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An Anatomical Study using CT Images for the Implantation of Micro-implants

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Surgical microscrews were introduced and used as one method to provide absolute anchorage. Some clinicians implanted microscrews or miniscrews into the basal bone below the roots of the teeth to evade damage to the roots. Because the implanted microscrews were positioned too low the applied force was insufficient to retract the anterior teeth or protract the posterior teeth, and the use of microscrews or miniscrews seemed limited in applying vertical force. However Park implanted microscrews(micro-implants (1.2 mm in diameter)) into the alveolar bone between the roots of the posterior teeth to change the direction of the applied force toward increasing horizontal component of the force. Moreover, these microscrew implants were positioned in the alveolar bone between the roots without causing discernable damage to the roots. This study was performed to provide guidelines and anatomic data to assist in the determination of the safe location for micro-implants.

By measuring the CT images from 21 patients, anatomical data were obtained which were then used as a guide to determine the location for the implantation of micro-implants.

The thickness of the cortical bones at the alveaolar bone region increased from the anterior to the posterior teeth area. The mandibular posterior teeth area showed thicker cortical bone.

A greater distance was observed in distance between the second premolar root and first molar root in the upper arch, between the first molar root and the second molar root in the lower arch.

The alveolar bone of the posterior teeth area is considered the best site for the implantation of micro-implants.

Key words : Micro-implant, Thickness of cortical bone, Distance between roots, Distance between bone surface and roots

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Many studies have been undertaken to obtain data on locations for suitable anchorage by using osseointegrated implants[1-4].

Osseointegrated implants are known to provide absolute anchorage for orthodontic treatment. Their use as orthodontic anchorages, however, has been limited

due to the limitations related to space, economy, and the waiting required for osseointegration .

Recently, Kanomi[5], Costa et al[6], and Park[7-11] used titanium microscrews and miniscrews for orthodontic anchorage. The advantages of these microscrews are their small size, which allows placement in any area of the bone in the mouth, the ease of implantation and removal, their low cost, and the short interval between implantation and orthodontic force application.

Kanomi[5] and Costa et al[6] implanted microscrews (1.2 mm in diameter) and miniscrews (2.0 mm in diameter) into the basal bone below the roots of the teeth to prevent root damage. Because the implanted microscrews were positioned too low the applied force was insufficient to retract the anterior teeth or protract the posterior teeth, and the use of microscrews or miniscrews seemed limited in applying vertical force. However Park[7-11] implanted microscrews(micro-implants (1.2 mm in diameter)) into the alveolar bone between the roots of the posterior teeth to change the direction of the applied force toward increasing horizontal component of the force. Moreover, these microscrew implants were positioned in the alveolar bone between the roots without causing discernable damage to the roots[7-11].

However little research has been undertaken to provide guidelines to determine the safe location for micro-implants.

This study was performed to provide anatomic data to assist in implantation of micro-implants.

MATERIALS AND METHODS

1. Patients

High resolution computerized tomograms, which were taken using a CT-i PRO, GE Co. U.S.A., of the maxillary and mandibular arch of 21 patients (14 male, 7 female, age range 13 to 60 years, and mean age 26 years), at the Kyungpook University Hospital and the Keimyung University Dongsan Hospital were selected as samples. Thirteen patients were under 25 years, and 8 patients were over 25 years.

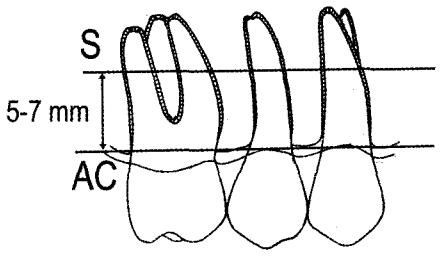

Fig. 1. The schematic diagram showing the section of CT image(S) at the level of the 5-7 mm apical from alveolar crest(AC).

Patients with facial deformities and severe crowding were excluded.

2. Method

The CT images at the level of the 5-7 mm apical of the alveolar crest (Fig. 1) were scanned and inputted into an IBM compatible personal computer.

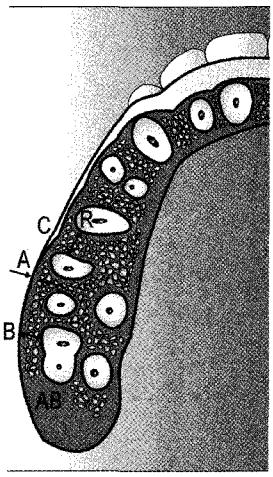

Fig. 2. The measurements concerning thickness of the cortical bone (A), the distance between cortical bone surface and root(B), and the distance between roots of the adjacent teeth (C); R, root, AB, alveolar bone.

The thickness of the cortical bone, the distance between the cortical bone surface and roots, and the distance between the roots of the adjacent teeth, which are illustrated in Fig. 2, were measured using the Scion image program (Beta release 4.02, Scion Co. U.S.A.).

The images were magnified 10 times on the computer display monitor and the midpoint of the blurred margin of the image was selected as the measurements point.

The mean and standard deviation of the measurements were calculated.

Table 1. The mean and standard deviation of thickness of cortical bone, distance between bone surface and roots, and distance between roots at maxilla and mandible.

			Mean	SD	Max	Min
Thickness of cortical bone	Mx	5	1.44	0.50	3.0	0.9
		6	1.37	0.49	2.5	0.8
		7	1.55	0.38	2.1	0.9
		6-Lingual	1.40	0.27	2.0	0.9
Distance between bone surface and root		5	2.75	1.18	4.4	1.0
		6	2.24	1.12	5.3	0.9
		7	2.8	1.01	5.4	1.4
		6-Lingual	2.29	1.06	4.4	0.5
		7-Lingual	2.08	0.94	4.9	0.9
Distance between roots		5~6	3.18	0.92	5.8	2.0
		6~7	2.11	1.22	5.0	0.8
		6~7 Lingual	4.03	0.87	5.7	2.8
Thickness of cortical bone	Mn	5	1.71	0.50	2.8	0.9
		6	2.48	0.71	3.1	1.3
		7	3.17	0.93	4.7	1.4
Distance between		4	1.60	0.49	2.2	0.8
bone surface and root		6	2.16	0.69	3.5	1.2
		7	5.33	2.00	8.7	3.1
Distance between roots		3~4	2.20	0.92	2.8	1.4
		5~6	3.47	1.09	4.8	2.0
		6~7	4.57	1.41	6.5	2.7

3. Reliability of the Method

The method error (ME) was calculated for the thickness of the cortical bone, and the distances between the roots of the adjacent teeth, and those between the cortical bone surface and the roots.

The CT images of 7 patients were selected and measured at 2-week intervals by the same observer.

The ME calculations were performed using the Dahlberg formula[11]

$$ME = \sqrt{\frac{\Sigma d^2}{2n}}$$

Where d is the difference between two measurements of a pair and n is the number of paired double measurements.

RESULTS

The MEs of the thicknesses of the cortical bone, and the distances between the roots of adjacent teeth, and the distances between the cortical bone surface and the roots were 0.14(n=34), 0.29(n=70), and 0.57(n=31), respectively. These differences were not statistically significant ($p>0.05$).

The mean and standard deviation of each measurements are shown in table 1.

DISCUSSION

The potential of high resolution computed tomography (CT) as a quantitative tool for obtaining linear and area measurements of skeletal tissue has been investigated. CT images have been used to measure the cross-sectional areas of the mandible[13] and the humerus[14].

Moreover, CT images tend to provide inaccurate measurements because structures are blurred at boundaries, and it may be difficult to decide where to place a measurement point. However, Tsunori et al[15] and Spoor et al[16] measured bone thickness using CT and concluded that the CT images could be used as a means to measure linear and area measurements.

The CT images at level of the 5-7 mm apical to the alveolar crest were selected for the measurements, because the apical portion of the micro-implant was positioned a little apical to this level clinically.

The author has usually placed micro-implants into the alveolar bone at 3-4 mm from the gingival margin, which is coincident with the 1-2 mm from the alveolar crest. The vertical length of the micro-implants embedded into the alveolar bone was 4.6 to 5.2 mm in the maxillary arch (Fig. 3). The apical portion of the micro-implants was located at 5-7 mm apically from the alveolar crest. The apical portion of the implanted micro-implants was more prone to contact with roots rather than the coronal portion. Therefore, the CT images at the level of the 5-7mm apical from the alveolar crest were selected for measurements.

Regarding the thickness of the cortical bone, the mandibular arch proved better than the maxillary arch for micro-implant implantation. The posterior teeth area has thicker cortical bone than the anterior teeth area. These results demonstrate that the alveolar bone at the anterior teeth area is unsuitable as a location for micro-implants. In case of the impalntation of micro-implants in the anterior teeth area, the basal bone might be a good site. However, it is difficult to apply force from micro-implants, implanted into the basal bone in the anterior teeth area, except for the purpose of applying an intruding force. These results also show that the alveolar bone in the posterior teeth area is a good location for the implantation of micro-implants. By implanting micro-implants at the alveolar bone, not the basal bone, clinicians can apply not only an intruding force but also an anterior-posterior directed force.

For retracting upper anterior teeth, in other words applying an upward and backwardly directed force, the alveolar bone between both the maxillary second premolar and second molar, and between the first molar and second molar can be considered as a suitable implantation site. This study shows the alveolar bone between the maxillary first premolar and the first molar was safer than between molars for the implantation of micro-implants in terms of avoiding root damage, because the distance between the roots is wider between the second premolar and the first molar than between the first and second molars.

Moreover, because the distance from the bone surface to the root at the maxillary first premolar is longer than that of the first molar, the mesial side of the alveolar bone is safer than the distal side. The author usually uses a 1.2 mm in diameter, 8 mm long micro-implant at the maxillary arch. Maxillary micro-implants were implanted 30-40 degrees to the long axis of the teeth and the micro-implants were embedded 6 mm into the alveolar bone. Therefore, the length of the maxillary micro-implants penetrating the alveolar bone at the horizontal plane was only 3 to 3.85 mm (Fig. 3), not 6 mm. By implanting micro-implants 30-40 degrees to the bone surface, the possibility of root contact can be reduced when compared with implanting the micro-implant perpendicular to the bone surface, and allows the implantation of a longer micro-implant, which results in increased stability.

In the mandibular arch, the author has typically uses 1.2 mm diameter, 6 mm long micro-implants, and places micro-implants into the alveolar bone at 10-20 degrees to the long axis of the teeth, embedding those 4 mm into the alveolar bone. The penetration Lenght of the mandibular micro-implants into the alveolar bone at the horizontal plane was only 0.7 to 1.45 mm (Fig. 3), not 4 mm.

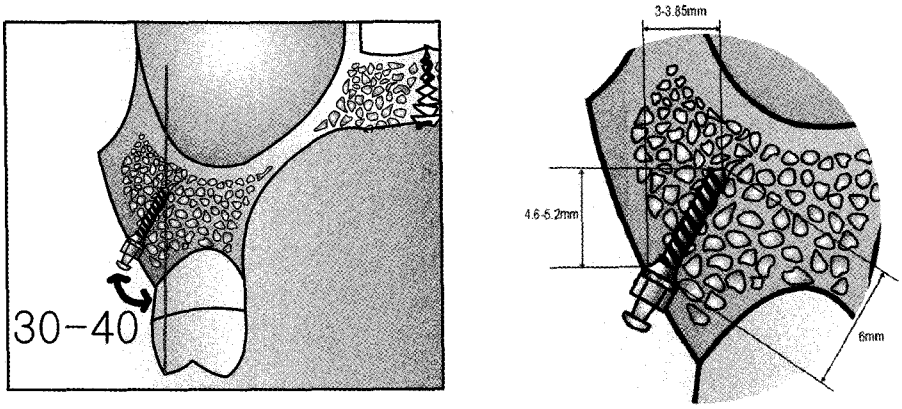

Fig. 3. The schematic diagram shows the relationships between maxillary micro-implant and roots of the adjacent teeth.

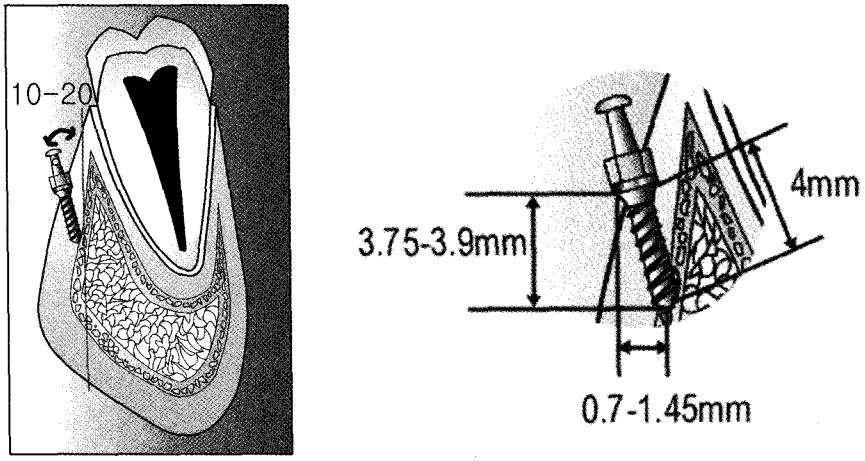

Fig. 4. The schematic diagram shows the relationships between mandibular micro-implant and roots of the adjacent teeth.

The average thickness of the cortical bone at the mandibular first and second molar area was 2.48 mm, and 3.17 mm, respectively, which is similar to the results of research by champy et. al[17]. Therefore, a 6 mm long mandibular micro-implant cannot penetrate into the bone marrow through implanting it at 10-20 degrees against the long axis of the teeth even when the micro-implant is implanted on the buccal side of the posterior teeth. However, because the minimum thickness of the cortical bone at the mandibular first and second molar were 0.71 mm, and 0.93 mm respectively, the clinician must examine the relationships between micro-implants and the adjacent roots carefully. Clinicians can implant micro-implants safely on the buccal side of the mandibular second molar to upright a lingually tipped molar by implanting the micro-implant at 10 degrees to the bone surface or implanting the micro-implants into a more apical position compared with the normal location. Considering that the micro-implants were implanted into the alveolar bone between the roots, the risk of contacting the roots is almost not present (Fig. 4).

With regard to the distance between the bone surface and the root, and the distance between the roots of adjacent teeth, the more posterior, the safer the location becomes for micro- implants. In the maxillary arch, the average distance between the palatal roots of the maxillary first and second molars was 4.03, which

means this area is a good location for maxillary palatal micro-implants.

From the results of this study, the following might be presumed.

The 1.2 mm diameter, 8 mm long maxillary micro-implants can be implanted into the alveolar bone between the maxillary second premolar and the first molar.

The 1.2 mm diameter maxillary palatal micro-implant can be implanted into the palatal alveolar bone between the maxillary first and the second molar safely.

The 1.2 mm diameter, 6 mm long mandibular micro-implant can be implanted into the alveolar bone between the mandibular first and second molars without the possibility of root damage.

However, the distances between the roots and the thickness of the cortical bones show large individual variations (table 1). Therefore, the clinician should evaluate the relatioships between the roots and the cortical bone thickness by examining dental and panoramic X-rays thoroughly before implanting micro-implants.

The sample in this study was too small to provide accurate guidelines for the implantation of micro-implants, and further studies using a larger sample from different age groups are required.

SUMMARY

By measuring the CT images from the 21 patients, anatomical data was obtained, and those can be used as a guide to determine the location for the implantation of micro-implants.

The thickness of the cortical bones at the alveolar bone region increased from the anterior to the posterior teeth area. The mandibular posterior teeth area showed thicker cortical bone.

A greater distance was observed between the second premolar root and the first molar root in the upper arch, between the first molar root and the second molar root in the lower arch.

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국문초록

CT 이미지를 사용한 Micro-implants 식립을 위한 해부학적 연구

박효상

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교정치료의 고정원으로서 수술용 Microscrew가 소개되고 사용되어 왔다. 몇몇 임상가들은 Miniscrew혹은 Microscrew를 치근의 손상을 피하기 위하여 치근 하방의 기저골에 식립하여 사용하여 왔다. 그러나 저자는 Micro-implant를 치근 손상없이 치근사이의 치조골에 식립하여 고정원으로 사용하여 왔다. 이렇게 하므로서 치근하방에 식립할 때 생기는 문제점인 수직 분력이 커지고 수평 분력이 작아지는 것을 방지하여 상악의 경우 적절한 후상방 교정력을 가할 수 있다. 그리고 치조골에 상악의 경우 치아 장축에 대하여 30-40도의 각도로, 하악의 경우 10-20도의 각도로 식립하여 교정력의 방향을 전술한 바와 같이 수평방향으로 바꾸고 긴 Micro-implant를 치근 손상의 위험성을 줄이며 식립하여 안정도를 높일 수 있었다.

그러나 Mciro-implant를 치근사이 치조골에 식립하는데 기준이 되는 어떠한 연구도 이루어 지지 않았다. 본 연구는 Micro-implant식립에 기준이 되는 즉 치근 손상 없이 비교적 안전하게 식립할 수 있는 부위의 선택을 위한 근거 자료를 얻기 위하여 시행되었다.

21명 환자를 대상으로 치조골로부터 5-7mm에 해당하는 CT 절단면을 선택하여 피질골의 두께, 피질골 표면과 치근과의 거리, 치근사이의 거리등을 측정하였다.

. 각 부위별 피질골의 두께, 골 표면과 치근사이의 거리, 인접 치근사이의 거리등을 구하였다.
. 피질골의 두께는 전치부에서 구치부로 이행할수록 두꺼웠다. 특히 하악골 구치부에서 가장 두꺼웠다.
.인접 치근 사이의 거리 계측 항목에서 상악에서는 제2소구치와 제 1대구치사이, 하악에서는 제 1대구치와 제 2 대구치 사이에서 가장큰 값을 보였다.

주요 단어 : Micro-implant, 피질골 두께, 골표면과 치근사이의 거리, 인접치근사이의 거리