บทวิทยาการ
Original Article

การเปรียบเทียบแรงบิดสูงสุดระหว่างการฝังวัสดุฝังเกลียวขนาดเล็กในบริเวณกึ่งกลางเพดานปากของศพผู้ใหญ่ที่มีและไม่มีปุ่มกระดูกเพดานปาก

Comparison of Maximum Insertion Torque Applied to Miniscrew Implants Placed in the Midpalatal Region of Adult Cadavers with and without Torus Palatinus

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บทคัดย่อ

วัตถุประสงค์ของการศึกษาเพื่อ 1) เปรียบเทียบค่าแรงบิดสูงสุดของการฝังวัสดุฝังเกลียวขนาดเล็กในบริเวณกึ่ง กลางเพดานปากของศพผู้ใหญ่ที่มีและไม่มีปุ่มกระดูกเพดานปาก 2) วิเคราะห์ผลของขนาดปุ่มกระดูกเพดานปาก กับค่าแรงบิดสูงสุด การศึกษาครั้งนี้ใช้วัสดุฝังเกลียวขนาดเล็กขนาดเส้นผ่าศูนย์กลาง 1.6 มม. และความยาว 6.0 มม. จำนวน 120 ตัวฝังบริเวณกึ่งกลางเพดานปากของศพผู้ใหญ่ 40 ชิ้นที่ตำแหน่ง

Abstract

The purposes of this study were 1) to compare the maximum insertion torque (MIT) values of miniscrews placed in the midpalatal bone of adult cadavers with and without Torus Palatinus (TP), and 2) to analyze the influence of the TP size on the MIT values. One hundred twenty self-drilling titanium miniscrews (6.0 mm length and 1.6 mm diameter) were placed at

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ส่วนหน้าส่วนกลางและส่วนหลัง ของกระดูกเพดานปากวัดขนาด (ความกว้าง ความยาวและความสูง) และจัดกลุ่มของปุ่มกระดูกเพดานปาก ใช้เครื่องมือวัดแบบดิจิตอลในการวัดค่าแรงบิดสูงสุดของการฝังวัสดุฝังเกลียวขนาดเล็กและใช้การทดสอบแบบสติวเด้นท์ทีวัน- เวย์อะโนวาและเพียซองในการวิเคราะห์ทางสถิติ ($P<0.05$) ผลการศึกษาพบว่าค่าเฉลี่ยแรงบิดสูงสุดของวัสดุฝังเกลียวขนาดเล็กในกลุ่มที่มีปุ่มกระดูกเพดานปากเท่ากับ 16.5±6.1 นิวตันเซนติเมตรซึ่งมากกว่ากลุ่มที่ไม่มีปุ่มกระดูกเพดานปากที่มีค่าเฉลี่ยแรงบิดสูงสุดของวัสดุฝังเกลียวขนาดเล็กเท่ากับ 9.6±5.4 นิวตันเซนติเมตรอย่างมีนัยสำคัญทางสถิติในทุกตำแหน่งในบริเวณกึ่งกลางเพดานปากโดยพบค่าเฉลี่ยแรง บิดสูงสุดของวัสดุฝังเกลียวขนาดเล็กที่ตำแหน่งส่วนกลาง (20.9±5.8 นิวตันเซนติเมตร) มากกว่าค่าเฉลี่ยแรงบิดสูงสุดในส่วนหน้า (14.4±4.8 นิวตันเซนติเมตร) และส่วนหลัง (14.3±5.5 นิวตันเซนติเมตร) ไม่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติของค่าเฉลี่ยแรงบิดสูงสุดของวัสดุฝังเกลียวขนาดเล็กในกระดูกเพดานปากที่ไม่มีปุ่มกระดูกเพดานทั้งตำแหน่งส่วนหน้า (9.2±6.1 นิวตันเซนติเมตร) ส่วนกลาง (10.1±6.2 นิวตันเซนติเมตร) และ ส่วนหลัง (9.3±3.6 นิวตันเซนติเมตร) และยังพบความสัมพันธ์อย่างมีนัยสำคัญระหว่างค่าแรงบิดสูงสุดของวัสดุ ฝังเกลียวขนาดเล็กกับความสูงของปุ่มกระดูกเพดานปากในตำแหน่งส่วนกลางของกระดูกเพดานปากอีกด้วย สรุปการฝังวัสดุฝังเกลียวขนาดเล็กบริเวณกึ่งกลางกระดูกเพดานปากที่มีปุ่มกระดูกทำให้ค่าแรงบิดสูงสุดของวัสดุฝังเกลียวขนาดเล็กมีค่าสูงขึ้นและขนาด (ความสูง) ของปุ่มกระดูกเพดานปากมีความสัมพันธ์กับค่าแรงบิด สูงสุดที่เพิ่มขึ้นในปุ่มกระดูกเพดานปากที่มีขนาดใหญ่

คำสำคัญ: วัสดุฝังเกลียวขนาดเล็ก บริเวณกึ่งกลางเพดานปาก แรงบิดสูงสุดของการฝังวัสดุฝังเกลียวขนาดเล็ก ปุ่มกระดูกเพดานปาก

anterior median (AM), middle median (MM) and posterior median (PM) sites of the maxilla of 40 adult cadavers. TP sizes (height, width and length) were measured and classified. MIT values were assessed with a digital torque gauge. The Student t test, one-way analysis of variance (ANOVA) and Pearson correlation were performed for the statistical analysis ($P<0.05$). MIT values were significantly higher in the group with TP (16.5±6.1 Ncm) than the group without TP (9.6±5.4 Ncm) at all implants sites. The highest MIT value was observed at the MM site of the TP group (20.9±5.8 Ncm) while the MIT value at the AM site was 14.4±4.8 Ncm and that at the PM site was 14.3±5.5 Ncm. No significant differences in MIT values between AM (9.2±6.1 Ncm), MM (10.1±6.2 Ncm) and PM (9.3±3.6 Ncm) sites in the group without TP were observed. MIT values were correlated to the TP height at the MM sites. The presence of TP increased the MIT values during miniscrew insertion in the midpalatal region. TP size (height) is related to the MIT value in the middle median region of large TP.

Keywords: Miniscrew implants, Midpalatal Region, Maximum Insertion Torque (MIT), Torus palatinus (TP).

Introduction

Achieving absolute anchorage has been very important for the best outcome in the field of orthodontic treatment. Miniscrew implants have become an important approach to obtaining skeletal anchorage during orthodontic treatment, because they are small, have low cost, allow immediate loading, can simplify treatment mechanics and can be inserted in several maxillary and mandibular sites.[1-6]

In order to avoid risks and complications, the midpalatal region bone can serve as a potential alternative for miniscrew implant placement in the maxillary arch. The midpalatal and paramedian regions are covered by a thin attached mucosa,[11] compact cortical bone with sufficient bone depth to allow safe and stable miniscrew placement with high success rate.[2,6,11-17] Moreover, miniscrew implants inserted in the midpalatal region, allows the application of various force systems, such as; molar intrusion, distalization, retraction of anterior teeth.[1,2,4,6]

However, the presence of torus palatinus (TP) might compromise or contraindicate the insertion of miniscrew implants in the midpalatal region. Though the TP is a non-pathologic bony overgrowth that is occurs in the palate, it consists of dense cortical bone and sometimes trabecular bone in the inner zone of large TP.[18] The differences in amount and quality of the bone in the TP might influence the primary stability of miniscrew implants, and consequently the success rates of miniscrews inserted in the palate.

Previous studies have reported a high prevalence of TP in the Thai population.[19-23] Jainkittivong et al.[20] reported that the occurrence of TP was 60.5%, most of them located at the premolar or premolar to molar regions (47.4% vs 46.4%), with a preponderance of lesions of small and medium size (52.1% vs 41.8%). Although no treatment is usually needed, surgical removal is recommended only for prosthodonticpurposes.[18]

To date, there is no study providing information about the safety of miniscrew implant placement in this area. Therefore, the purposes of this study were 1) to compare the maximum insertion torque (MIT) values of miniscrews placed in the midpalatal bone of adult cadavers with and without TP, and 2) to analyze the influence of the TP size on the MIT values.

Materials and Methods

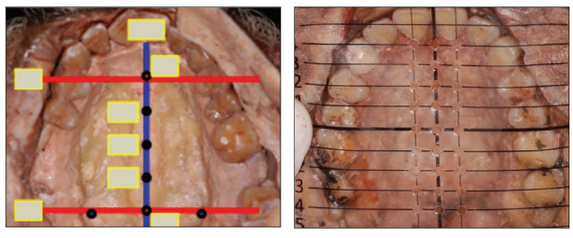
To obtain the research purpose, the investigator designed a cross-sectional study and implemented a human adult cadaveric model composed of 40 maxillas (20 with torus palatinus and 20 without torus palatinus)retrieved from formalin-fixed human heads of subjects who had donated their bodies to the Department of Anatomy (Faculty of Medicine, Chiang Mai University) for scientific research. The subjects were 26 males and 14 females with ages ranging from 36 to 96 years (average age 70.4 years, SD 13.6 years) at the time of death.

Torus palatinus measurement

The presence of TP was detected by duplicating the maximum outgrowth of the TP using metal contour gauge, to allow the TP size measurement. The two deepest points of the TP were marked on the base of TP. A line connecting the two deepest points of the TP was drawn on the base of TP as a reference line. Small outgrowth less than 1 mm in height and questionable outgrowth were regarded as absence of TP.

Torus palatinus size was measured by a

MotoMac Electronic Digital Caliper with an accuracy of 0.01 mm. Height: The maximum elevation from the palatal vault of the palate that will be graded according to the method of Eggen et al.[24] as 1) small (<2 mm), 2) medium (2-4mm) and 3) large (>4 mm). Width: The maximum width in mediolateral of the palate that will be graded according to the method of Eggen[25] as 1) small (<10 mm), 2) medium (10-15 mm) and 3) large (>15 mm). Length: The maximum length in anteroposterior of the palate that will be graded according to the method of Eggen[25] as 1) small (<15 mm), 2) medium (15-25 mm) and 30 large (>25 mm).



A B

Figure 1 *A. miniscrew implant placement sites; MSL = midpalatal suture line, IL = posterior border line of incisive foramen, GL = line between the anterior border of greater palatine foramens, AP = anterior point, PP = posterior point, AM = anterior median, MM = middle median and PM = posterior median, B. Template guide for miniscrew implant placement site.*

รูปที่ 1 *A. ตำแหน่งการฝังวัสดุฝังเกลียวขนาดเล็ก; MSL = เส้นกึ่งกลางเพดานปาก, IL = เส้นขอบหลังของอินซิซีฟฟอราเมน, GL = เส้นขอบหน้าของเกรเทอพาลาทีนฟอราเมน, AP = จุดด้านหน้า, PP = จุดด้านหลัง, AM = ตำแหน่งกึ่งกลางเพดานปากส่วนหน้า, MM = ตำแหน่งกึ่งกลางเพดานปากส่วนกลาง, PM = ตำแหน่งกึ่งกลางเพดานปากส่วนหลัง, B. แผ่นแบบกำหนดตำแหน่งการฝังวัสดุฝังเกลียวขนาดเล็ก*

The position of TP was classified in relation to the maxillary teeth in antero-posterior of the arch according to Jainkittivong et al.[20] as a molar, premolar, canine, premolar to molar, canine to molar, canine to premolar areas.

Miniscrew implant placement

The main reference line was constructed along the midpalatal suture of the palate (MSL). The anterior horizontal line was determined as a tangent to the posterior border of the incisive foramen, perpendicular to the midpalatal suture line (IL). The posterior horizontal line was a line between the anterior borders of the greater palatine foramina (GL), also perpendicular to the mid-palatal suture line. The anterior point (AP) was determined by the intersection between the midpalatal suture line and the posterior border line of incisive foramen and the posterior point (PP) was determined by the intersection between the midpalatal suture line and the line between the anterior borders of the greater palatine foramina. Three miniscrew implant placement sites were defined along the midpalatal suture line from the anterior point to the posterior points of each palate called the anterior median (AM), middle median (MM) and posterior median (PM) sites (Fig 2 A).

One hundred twenty self-drilling titanium miniscrew implants (diameter of 1.6 and length of 6.0 mm Dual Top Anchor system, Jeil Medical Co., Seoul, Korea) were systematically inserted by manual screwdriver (Dual Top Anchor System, Jeil Medical Co., Seoul, Korea) in the placement site of 40 adult cadavers with torus palatinus (n=60) and without torus palatinus (n=60) sites, aided by a template (Fig 2 B).

Maximum insertion torque measurement

Maximum insertion torque assessment was performed with an Imada torque wrench (DIS-RL, Imada Inc., Northbrook, Ill., USA). The appropriate screwdriver of the corresponding miniscrewí s manufacturer was adapted into the Jacobs chuck of the torque wrench and applied to the miniscrew implant. The MIT value (Ncm) was recorded at the terminal turning applied to tighten the miniscrew implant into the palatal bone. The terminal turning was determined; when the platform of the miniscrew contacted the bone surface.

Statistical analysis

The statistical analyses were performed using the SPSS program (version17.0, SPSS Inc, Chicago, Ill). Studentís t-test, ANOVA and the Pearson correlation were performed for the statistical analysis. Results were considered statistically significant at $P<0.05$.

Result

In the cadavers with TP, the mean size of TP was 4.3±1.5 mm in height, 11.9±3.6 mm in width and 26.1±6.1 mm in length. Torus palatinus were classified into small, medium and large among height, width and length as in Table I.

Table I *Torus palatinus size classification.*

ตาราง I *การจัดกลุ่มของปุ่มกระดูกเพดานปากตามขนาด*

TP Classification											
Height				Width				Length			
Total n (%)	S	M	L	Total n (%)	S	M	L	Total n (%)	S	M	L
	(<2)	2-4	>4		<10	10-15	>15		<15	15-25	>25
20 (100)	0 (0)	9 (45)	11 (55)	20 (100)	6 (30)	9 (45)	5 (25)	20 (100)	0 (0)	9 (45)	11 (55)

S = Small, M = Medium and L = Large
S = เล็ก, M = กลาง และ L = ใหญ่

Table II *Comparison of MIT value (Ncm) between the miniscrew implants placement site of cadavers with and without TP.*

ตาราง II *การเปรียบเทียบแรงบิดสูงสุด (นิวตันเซนติเมตร) ของการฝังวัสดุฝังเกลียวขนาดเล็กในตำแหน่งต่างๆ ของศพที่มี และไม่มีปุ่มกระดูกเพดานปาก*

MIT (Ncm)							
Variables	**With TP**			**Without TP**			
	n	**Mean**	**SD**	**n**	**Mean**	**SD**	**Sig.**
AM	20	14.4	4.8	20	9.2	6.1	*
MM	20	20.9	5.8	20	10.1	6.2	***
PM	20	14.3	5.5	20	9.3	3.6	*
Total	60	16.5	6.1	60	9.6	5.4	***
Sig.	***			NS			

** significant difference (p<0.05), *** significant difference (p<0.001), no significant difference (NS)*
** แตกต่างอย่างมีนัยสำคัญทางสถิติ (p<0.05), *** แตกต่างอย่างมีนัยสำคัญทางสถิติ (p<0.001), ไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติ (NS)*

A statistically significant difference was observed between the MIT values (P<0.001) in the cadavers with TP and without TP. The cadavers with TP showed higher MIT values than did the cadavers without TP in all positions. The middle median position of the cadavers with TP showed the highest MIT values (20.9±5.8 Ncm) as in Table II.

Table III *Correlation of MIT values (Ncm) and the size of TP (height, width and length).*

ตาราง III *ความสัมพันธ์ของแรงบิดสูงสุด (นิวตันเซนติเมตร) กับขนาดของปุ่มกระดูกเพดานปาก (ความสูง, ความกว้างและความยาว)*

MIT (Ncm)			
Size of TP			
	Height	**Width**	**Length**
Peason correlation	.241	-.023	-.015
Sig. (2-taileds)	.046 *	.861	.912
n	60	60	60

** significant difference (p<0.05)*

** แตกต่างอย่างมีนัยสำคัญทางสถิติ (p<0.05)*

There is correlation between the MIT values and the TP height, but no correlation between the MIT values and the TP width and length (Table III).

When comparing the MIT value of cadavers with medium and large TP height at each placement site, there were no statistically significant differences among the placement sites of medium TP height, but statistically significant differences among the placement sites of large TP height (P< 0.001). And when comparing the MIT values between each placement site and TP height, there was statistically significant difference between the medium and large TP height at the MM position (P<0.01) as shown in Table IV.

Discussion

Palatal bone is regarded as the safest site for miniscrew implant placement in the maxilla, since it is composed of dense cortical bone and is covered with attached mucosa.[26-30] Moreover, it has been suggested as an option for the placement

Table IV *Comparison of MIT value (Ncm) between the anterior, middle and posterior median position and the TP sizes (height, width and length).*

ตาราง IV *การเปรียบเทียบแรงบิดสูงสุด (นิวตันเซนติเมตร) ระหว่างตำแหน่งส่วนหน้า ส่วนกลาง และส่วนหลังกับขนาดของปุ่มกระดูกเพดานปาก (ความสูง, ความกว้างและความยาว)*

MIT (Ncm)										
Size of TP										
Position	**Height**			**Width**				**Length**		
	M	L	Sig.	S	M	L	Sig.	M	L	Sig.
AM	13.8±6.2	14.8±3.6	NS	17.2±4.5	12.6±5.2	14.1±3.4	NS	13.7±4.7	15.0±5.0	NS
MM	17.0±2.8	24.1±5.8	**	22.8±2.3	18.1±4.3	23.8±9.2	NS	19.9±3.9	21.7±7.1	NS
PM	12.5±5.5	15.8±5.2	NS	16.5±7.1	13.2±5.4	13.7±3.2	NS	14.7±6.0	14.0±5.3	NS
Sig.	NS	***		NS	NS	NS		NS	NS	

S = small, M = medium, L = large

*** significant difference (p<0.01), *** significant difference (p<0.001), no significant difference (NS).*

S = เล็ก, M = กลาง และ L = ใหญ่

*** แตกต่างอย่างมีนัยสำคัญทางสถิติ (p<0.01), *** แตกต่างอย่างมีนัยสำคัญทางสถิติ (p<0.001), ไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติ (NS)*

of miniscrews when the availability of inter-radicular space in the dentoalveolar bone is not sufficient for their safe insertion.[10,31-33] However, TP is a common finding in the Thai population and consequently might interfere or contraindicate the placement of miniscrew implant in the midpalatal suture site. Therefore, in order to evaluate whether the TP represents a hazard for miniscrew implant placement, comparisons of MIT values of mini-screws inserted into the palate of adult cadavers with and without TP was carried out.

In the present study, the overall MIT values were significantly higher for the TP group compared to the palates without TP. The overall MIT values were almost 2 times higher in the TP group. This result, as expected, might be explained by the anatomical characteristics of the TP itself. The TP is defined as a larger mass of cortical bone with greater bone density that grows pro-gressively.[18] On the other hand, normal palates, without TP did not present similar increase in the cortical bone volume nor density.[11,12,15]

The findings of the present study is in accor-dance to previous reports which demonstrated that the increased cortical bone thickness would result in significant increase in the mechanical properties such as; insertion torque,[6,34,35] and pull out strength.[35,36] In contrast, the decreased of bone density results in a significant decrease of the mechanical properties of the bone.[34]

The TP found in the present study were medium-large in size and were frequently located in the premolar-to-molar area, as in agreement with previous reports.[20,23] The maximum height was mostly found in the first maxillary molar region, corresponding to the MM position. According to the results of this study, this region provided the highest MIT values within the TP group, therefore we suppose that this region might contain the maximum bone thickness and bone density. Hence, the MIT values at the middle median were significantly higher than in other positions.

Although the insertion of miniscrew implants was limited to the midpalatal region, the width and length of TP showed no influence on MIT in any position. However, MIT values were correlated to the TP height in the MM sites.

In the maxilla without TP, no statistically significant differences in MIT values at all positions were observed. The results of the present study are also in agreement with the findings of Setthayon et al.[37] who assessed the MIT values of miniscrews inserted at several sites of the hard palate of cadavers without TP. The authors did not observe a significant difference in the MIT values along to the midpalatal suture area. However, in their study, only maxillary bone without TP was investigated. A possible explanation for the non-difference in the antero-posterior regions of the midpalatal suture area might be explained by the fact that the bone thickness and bone density antero-posteriorly along the midpalatal region are similar.[12,15] Kang et al.[12] measured the bone thickness of the midpalatal area and its vicinity posterior to the incisive foramen using computer tomography. The authors observed similar bone thickness along the midpalatal area. Moon et al.[15] also observed that the high bone density of the midpalatal region was constant antero-posteriorly. Therefore, in the midpalatal region, no significant variation in bone thickness or bone density is expected to be observed. Stockman et al.[38] who performed a histomorphometric study on human cadavers, reported that the amount and quantity of bone along the anterior palatal midline was constant and sufficient for miniscrew implantation.

A similar study reporting the MIT values of miniscrews implants inserted in the midpalatal suture area was performed by Suzuki and Suzuki.6 However, in their study, the MIT values was assessed in patients. A mean MIT value of 14.5±1.6 Ncm for predrilling miniscrew implants and 21.1±2.2 Ncm for self-drilling miniscrew implants placed in the midpalatal region was observed. Although the presence of TP was not reported by the authors, the MIT values obtained in the midpalatal suture of the patients was similar to the MIT values obtained in the MM sites (20.9±5.8 Ncm) of the present study. Therefore, we considered that the cadaveric model used in the present study might be a reliable and reproducible approach to investigate the mechanical properties of miniscrew implants in *ex-vivo*.[4,37,39,40]

A limitation of this study pertains to the small number of samples. Another limitation was that the cadaversí ages were high, but many patients who seek orthodontic treatment are adolescents, who have significantly lower bone density, as reported by Korbmacher et al.[41] On the other hand, although the MIT value could be easily assessed during placement, it could not exactly predict the success rate of miniscrew implants because there are many factors associated with the maintenance of miniscrew implants during orthodontic loading. Therefore, further clinical studies should be done throughout the application of orthodontic loading to confirm the stability of miniscrew implants during orthodontic loading. Also, because of the high prevalence of TP in the Thai population, the quality and quantity of bone in patients with TP should be investigated for the optimal guideline to select the miniscrew implant size or the optimal protocol for orthodontic miniscrew implant placement in cases of TP presented.

During the experiment, one miniscrew implant was fractured during placement in a cadaver with TP with high MIT values. This supports the report of Wilmes et al.[42] that a high insertion torque might result in miniscrew fracture. One option to reduce the MIT values and consequently, avoid the risks of miniscrew implant fracture during insertion would be the use of the pre-drilling procedures prior to the miniscrew insertion. According to the studies of Suzuki and Suzuki, the MIT values of miniscrews that were inserted with pre-drilling procedures into the palatal bone was reduced approximately 30% of the MIT values.[6] Therefore, the pre-drilling procedures might be an excellent option to reduce the risks and complications of having a miniscrew implant fractured during the insertion into a dense cortical bone.[6,34,42,43]

Although the findings of the present study appear to be evident, this is the first report on the assessment of MIT values in the TP sites. Therefore, it would provide substantial information about the biomechanics of the TP structure. Further studies involving the use of pre-drilling procedures for the reduction of MIT in the TP should be investigate. Therefore, further clinical studies should be done throughout the application of orthodontic loading to confirm the stability of miniscrew implant during orthodontic loading and because of high prevalence of TP in Thai population, the quality and quantity of bone in patient with TP should be clarify investigated for the optimal procedure for orthodontic miniscrew implants placement in case of presenting of TP in the palate.

Conclusion

In terms of maximum insertion torque assessment, the presence of TP increased the MIT values during miniscrew insertion in the midpalatal region throughout the anterior, middle and posterior median positions. TP size (height) is related to the MIT value in the middle median region of large TP.

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