CHAPTER 4

ASSESSMENT OF MAXIMUM INSERTION TORQUE DURING MINISCREW IMPLANT PLACEMENT IN DIFFERENT AREAS OF THE PALATE

Introduction

Miniscrew implants have become an important alternative to provide stationary anchorage during orthodontic treatment.[9,66,67] Because these miniscrews use the bone as anchorage, they have become broadly accepted as viable alternatives to extra-oral devices in patients who either have insufficient dental support suitable for anchorage or who are not compliant in wearing extra-oral devices.[9,67,68]

Miniscrew implants present several advantages over the conventional methods of skeletal anchorage, such as the relatively simple implantation and removal procedures and reduced costs.[68,69] Moreover, their small diameter allows their insertion into several areas of the maxilla and mandible that were previously unavailable, such as the alveolar bone between the roots of adjacent teeth, thus allowing the application of relatively simple orthodontic force systems.[14,33]

However, palatal sites should be considered as a safe and viable alternative for miniscrew placement if the availability of interradicular bone between the roots is insufficient to allow safe miniscrew placement.[14,34]

Palatal bone is composed of dense cortical bone and is covered with attached mucosa.[34,37,70] Therefore, it is regarded as the safest site for miniscrew implant placement in the maxilla. Midpalatal suture sites have been recommended as suitable sites for miniscrew implant placement in the maxilla.[32,34,36,70] Lim et al., using midpalatal miniscrews in adult patients to perform the distalization of molars, have observed no failure in miniscrews inserted at the midpalatal suture.[33] However, the use of the midpalatal suture site is not recommended for growing patients, since the miniscrew insertion direct into the suture may cause impairment of maxillary growth.[34,71] Therefore, the parasagittal region has been suggested as an alternative for the placement of miniscrews in the palate of growing patients.[71]

However, the differences in the amount and quality of the bone in these anatomical locations might influence the primary stability of miniscrew implants, and consequently the success rates of the miniscrews inserted in the palatal bone.[39,65]

Therefore, the purpose of this study was to analyze the maximum insertion torque values applied to orthodontic miniscrews inserted in the midpalatal and parasagittal regions of the palate in human cadavers.

Methodology/Experimental design

Study design and samples

To address the study purpose, the investigators designed a cross-sectional study and implemented a human cadaveric model composed of 20 maxillae retrieved from formalin-fixed human heads of subjects who had donated their bodies to the Department of Anatomy (Faculty of Medicine, Chiang Mai University) for scientific research. The subjects were 10 males and 10 females with ages ranging from 40 to 89

years (average age 71.7 years, SD 12.4 years) at the time of death. Bones free from perceptible bone pathosis and containing complete dentitions were selected. The miniscrew implantation was carried out bilaterally in different anatomical regions of the palatal bone (midpalatal and parasagittal sites). The maximum insertion torque (MIT) value was recorded during implantation procedures.

Miniscrew Implant Procedure

One hundred eighty self-drilling titanium miniscrew implants (1.6 x 6.0 mm Dual Top Anchor system, Jeil Medical Co, Seoul, Korea) were systematically inserted in midpalatal (n= 60) and parasagittal (n= 120) sites of the hard palate of 20 cadavers (See Figures 4.1A and 4.1B).

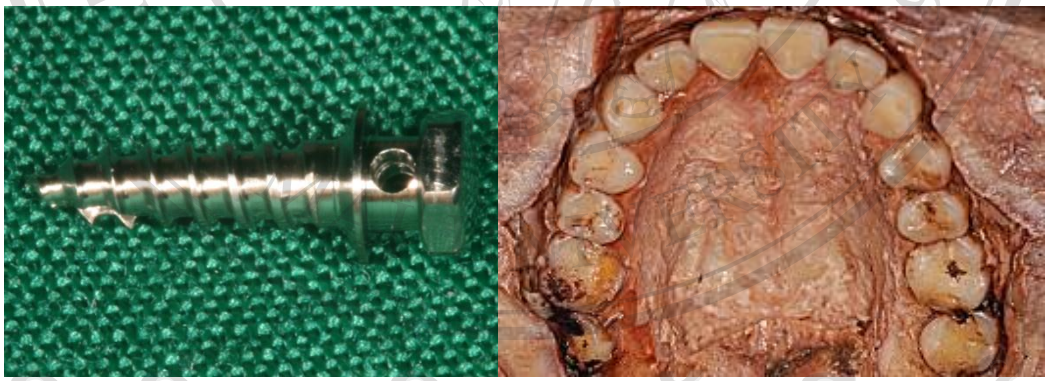

Figure 4.1 A. Self-drilling titanium miniscrew implants used in the present study. B. Hard palate of cadaver.

For each palatal bone, a total of nine miniscrews were inserted in the midpalatal (n= 3) and parasagittal (n= 6) regions of each hard palate, aided by a template (See Figure 4.2). Insertion sites were defined on each palate using construct

reference lines (anterior, middle and posterior). The main reference line was constructed on the midpalatal suture dividing the palate in two (right and left) segments. A perpendicular line to the midpalatal suture line divided the palate into four parts from the posterior border of the incisive foramen to a line between greater palatine foramina. On each line, three points were marked at the midpalatal suture and at 5 mm intervals on the left and right sides of the midpalatal suture (See Figure 4.3).

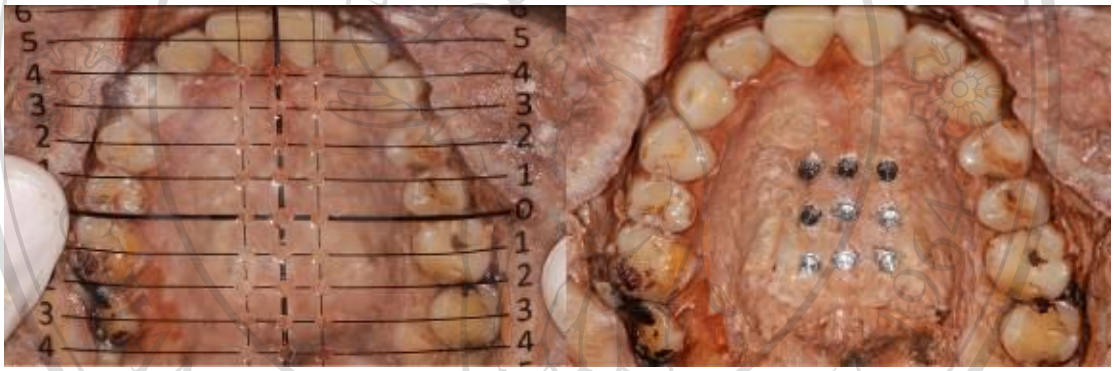

Figure 4.2 Palatal bone, a total on nine miniscrews were marked by a template in the midpalatal (n= 3), parasagittal (n= 6) suture sites.

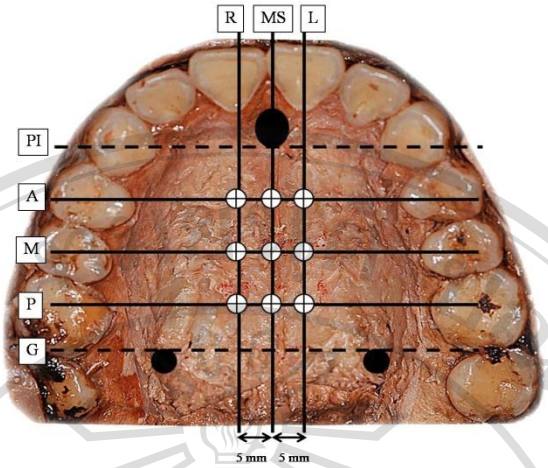

Figure 4.3 Miniscrew implant placement sites; A = anterior reference line, M = middle reference line, P = posterior reference line, PI = posterior border line of incisive foramen, G = line between greater palatine foramens, MS = midpalatal suture line, R = right parasagittal line, L = left parasagittal line.

Torque Measurement

Assessment of maximum insertion torque (MIT) was performed with an Imada torque wrench (DIS-RL, Imada Inc., Northbrook, Ill., USA) (See Figure 4.4A). The appropriate screwdriver of the corresponding miniscrew's manufacturer was adapted into the Jacobs chuck of the torque wrench and applied to the miniscrew (See Figure 4.4B). In this study, miniscrew placement into the palatal bone and assessment of insertion torque applied to all miniscrews was performed by the same orthodontist.

Figure 4.4 A. Imada torque wrench (DIS-RL, Imada Inc., Northbrook, USA). B. Jacobs chuck of the torque wrench for applied to the miniscrew.

Maximum Insertion Torque (MIT)

Assessment of MIT was carried out simultaneously with the miniscrew placement procedures into the bone. Miniscrew implants were screwed directly into the bone (self-drilling).

The MIT was recorded at the terminal turning applied to tighten the miniscrew into the bone. The terminal turning was determined, when the platform of the miniscrew was 1 mm from the cortical bone.

Statistical analysis

The statistical analyses were performed using the SPSS program on a personal computer. Descriptive statistics and multiple comparisons between groups were performed using the Kruskal-Wallis H and Mann-Whitney U tests to detect any differences in MIT values between the miniscrews inserted in different locations. Significance was established at the 0.5 % level.

Results

No fracture of miniscrews was observed. The overall MIT value in the palatal bone was 7.6 Ncm (95% CI, 6.8-8.3). The values of MIT are shown in Table 4.1. MIT values were significantly higher at the midpalatal sites (mean, 9.7 Ncm; 95% CI, 8.3-11.2) than at the parasagittal sites (mean, 6.5 Ncm; 95% CI, 5.7-7.2). The comparison of MIT values are shown in Table 4.2 and Figure 4.5.

Table 4.1 Maximum insertion torque value (Ncm) at each measurement site.

Placement site (n)			Mean	SD
Parasagittal (120)	Anterior	(40)	6.8	4.0
	Middle	(40)	7.3	4.8
	Posterior	(40)	5.5	3.3
Midpalatal (60)	Anterior	(20)	9.2	6.1
	Middle	(20)	10.1	6.2
	Posterior	(20)	9.9	4.1
Total (180)			7.6	4.9

Table 4.2 Maximum insertion torque value (Ncm) between parasagittal and midpalatal sites.

Placement site	Parasagittal		Midpalatal		Sig
	Mean	SD	Mean	SD	
Anterior	6.8	4.0	9.2	6.1	NS
Middle	7.3	4.8	10.1	6.2	NS
Posterior	5.5	3.3	9.9	4.1	*
Average	6.5	4.1	9.7	5.5	*

* The mean difference is significant at the .05 level (Mann-Whitney U tests)

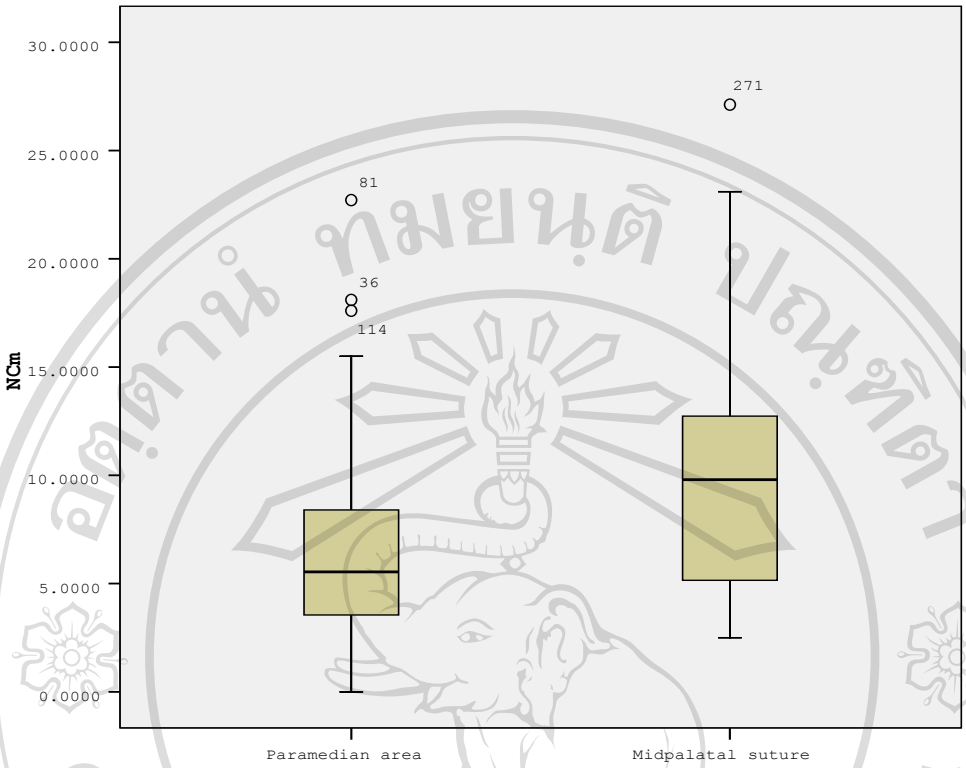

Figure 4.5 Box plot graph of maximum insertion torque value (Ncm) of parasagittal and midpalatal suture regions.

In the palatal bone, combining the midpalatal and parasagittal sites, no significant difference in MIT values between the anterior, middle and posterior sites was observed (shown in Table 4.3 and Figure 4.6).

Table 4.3 Maximum insertion torque value (Ncm) between the anterior, middle and posterior sites.

Placement site	Parasagittal		Midpalatal	
	Mean	SD	Mean	SD
Anterior	6.8	4.0	9.2	6.1
Middle	7.3	4.8	10.1	6.2
Posterior	5.5	3.3	9.9	4.1
Sig	NS		NS	

NS: no significant difference at the .05 level (Kruskal-Wallis)

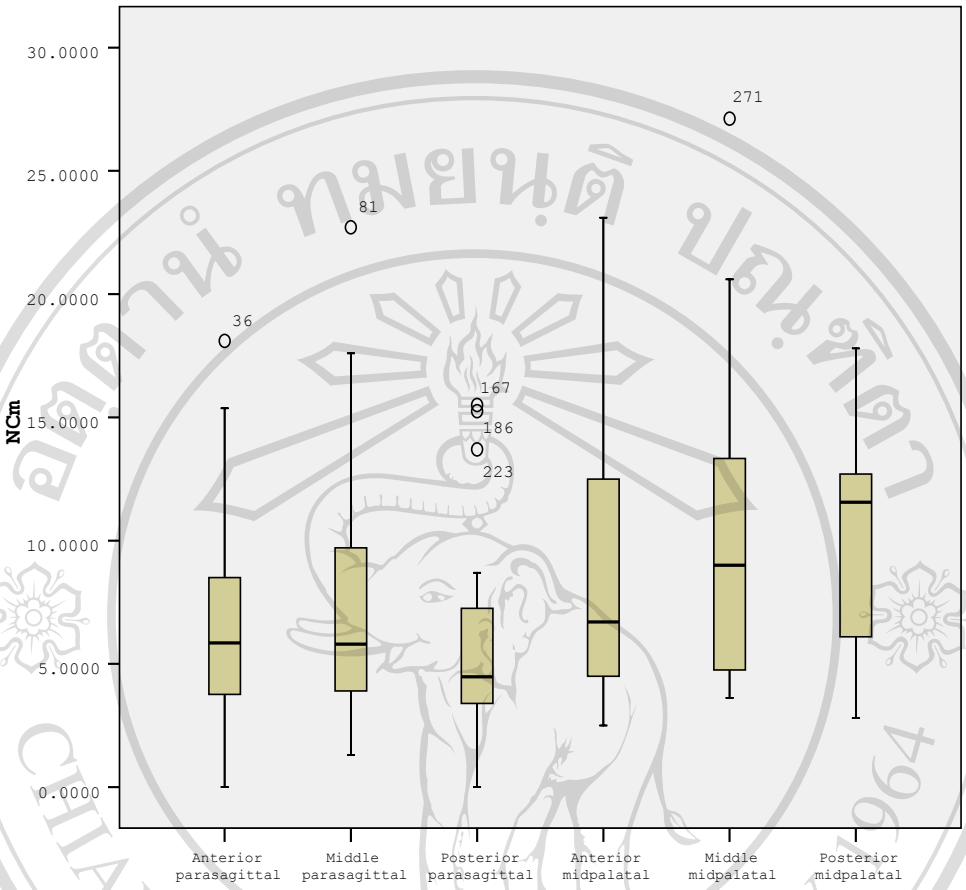

Figure 4.6 Box plot graph of maximum insertion torque value (Ncm) between the anterior, middle and posterior sites.

However, comparisons of MIT values for miniscrews inserted in the midpalatal and parasagittal sites indicated that the MIT values for miniscrews inserted in the posterior sites of the midpalatal suture (mean, 9.9 Ncm; 95% CI, 7.9-11.8) was significantly higher than those of the posterior sites in the parasagittal region (mean, 5.5 Ncm; 95% CI, 4.4-6.6) (shown in Table 4.2).

Discussion

Placement sites

Palatal bone sites are regarded as the safest sites for miniscrew implant placement in the maxilla, since it is composed of dense cortical bone and is covered with attached mucosa.[72-76] Moreover, it should be considered as an option for the placement of miniscrews when the availability of interradicular space in the dentoalveolar bone is not sufficient for their safe insertion, or when the distalization of maxillary molars is planned.[5,14,34,77]

However, placement of miniscrew implants in the midpalatal suture of growing patients should be avoided since it might cause impairment of transverse maxillary growth.[34,71] As an alternative, the parasagittal region has been suggested as a potential site for the placement of miniscrews in the palates of growing patients.[71]

Therefore, the purpose of this study was to analyze the maximum insertion torque values applied to orthodontic miniscrews inserted in the midpalatal and parasagittal regions of the palate in human cadavers.

MIT values with previous study

In the present study, a relatively low overall MIT value (7.6 Ncm) was observed with miniscrews inserted into the palatal bone. These results are lower than those of previous studies that assessed the stability of miniscrew implants inserted in the maxillary bone.[20] Suzuki and Suzuki[78] evaluated the maximum insertion and removal torque applied to miniscrews inserted into several sites in the maxilla and mandible of orthodontic patients. They observed average MIT values of 14.5 Ncm and 21.1 Ncm for respectively, pre-drilling and self-drilling miniscrews, inserted in

the midpalatal suture of adult patients. In the present study, the MIT value difference can be attributed to two main factors: 1) Only subjects with visible bone pathology, such as torus palatinus, were included for analysis in this study, and 2) the cadavers used in the present study were preserved in a solution of formalin and glycerin, that might have affected the mechanical properties of the bone.[79,80] A possible effect of the formalin and glycerin on the bone properties can be clearly seen when *in vivo* and *ex-vivo* comparisons are performed. Motoyoshi et al.[39] observed an overall MIT of 8.3 Ncm for miniscrews (1.6 X 8mm) that were placed in the dentoalveolar sites of living subjects, whereas McManus et al.[81] found a MIT of 4.65 Ncm for miniscrews (1.5 x 11mm) inserted in dentoalveolar bone of cadavers. Although the miniscrew size was slightly different, a drastic drop in the MIT value was observed when using a cadaveric sample.

MIT values between midpalatal suture and parasagittal sites

In general, miniscrew implants inserted in the midpalatal region produced the higher MIT values (20%-40%) than did those inserted in the parasagittal region. These results are in agreement with previous studies that assessed the bone densities and the amount of bone present in these regions.[35,55] According to Kim et al.[36] the midpalatal suture region is composed of dense cortical bone and, therefore, has been recommended as the best anchorage site in the maxilla.[22] Kang et al.[35] assessed the bone thickness of the palate in adults to determine the recommended length of miniscrews. They observed that the bone thickness in the midpalatal region (5 to 6 mm) was higher than in the parasagittal region (3 to 5 mm). Moon et al.[55] assessed the bone density of the palate in adult patients. They observed that the palatal bone

densities showed a tendency to decrease laterally and posteriorly. Moreover, they observed that the midpalatal area within 3 mm of the midpalatal suture had the densest bone in the entire palate.[55] In the present study, the parasagittal region was defined as an area at least 5 mm removed from the midpalatal suture.

MIT values between the anterior, middle and posterior sites

In the present study, no significant difference in MIT values between the anterior, middle and posterior sites for either the midpalatal or parasagittal regions was observed.

In the midpalatal suture region, the result can be explained by the similar amount of bone thickness and bone density at each site.[35,53,55] Kang et al. observed that the bone thickness in the midpalatal region did not vary antero-posteriorly.[35] The same findings were confirmed by Stockmann et al.,[53] who performed a histomorphometric study on human cadavers. Moon et al.[55] observed that the high bone density of the midpalatal region was constant antero-posteriorly. Therefore, in the midpalatal region, no great variation in bone thickness nor bone density is expected to be observed. From the clinical point of view, the mechanical stability of miniscrew implants placed in midpalatal sites would not be affected by their placement position.

In the parasagittal region, no significant difference in MIT values between the anterior, middle and posterior sites was observed. This result contradicts the findings of previous studies. Kang et al.[35] observed that the bone thickness in the parasagittal sites (6 mm away from the midpalatal suture) varied from 5 mm in the anterior region,

to less than 3 mm in the posterior. Moon et al.[55] observed that the bone density in the parasagittal region dropped significantly from the anterior to the posterior.

This contradictory result can be explained by several factors: 1) the large amount of variation of density of palatal bone within individuals as pointed by Moon et al.[55] 2) the limited sample number that was utilized in the present study (20 subjects) (possibly, by increasing the sample number, the differences between the parasagittal suture sites would become more evident); and 3) the torque assessment approach might not be as sensitive in detecting the small variations in the morphological characteristics of the bone, as the morphometric assessment of the bone thickness or bone density.

Nevertheless, the effect of the bone thickness and the bone density can be clearly observed in the posterior region of the palate. A significant difference in the MIT values was observed between the midpalatal and parasagittal sites in the posterior area. The explanation is that, whereas no difference is observed in the midpalatal suture sites, a decrease in both bone thickness and bone density is observed in the parasagittal sites.[35,53,55]

In the present study, direct analysis was performed to compare the biomechanical differences between the midpalatal and parasagittal regions by maximum insertion torque assessment. The midpalatal suture region provided improved biomechanical retention for miniscrew implants throughout its antero-posterior extent with predictable outcomes. From the clinical point of view, miniscrew implants can be inserted in the anterior, middle or posterior sites and achieve similar stability. Nevertheless, although the parasagittal region exhibited inferior biomechanical properties, it also provided sufficient mechanical retention for

miniscrew implants for a safe and stable placement. Therefore, it should be considered as a potential option for miniscrew implant placement in the palate when the midpalatal suture region is unavailable.

Conclusions

Palatal bone can provide safe sites for miniscrew placement. Although the midpalatal suture area provides higher MIT values than parasagittal area in posterior region, both midpalatal suture and parasagittal areas can be selected for miniscrew placement in terms of maximum insertion torque assessment.