upper dental arch forward, is a key part of this treatment. This movement, however, needs strong and stable anchorage to be succeed. Traditional anchorage methods, such as reverse headgear or inermaxillary elastics, often fail because of side effects or poor patient compliance. For this reason, temporary anchorage devices (TADs) are used often in modern orthodontic treatment approaches[5]. Mini-screws, a form of skeletal anchorage, are a reliable and minimally invasive option that can support difficult tooth movements.

Mini-screws are often placed in the buccal interradicular area, but this spot can sometimes interfere with the planned tooth movement. To eliminate that risk, the anterior palate can be chosen for TAD placement [6, 7].

Palatal mini-screws have several advantages. The amount of cortical bone in this region leads higher primary stability of mini-screws [8]. This region also has a low risk of damaging tooth roots, and high success rates [9, 10].

There are different ways to use palatal anchorage to move the upper arch mesially. This study compares two methods of full-arch mesialization using palatal mini-screw anchorage in patients needing Class III camouflage: a Cap Splint appliance covering all teeth, and a method that applies force only to the molars via TPA from the same anchorage site.

MATERIALS AND METHODS

In this retrospective study the digital records and files of 142 patients treated for Class III malocclusion between 2018 and 2025 at the Department of Orthodontics, Istanbul Okan University Mecidiyeköy Dental Hospital were reviewed. From these records, patients who had maxillary arch mesialization with palatal mini-screw support, using one of following two methods were selected: a palatal mini-screw-supported acrylic Cap Splint, or NiTi closed-coil springs between a TPA and palatal mini-screws. Patients were divided into two groups accordingly: the Cap Splint group and the TPA group.

Lateral cephalometric radiographs taken before and after treatment were collected. Patients with complete records were included; those with missing records, poor image

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quality, or incomplete treatments were excluded. In total, 26 patients met these criteria: 11 in the Cap Splint group and 15 in the TPA group.

Cephalometric analysis was done using NemoStudio software (Software Nemotec, Madrid, Spain). The study was approved by the Istanbul Okan University Non-Interventional Clinical Research Ethics Committee for Science, Social, and Health Sciences on 05.03.2025.

Cap Splint Protocol: According to the patient records, those treated with the Cap Splint wore an acrylic splint covering the buccal and palatal surfaces of all teeth, connected to the palatal mini-screws with a connector bar and four NiTi closed-coil springs.

TPA Protocol: Records showed that patients treated with the TPA method had Mini Master 0.022×0.025-inch MBT brackets (American Orthodontics). Leveling was done with NiTi archwires, after which mesialization was carried out using closed-coil springs placed between the palatal mini-screws and the TPA. 0.018-inch stainless steel archwires were used in patients with diastemas; 0.017×0.025-inch stainless steel archwires were used in those without diastemas.

Palatal Mini-Screw: Records showed that palatal anchorage was routinely provided with 1.6×8 mm stainless steel Erverdi screws (TasarımMed), placed with a self-drilling technique and positioned behind the third and fourth palatal rugae, on both sides of the midpalatal suture.

Mesialization Methods: According to the records, patients in the Cap Splint group received about 800 g of force through four closed-coil springs and a connector bar. In the TPA group, records showed that immediate loading was applied, using three NiTi closed-coil springs between the mini-screws and the TPA, applying about 600 g of force.

Cephalometric Reference Points: Sella (S): the center of the sella turcica. Nasion (N): the point where the frontal and nasal bones meet, at its most forward point. Point A: the deepest point of the maxilla, front to back. Point B: the deepest point of the mandible, front to back. Gonion (Go): the point where the ramus meets the body of the mandible. Menton (Me): the lowest point where the body and symphysis of the mandible meet. Anterior Nasal Spine (ANS): the most forward point of the maxilla. Posterior Nasal Spine (PNS): the most backward point of the hard palate.

Reference Planes: SN plane: connects Sella (S) and Nasion (N). GoMe plane: connects Gonion (Go) and Menton (Me), representing the mandible. Occlusal plane (OP): based on the incisal edges of the incisors and the contact points of the back teeth. Horizontal plane (HD): drawn at about 7° to the SN plane. Vertical plane (VD): passes through subnasale, at a right angle to the horizontal plane.

Angular Parameters: SNA: the angle between the Sella-Nasion line and the Nasion-A line. SNB: the angle between the Sella-Nasion line and the Nasion-B line. ANB: shows the front-to-back relationship between the maxilla and mandible. GoMe-SN: the angle between the mandibular plane and the SN line. OP-SN: the angle between the occlusal plane and the SN line. U6-HD: the angle between the long axis of the upper first molar

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and the horizontal plane. I-HD: the angle between the long axis of the upper central incisor and the horizontal plane.

Linear Parameters: U6-VD: the distance, in mm, from the back of the upper first molar to the vertical plane. I-VD: the distance, in mm, from the edge of the upper central incisors to the vertical plane. Overjet: the horizontal distance between the upper and lower incisors. Overbite: how much the upper incisors cover the lower incisors vertically.

Statistical Analysis: Data were analyzed using IBM SPSS Statistics 27. The Shapiro-Wilk test checked whether the data followed a normal distribution. Results are given as mean and standard deviation. For comparisons between groups, we used the Student's t-test for normally distributed data and the Mann-Whitney U test for non-normal data. Within-group changes were assessed with the paired-samples t-test. Sex distribution was compared using the Chi-square test. Measurement reliability was checked with the intraclass correlation coefficient (ICC). Significance was set at $p<0.05$.

RESULTS

The study included 26 patients aged 12 to 37 years: 13 (50%) were female and 13 (50%) were male. The mean age was 16.81±5.23 years, and the median age was 15 years. Patients in the Cap Splint group were significantly younger, on average, than those in the TPA group ($p=0.002$). Sex distribution did not differ between groups ($p>0.05$) (Table 1).

Table 1: Evaluation of the Groups In Terms of Age and Sex

	Cap Splint (n=11)	TPA (n=15)	p
Age (mean±SD)	13.45±0.69	19.27±5.76	0.002*
Female n (%)	5 (45.5)	8 (53.3)	0.691
Male n (%)	6 (54.5)	7 (46.7)	

Age: Student's t-test; Sex: Chi-square test. *$p<0.05$.

U6-VD was similar in both groups at T0 and T1 ($p>0.05$). Within each group, though, it dropped significantly from T0 to T1 (Cap Splint, $p=0.012$; TPA, $p=0.001$).

U6-HD was significantly higher in the Cap Splint group than the TPA group at both T0 and T1 ($p=0.001$). Neither group changed significantly over time ($p>0.05$).

GoMe-SN stayed stable in both groups, with no significant differences between or within groups ($p>0.05$). SNA was similar between groups at T0 and T1 ($p>0.05$). It increased significantly in the Cap Splint group ($p=0.001$) but not in the TPA group.

SNB did not change significantly, either between or within groups ($p>0.05$).

At T0, ANB was significantly lower in the Cap Splint group than the TPA group ($p=0.037$); this difference disappeared by T1. Within groups, ANB increased significantly in the Cap Splint group ($p=0.003$) and decreased significantly in the TPA group ($p=0.013$).

I-VD decreased significantly in both groups (Cap Splint, $p=0.005$; TPA, $p=0.009$), with no significant difference between groups at either time point.

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I-HD was similar between groups at T0 and T1 (p>0.05). It did not change in the Cap Splint group but increased significantly in the TPA group (p=0.010).

OP-SN showed no significant change, either between or within groups (p>0.05).

Overjet was significantly lower in the Cap Splint group than the TPA group at T0 (p=0.016), but this difference was gone by T1. Both groups showed a significant increase over time (Cap Splint, p=0.002; TPA, p=0.009). Overbite did not change significantly in either group, and there was no significant difference between groups at either time point.

In total, 5 of the 11 parameters changed significantly within each group: U6-VD, SNA, ANB, I-VD, and overjet in the Cap Splint group; U6-VD, ANB, I-VD, I-HD, and overjet in the TPA group (Table 2).

Table 2: Between-Group and Within-Group Comparisons of the Parameters (T0-T1)

Parameter	Cap Splint T0	Cap Splint T1	TPA T0	TPA T1	Within-group p
U6-VD (mm)	50.10±3.76	48.74±3.43*	50.43±3.97	46.86±4.99*	CS:0.012/TPA:0.001
U6-HD (°)	84.51±5.54	84.05±4.64	75.75±6.10	75.0±6.70	CS:0.632/TPA:0.750
GoMe-SN (°)	30.27±5.93	30.45±5.84	31.47±7.76	30.87±7.23	CS:0.588/TPA:0.328
SNA (°)	78.45±2.88	80.36±3.04*	81.27±5.59	81.00±5.15	CS:0.001/TPA:0.433
SNB (°)	80.27±3.95	80.64±3.78	81.13±5.95	81.67±5.47	CS:0.104/TPA:0.120
ANB (°)	-1.82±2.32	-0.27±2.45*	0.13±2.17	-0.73±2.09*	CS:0.003/TPA:0.013
I-VD (mm)	12.97±2.82	10.65±2.32*	12.32±2.85	10.55±3.05*	CS:0.005/TPA:0.009
I-HD (°)	113.80±7.25	114.63±6.92	112.33±10.44	118.07±10.87*	CS:0.275/TPA:0.010
OP-SN (°)	13.55±4.52	14.64±4.80	12.67±7.03	12.0±6.56	CS:0.154/TPA:0.284
Overjet (mm)	1.34±3.11	2.95±3.51*	3.70±1.48	4.70±1.02*	CS:0.002/TPA:0.009
Overbite (mm)	1.73±1.70	1.08±1.46	0.78±1.09	1.14±1.68	CS:0.220/TPA:0.266

*p<0.05; CS: within-group p value for the Cap Splint group (T0-T1); TPA: within-group p value for the TPA group (T0-T1).

When we compared the total change from T0 to T1 between groups, the Cap Splint group showed a smaller U6-VD decrease (-1.36±1.49 mm) than the TPA group (-3.57±2.50 mm) (p=0.014), meaning the molars moved about 0.17 mm per month in the Cap Splint group versus 0.44 mm per month in the TPA group. SNA and ANB also changed differently between groups (both p=0.001): both increased in the Cap Splint group and decreased in the TPA group. No other parameter (GoMe-SN, U6-HD, SNB, I-VD, I-HD, OP-SN, overjet, overbite) showed a significant difference between groups (p>0.05) (Table 3).

Table 3: Comparison of the Groups In Terms of Change Amounts from Baseline to the End of Treatment

Parameter (T0-T1 change)	Cap Splint (Mean±SD)	TPA (Mean±SD)	p
U6-VD (mm)	-1.36±1.49	-3.57±2.50	0.014*
U6-HD (°)	-0.45±3.05	-0.75±8.97	0.659
GoMe-SN (°)	0.18±1.08	-0.60±2.29	0.313
SNA (°)	1.91±1.22	-0.27±1.28	0.001*

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SNB (°)	0.36±0.67	0.53±1.25	0.568
ANB (°)	1.55±1.29	-0.87±1.19	0.001*
I-VD (mm)	-2.31±2.17	-1.77±2.24	0.378
I-HD (°)	0.76±2.19	5.73±7.46	0.073
OP-SN (°)	1.09±2.34	-0.67±2.32	0.075
Overjet (mm)	1.61±1.28	1.00±1.27	0.232
Overbite (mm)	-0.65±1.63	0.36±1.20	0.107

Mann-Whitney U test. *$p<0.05$.

Method error was calculated separately for each parameter in both groups. The intraclass correlation coefficient (ICC) was close to 1.00 for every parameter (ICC>0.93, $p<0.001$), showing that the measurements were highly reliable and repeatable.

DİSCUSSİON

Camouflage treatment for Class III malocclusion is one of the more difficult areas of orthodontics. Adult patients cannot benefit from orthopedic correction, so treatment relies mainly on dentoalveolar changes. Moving the upper arch mesially is especially demanding, both technically and because of possible side effects. There is also relatively little research comparing different biomechanical approaches for Class III camouflage, which makes a closer look at these methods useful [11–13].

In recent years, skeletal anchorage devices are being used frequently. They help reduce the side effects of tooth-borne appliances such as Class III elastics and facemasks, and they allow more mesial movement of the upper arch [14–17]. Mini-screw anchorage can move either the teeth alone or the whole dentoalveolar segment together [7, 18]. The anterior palate is a good location for this, because mini-implants placed there do not block tooth movement [7].

This retrospective study compares full-arch mesialization using a palatal mini-screw supported Cap Splint, which covers all teet and, with full-arch mesialization that applies force from TPA only to the molars from the same anchorage site, in patients needing Class III camouflage. Both methods are simple to use in daily practice and could see wide clinical use, so we aim this study provides useful information to the literature on orthodontic camouflage.

Patient age is one factor that affects how well mini-screws work. Since this is a retrospective study, patient groups could not be standardized beforehand. The Cap Splint group had a mean age of 13.45 years, while the TPA group had a mean age of 19.27 years.

The lower average age in the Cap Splint group may relate to growing and remodeling bone, which can lead to an easier full-arch mesialization. In growing patients, skeletal effects can be observed readily, which could have been caused this choice of method.

In older patients, a slower, more controlled approach to mesialization may have been preferred. Clinicians likely aimed to move the molars gradually with lighter forces, closing

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spaces step by step through a chain of tooth movements. Older patients may also find a Cap Splint less comfortable to wear, which could also explain the treatment choice.

The literature gives mixed results on how age affects mini-screw success. Some studies suggest that primary stability is weaker in younger patients. Lee et al. found lower success rates in patients under 20 [20], while Jing et al. found the opposite pattern, with lower success under age 12 and higher success in adults [20]. This is often explained by younger patients having thinner cortical bone and lower bone density than adults. Hemmatpour et al. described a case where a 25-year-old patient had total arch mesialization in both jaws using a mini-screw-supported system, with good aesthetic and occlusal results [18]. However, it is a single case report, so it offers limited evidence. Other studies report no clear effect of age on success, which matches our findings [21–25]. We found no difference in sex distribution between our groups. Several studies have looked at whether sex affects mini-screw success. Baek et al. reported higher success in women, linking this to thinner cortical bone and lower bone density, which allows screws to be placed with less torque [25]. Manni et al., on the other hand, reported higher success in men [22]. Most studies, though, found no clear link between sex and mini-screw success [19, 20, 24, 26–28], which matches our results. Overall, the effect of sex on mini-screw outcomes remains unclear in the literature.

Comparing pre- and post-treatment measurements, we found significant changes in 5 of the 11 parameters in both groups, and no significant change in the other 6.

SNA increased significantly in the Cap Splint group, while SNB did not show significant change. ANB increased significantly by a mean of 1.55°. In the TPA group, neither SNA nor SNB changed significantly, but ANB decreased significantly by 0.87°. In the Cap Splint group, the whole dentition likely moved together, so the incisors shifted position without tipping labially, which may have moved Point A slightly forward too. This could explain the increase in both SNA and ANB angles. In the TPA group, teeth movements seem to have been mostly in buccal segments, without obvious bodily movement of the incisor roots, and more of a tipping motion. This finding may explain why SNA did not change in that group. GoMe-SN did not change significantly in either groups, suggesting that the mandibular plane did not rotate during mesialization. This finding matches with Kahraman’s study[29]. OP-SN also did not change significantly in either groups, suggesting no major rotation of the occlusal plane.

U6-HD, the angle of the upper molar relative to the horizontal plane, did not change significantly in either groups, suggesting the molars did not tip mesially or distally. However, U6-HD was higher in the Cap Splint group than the TPA group at both time points. This may be occured because, in the TPA group, molar movement began only after leveling was finished and stiffer wires were placed, while in the Cap Splint group the rigid, single-unit force applied before any leveling, and that may have kept the molars from tipping during movement.

U6-VD, which shows how far the molars moved mesially, decreased by 1.36 mm in the Cap Splint group and 3.57 mm in the TPA group. Over an average 8-month treatment

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period, this works out to about 0.17 mm per month in the Cap Splint group and 0.44 mm per month in the TPA group. These rates are lower than the 0.54 mm per month reported by Kahraman [29], possibly because that study also included cases of single-tooth movement, which can move faster. Becker et al. [30], using the Mesialslider appliance, reported 0.45 mm per month, close to our TPA group results; the slower movement in our Cap Splint group may be because the teeth moved together as one unit, spreading the force across the whole arch and increasing anchorage control.

I-VD, which shows how far the incisors moved labially, decreased significantly in both groups: 2.31 mm in the Cap Splint group and 1.77 mm in the TPA group. This shows that mesialization affected the anterior teeth too. Becker et al. [30] reported 0.45 mm of labial incisor movement after bilateral molar mesialization with the Mesialslider system. The numbers are not directly comparable, but both studies show that the incisors are affected by this treatment.

I-HD, the inclination of the upper incisors, did not change in the Cap Splint group but increased significantly by 5.73° in the TPA group, showing more labial tipping, or proclination, in that group. This suggests the Cap Splint group had more bodily tooth movement, while the TPA group had more tipping. Wilmes et al. [31] also reported obvious incisor proclination using the B-mesialslider appliance. Kawamura et al. [32], in a finite element study, likewise found increased incisor proclination during mesialization.

Overjet increased significantly in both groups: 1.61 mm in the Cap Splint group and 1 mm in the TPA group. This increase is likely linked to the mesialization movement itself in the Cap Splint group, and to incisor proclination in the TPA group.

Overbite did not change significantly in either groups. Along with the lack of occlusal plane rotation, this suggests that the mesialization force was applied close to the center of resistance of the dentoalveolar segment. Kawamura et al. [32] reported a similar finding: no rotation occurs when force passes through the center of resistance.

CONCLUSİON

Both methods moved the maxillary arch mesially effectively. In the Cap Splint group, the whole dentoalveolar segment moved together; in the TPA group, the molars moved further mesially. Both methods provided increase in overjet. Since the vertical parameters did not change significantly, neither method appears to cause major vertical side effects. Tooth movement was more bodily and parallel in the Cap Splint group, while the TPA group showed a tendency toward labial tipping of the upper incisors. Both methods can be used in practice, but patient age and the type of required tooth movement should guide the choice.

Limitations: This study has some limitations. Because the data came from existing patient records, we could not standardize every treatment variables. Different clinicians performed the treatments, which may have caused some variation in screw placement, force control, and mechanics. Also, because we used two-dimensional lateral cephalograms, we could not examine three-dimensional dentoalveolar changes in detail.

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Recommendations: Future studies with larger and prospective samples are required. Matching patient groups by growth stage would allow a more reliable comparison between methods. Three-dimensional imaging would allow more detailed evaluation of dentoalveolar changes, and long-term follow-up data would provide more information about stability over time.

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