Assessment of the Ideal Locations of Midpalatal Anchorage Miniscrews on Cadaver Maxilla

Midpalatal Ankoraj Minividalarının İdeal Lokalizasyonlarının Kadavra Maksillalarında Değerlendirilmesi

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ABSTRACT Objective: The aim of this study was to determine neighboring tissue damage and potential risks during midpalatal miniscrew placement and provide an ideal insertion method for miniscrew placement. **Material and Methods:** Bilateral twelve midpalatal anchorage miniscrew insertions were performed on six adult human cadaver maxillas and all maxillas were sectioned into hemimaxillas. The closest direct distance between the lateral incisior root, nasal floor and miniscrew was measured with a caliper. The cortical bone, trabecular bone and attached gingiva thicknesses around the miniscrew were recorded. The ideal placement angle and safety distance of the central incisor was determined. Statistical evaluation was performed with One Way ANOVA. **Results:** The possibility of injury to the root surface of lateral incisors was increased at drilling angles greater than 50˚. In three models screws were closer than 1mm to the lateral incisor root surface and perforation of the root surface was observed in two models. The penetration of the miniscrew to the cortical bone of nasal floor was seen in one model. No statistically significant difference was present between the distance of neighboring landmarks, and between the drilling angle of injured and non-injured samples. **Conclusion:** During the insertion of midpalatal anchorage miniscrews, the angle between the lateral incisor long axis and the drill is advised to be less than 50˚ to avoid neighboring tissue damage.

Key Words: Orthodontic anchorage procedures; cadaver; maxilla

ÖZET Amaç: Midpalatal bölgede ortodontik tespit amaçlı minividalar yerlestirilirken komşu dokularda oluşabilecek hasarı ve olası riskleri görmek, minividaların ideal yerleştirilebilmeleri için bir yöntem belirlemektir. **Gereç ve Yöntemler:** Altı insan kadavrasının maksiller kemiklerine bilateral olmak üzere on iki midpalatal ankoraj minividası yerleştirilmiştir ve her bir maksiller kemik iki yarım çeneye ayrılmıştır. Minivida ile lateral dişin kökü ve burun tabanı arasındaki en kısa dik mesafe kumpas yardımıyla ölçülmüştür. Minividanın etrafındaki kortikal kemik, spongioz kemik ve yapışık diş eti kalınlıkları da kaydedilmiştir. Minividanın ideal yerleştirilme açısı ve santral diş ile olan güvenli uzaklık belirlenmiştir. İstatistiksel değerlendirme Tek Yönlü ANOVA analizi ile yapılmıştır. **Bulgular:** Rehber oluk açısı 50º'den daha büyük olan vida yerleşimi sonrasında lateral dişin kök yüzeyinde oluşabilecek hasar riskinin arttığı bulunmuştur. Üç modelde minividalarla lateral dişin kök yüzeyi arasındaki mesafe 1mm'den az olarak saptanmış olup, kök perforasyonu iki örnekte gözlenmiştir. Minividanın burun tabanında kortikal kemiğe penetrasyonu bir örnekte görülmüştür. Hasarlı ve sağlam örnekler arasında yapılan istatistiksel değerlendirmeye göre komşu referans noktalarına olan uzaklık ve drilleme açıları arasında anlamlı fark bulunmamıştır. **Sonuç:** Komşu doku hasarını önlemek için midpalatal ankoraj minividalarını yerleştirirken rehber oluk ve lateral keser dişin uzun aksı arasındaki açısının 50˚'den daha az olması önerilmiştir.

Anahtar Kelimeler: Ortodontik tespit işlemleri; kadavra; maksilla

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Nonextraction treatment of dental Class II malocclusions sometimes requires distalization of upper molars. During distalization of maxillary molars, it is easier for the adolescents to accept the use of conventional extraoral devices like headgear; however, in adults the use of extraoral appliances presents a social obstacle. Due to this social obstacle, bone anchorage methods for maxillary molar distalization are preferred in adult patients. Furthermore, there is an increasing usage of bone anchorage methods due to their simplified insertion and removal techniques.[1,2]

Skeletal anchorage is provided with osteointegrated implants, miniscrews, non-osteointegrated anchorage devices, mini plates or onplants.[3,4] Osteointegrated implants are used only in a very limited group of patients due to their relatively traumatic insertion and removal procedures and their cost. Miniscrews are commonly used in adults for provide orthodontic anchorage because their placement and removal are easy and stability is reliable.[5] Miniscrews are mostly used between the roots of teeth and placed buccally.[1] Rootless areas like maxillary tuberosity, inferior crest of the zygomatic arc and the hard palate can also be used for orthodontic bone anchorage.[6] Midpalatal area is the most preferred anatomic area for maxillary molar tooth distalization because the force vector is close to the center of resistance of maxillary first molars and the bone structure is sufficient for screw maintenance.[7]

In lingual orthodontics, midpalatally inserted miniscrews are commonly used as an anchorage device for the retraction of anterior teeth in extraction cases.[7] It can also be used for posterior tooth intrusion or palatal expansion.[1] The anterior part of the palatal bone has highly dense structure with sufficient bone height up to the nasal crest.[8] However, the thickness varies from one patient to another, anterior to the posterior and median to paramedian areas.[9]

During the insertion of the midpalatal screws, the depth of the palate, thickness of soft and hard tissues, angulations of the roots of incisors should be taken into consideration. Without sound anatomical knowledge, although the hard palate is considered as a safe place, clinicians still may harm the neighboring teeth, perforate the nasal floor or insert the screw to an area without sufficient bone support. The soft tissue thickness at the site of insertion should also be considered for the selection of screw length.

There are several studies in the literature which report on the success rate, stability, loosening or ideal location of midpalatal miniscrews or mini-implants.[9-13] These studies were mostly performed on tomographic records. No studies about palatal bone thickness were performed on cadaver maxilla and moreover, the literature is lacking information concerning the complication ratio of midpalatal miniscrews. The aim of this article is to determine the ideal location of midpalatal miniscrews on cadaver maxillas and the complication ratio of midpalatally inserted screws with assuming that the miniscrews were inserted ideally.

MATERIAL AND METHODS

The present study was approved by Baskent University Institutional Review Board (Project no: D-KA 11/01) and supported by Baskent University Research Fund.

The sample of the study was consisted of six adult human maxillary bones (5 males, 1 female) which were supplied from Department of Anatomy at Baskent University. The bodies of the all included maxillas were intact and without bone pathology.

Prior to the insertion of the screws, the location of the screws was marked on the palate of maxilla by an orthodontist. All midpalatal miniscrews were inserted to ideal place in the anterior paramedian region of the midpalatal suture.[6] The location of the screws was 4-5 mm posterior to the foramen incisivum and 3-4 mm lateral to the medial line.

Maxillas were positioned and fixed simulating 45 mm mouth opening by mouth gag. Twelve intermaxillary fixation (IMF) screws (Stryker, Leibinger, Germany) were placed bilaterally

to the midpalatal area by the same clinician. 1,7 mm X 8 mm IMF screws were used for all models. Following the insertion of the screws maxillary bones were removed by Le Fort I osteotomy and specimens were preserved in formaline solution.

The distance between the insertion point and the free gingival margin of palatal surface of the central incisor and first premolar was measured (Figure 1). All removed maxillas were sectioned into two samples from the midpalatal suture by using a saw and 12 hemimaxillas were obtained (Figure 2). Hemimaxillar models were cut off with a dental cast trimmer from the middle of screws in axial plane (Figure 3).

The closest distance between the upper lateral incisor root, the nasal floor and the apex of miniscrew was measured separately with a milimetric sensitive caliper (Figure 4). The thickness of the cortical bone, trabecular bone and gingiva at the screw insertion point was also recorded for all models (Figure 5). The angle between the long axis of lateral incisor and long axis of the screw was measured for all models. Ideal placement angle of the screw and safety distance from the palatal free gingival margin of the central incisor was determined. All parameters were statistically evaluated by Statistical Package for Social Science version 16.00 (Chicago, IL, USA) with *One Way ANOVA.*

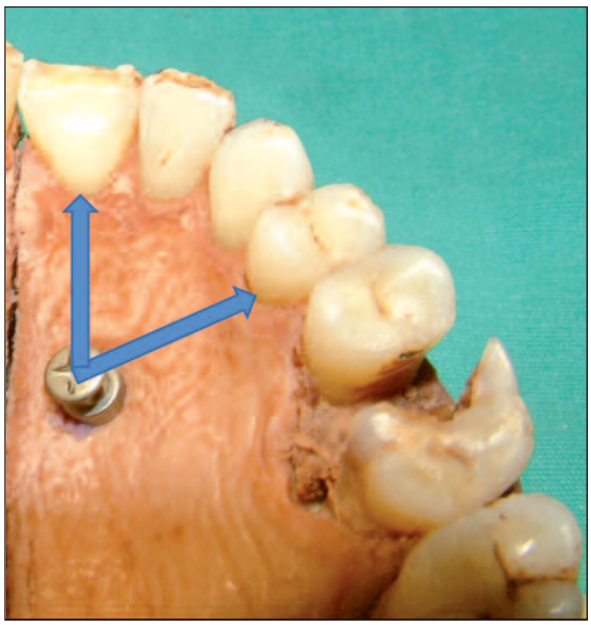

FIGURE 1: The measured distances between the insertion point and the free gingival margin of palatal surface of the central incisor and first premolar were shown.
(See color figure at http://dishekimligi.turkiyeklinikleri.com/)

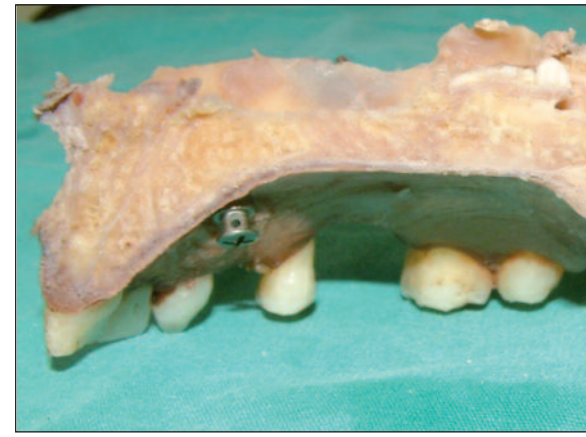

FIGURE 2: Maxillas were sectioned into two samples from the midpalatal suture by using a saw.
(See color figure at http://dishekimligi.turkiyeklinikleri.com/)

FIGURE 3: All hemimaxillar models were cut with a dental cast trimmer from the middle of screws in axial plane.
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RESULTS

The angulations between the drill and the long axis of the lateral incisor were shown for all models in Table 1. The angle between the drill and the long axis of lateral incisor teeth was 39.5^0 to 59^0 (mean: $47.7^o \pm 7.12$).

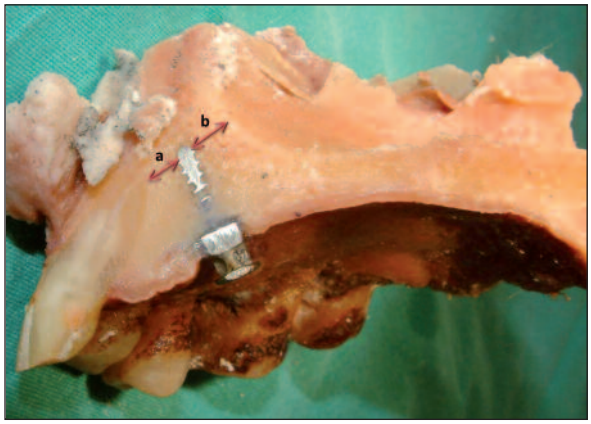

FIGURE 4: a) Distance is the closest measured distance between the upper lateral incisor root surface and miniscrew; **b)** Distance is the closest distance between the nasal floor and the apex of miniscrew.
(See color figure at http://dishekimligi.turkiyeklinikleri.com/)

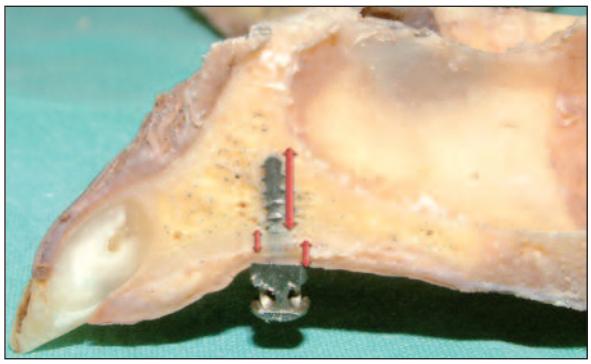

FIGURE 5: The thickness of soft tissue, cortical bone and trabecular bone were measured separately at the screw insertion point.
(See color figure at http://dishekimligi.turkiyeklinikleri.com/)

The direct distance between the screw insertion point and the palatal free gingival margin of the central incisor was 6-13 mm (mean 9.75 mm ±1.95). The direct distance between the screw insertion point and palatal free gingival margin of the first premolar was also evaluated and values were shown in Table 1. This distance was varried between 10-16 mm; and mean value was 10.66 mm ±1.92.

The thickness of the soft tissues, cortical bone and spongious bone around the screw heads were measured for all models (Table 1). The average thickness of cortical bone was 1.38±0.41 mm, spongious bone was 4.73±0.85 mm and soft tissue thickness was 1.67±0.30 mm.

The distance between the root surface and the screw was 0 to 7 mm and the mean value was 3.33±2.64 mm. In three models (Model III, IV, XI) screws were closer than 1mm to the lateral incisor root surface and perforation of the root surface was observed in two models (Model IV, XI) (Figure 6). These three samples were considered as unsafe models.

The direct distance between the apex of the screw and the nasal floor changed from 0 to 14 mm (mean: 4.38±1.5 mm). Unsafe close contact to nasal floor was seen in one model (Model XII) (Figure 7).

Statistical results were shown in Table 2. No statistically significant difference was present between the distance of neighboring landmarks of safe and unsafe samples; and between the drilling angle of safe and unsafe samples.

The drilling angle was 50^0 or greater to the lateral incisor in all samples with root surface injury. There was a statistically significant difference in root surface injury at 50^0 or greater angles (p:0.002); whereas, no statistically significant finding was present when the injury to the nasal floor was assessed (p:0.131) in all samples (Table 2).

DISCUSSION

Although the hard palate is considered as a 'safe zone' for implant placement, some possible complications are still present. The complications of miniscrew insertion procedure include; trauma to the periodontal ligament or tooth root, nerve damage, subcutaneous emphysema, nasal floor or maxillary sinus perforation, necrosis or local ischemia of the surrounding palatal bone because of dense or thick cortical bone, infection and miniscrew bending, fracture, slippage or partial osteointegration.[10,11,14,15] In order to prevent the neighboring tissue damages, the screws must be placed carefully behind the incisive canal toward spina nasalis anterior in the anterior part of the palatal vault.[16] This precise screw insertion sometimes becomes a challenging practice for the clinicians.

The risk of nasal floor perforation and screw instability is increased at the posterior part of the palatal bone due to the reduced thickness of the

TABLE 1: Measurements of each cadaver sample.*

Samples	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Mean (±SD.)
The angle between screw axis and lateral incisor long axis (degrees)	440	450	530	590	490	500	350	420	580	39.50	500	490	47.7 (±7.12)
Distance between insertion point and palatal margin of central incisor (mm)	13	12	11	11	11	10	8	9	6	9	8	9	9.75 (±1.95)
Distance between insertion point and palatal margin of first premolar (mm)	15	16	11	12	11	10	11	10	11	11	10	12	10.66 (±1.92)
Thickness of cortical bone around the miniscrew (mm)	1.2	1.5	1.1	1	1.2	1.1	1.7	2.4	0.9	1.7	1.5	1.3	1.38 (±0.41)
Thickness of spongious bone around the miniscrew (mm)	3.9	4.2	4.3	5.4	5.9	5.5	5.3	5.6	4.6	4.1	5	3	4.73 (±0.85)
Thickness of gingivae around the miniscrew (mm)	1.3	1.8	2	1.9	1.8	2.1	1.2	1.5	1.7	2	1.3	1.5	1.67 (±0.30)
Distance between root and apex of the screw (mm)	7	6.5	0.5	0*	3.5	4.5	4	6.5	1	5	0*	1.5	3.33 (±2.64)
Distance between nasal floor and apex of the screw (mm)	1.5	3.5	13	14	4	3	1	7	1	2.5	2.1	0*	4.38 (±1.5)

* Distances less than 1 mm were accepted as safe samples.
SD represents standard deviation.

bone towards the posterior part of the palatal bone. Insertion of the midpalatal screws more anteriorly is beneficial to maintain stability. However, anterior insertion of midpalatal screws, in parallel with the long axis of lateral incisor tooth to avoid the root damage, may not be possible because of the drill angulation. This fact leaves a dilemma for optimal placement of midpalatal screws and poses a risk for neighboring tissue damage.

Skeletal growing pattern or habits such as mouth breathing may lead to Class II malocclusions and characteristic deepening of the palatal vault. The depth of the palatal vault is one of the factors that affect the angulation of the drill during the midpalatal miniscrew placement. Patient's mouth opening, the length and the angulations of root of incisor teeth are the other critical factors that affect the midpalatal drilling angulation. The mouth opening was standardized as 45 mm in the present study; however, there were differences in drilling angles because of the anatomical differences including palatal depth or incisor teeth angulation in different models.

In the present study the angle between the long axis of the screw and the long axis of the lateral incisor tooth was measured with a protractor following the preparation of the models. The angle varied between 35^0 to 59^0. The risk of root or nasal floor injury diminished if the angle between the drill and the lateral incisor tooth axis was kept at less than 50 degrees. The direct distance between the root surface and the apex of the screw was not safe in three models (Model III, IV and XI). Root surface perforation was observed in two model and unsafe close contact to the cortical bone of nasal floor was observed in one model out of twelve. (Total unsafe insertion ratio: 25%.) Screw and root

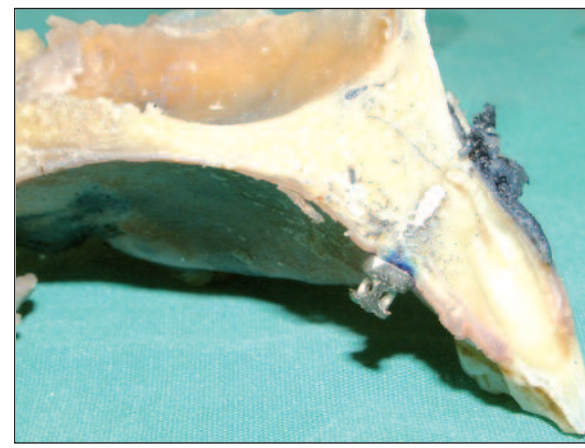

FIGURE 6: Miniscrew contacted the lateral incisor root.
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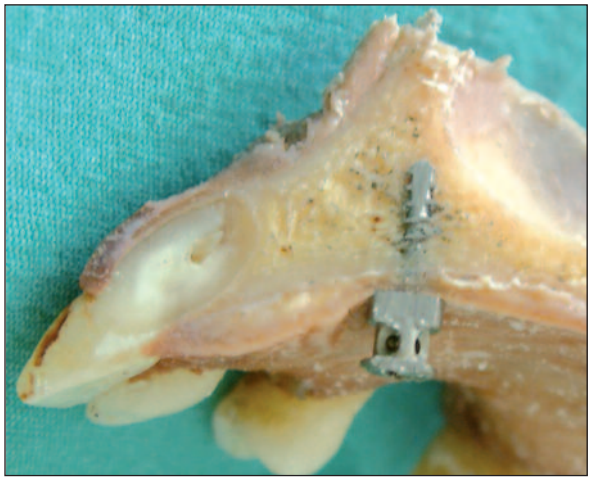

FIGURE 7: Contact of the apex of the screw to the cortical bone at the nasal floor was observed.
(See color figure at http://dishekimligi.turkiyeklinikleri.com/)

contact has been reported to be the major risk factors for screw failure.[10,14] Furthermore, root injury may lead to loss of tooth vitality, osteosclerosis, or dentoalveolar ankylosis.[17,18] The prevention of contact of miniscrew and the tooth is important for miniscrew maintenance, stability and prevention of tooth damage.[19]

The thickness of the gingiva around the implants was measured between 1.5-2.0 mm and the thickness of the cortical bone was measured between 0.9-2.4 mm. The screw length was 8 mm in the present study. In one sample, apex of the screw contacted to the cortical bone of nasal floor and in two samples, root perforation of the lateral tooth was observed. To prevent those kinds of complications, the shorter screw can be preferred; however, it is well known that length of the screw increases the stability. It was advised to use 8-14 mm length screws at midpalatal area for orthodontic anchorage.[16] However it should be kept in mind that as the length of the screw increases, the risk of nasal floor perforation also increases. In cases where longer screws cannot be used, diameter of the screw may be increased in order to maintain the stability.

Recently, self-drilling orthodontic anchorage screws have been commonly used as their placement protocol is not as invasive as self-tapping screws. The presence of a thick palatal mucosa and cortical bone makes the insertion of self-drilling screws more difficult. In order to provide a safer location at the midpalatal region, self-tapping screws are still preferred.[20] Computerized tomographic evaluation is not a routine procedure before miniscrew insertions; therefore the thickness of midpalatal mucosa and cortical bone cannot be determined before screw placement. Moreover thickness of midpalatal mucosa and cortical bone shows individual differences. According to the results of the present study it was observed that midpalatal cortical bone thickness can reach 2,4 mm and self-tapping screws should be used specially next to the midpalatal suture.

CONCLUSION

According to the results of the present study, even if midpalatal miniscrews are inserted into the ideal place on palate, the angle between the lateral incisor long axis and the drill should be less than 50˚ and preferably between 40-50 ^{0} for avoiding injury of the neighboring tissue.

TABLE 2: Statistical values of the safe and unsafe samples.

	Injuired		Safe		
	Mean	SD	Mean	SD	Sig. (P)
The angle between screw axis and lateral incisor long axis	52.70	4.50	45.31	7.07	0.087
Distance between root and apex of the screw	0.50	0.70	4.75	1.98	0.002*
Distance between nasal floor and apex of the screw	7.20	7.25	2.94	1.99	0.131
Distance between insertion point and palatal margin of central incisor	9.75	1.50	9.75	2.25	1.000
Distance between insertion point and palatal margin of first premolar	11.25	0.96	11.88	2.30	0.619

* $p<0.05$ is considered as significant.
SD represents standard deviation.

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