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Bone Morphology Measurements in Anterior Tooth Region of Edentulous Jaw

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In the present study, we determined the morphometry of the lateral incisor-canine and medial region of edentulous jaws to assess the region to place the implant for implant oven denture.

Ten formalin fixed cadavers were used in this study. On the labiolingual sections of cone-beam CT images, vertical distances between the alveolar crest and the inferior margin of the mandible, maximum widths, and bone area per tissue area (BA/TA) in cancellous bones of the mandible were measured.

The BA/TA ratio of cancellous bone and maximum width of alveolar bone were greater in the medial region than in the lateral incisor-canine region of the mandible.

The former region might be more adaptive than the latter for implant placement. Additionally, the thick cancellous bone in the medial region might have high load bearing capability.

Key words：implant overdenture, cone-beam CT, bone area per tissue area (BA/TA)

Introduction

For reconstruction to treat occlusion in edentulous patients, oral implants have recently been used as prosthetic treatment in addition to conventional dentures. Although implant treatment is more invasive and the cost is greater as compared to conventional removable dentures[1~3], both a fixed prosthesis using many implants and a two-implant overdenture (2IP-IOD) are known to increase the satisfaction of patients. A consensus statement based on evidence of the effects of a 2IP-IOD stated that it should be the first choice for restoration of an edentulous mandible[1]. Then in 2009, an additional consensus statement released by the British Society for Prosthetic Dentistry confirmed those findings[2,3]. With a 2IP-IOD, implants are placed around the lateral incisor to the canine region[4,5].

For reducing invasion associated with implant placement, use of a single implant overdenture (1IP-IOD) has been gaining recent attention[4,6]. In the present fundamental study, we examined

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treatment outcomes obtained with use of 1IP-IOD and 2IP-IOD by examining the morphometry of the mandible in the lateral incisor-canine region and midline using cone-beam computed tomography (CBCT) images.

Materials and Methods

Ten formalin-perfused cadavers were used in this study with the craniums set parallel to the floor. The examined region included each side of the mental foramen on CBCT images obtained with a 3DX Multi Image Micro CT FPD (Morita, Kyoto, Japan). All scanning was performed for 18 seconds at 80 Kv and 5 mA. Obtained images were reconstructed with the mandibular plane parallel to the horizontal plane, with the medial line set on the basis of the mental spine and multi-planer reconstructed (MPR) images along the outline of the mandible. This area, including 40% of the front between the medial line and mental foramen, was set as the lateral incisor-canine region (Fig. 1). The medial region and each side of the lateral-canine region were set as the region of interest, and measurements were performed. The study protocol was approved by the ethics committee of Ohu University (No. 185).

Using labio-lingual cross-sections, the vertical distance from the alveolar crest to inferior margin of the mandible, maximum width, and bone area per tissue area (BA/TA) in cancellous bone were determined. Measurements of the vertical distance and maximum width of the mandible were performed using the Morita One Volume Viewer application (Morita, Kyoto, Japan) and BA/TA was calculated using the public domain software application Image J[7]. The area of cancellous bone was selected and binarized using Image J prior to measurement of bone area in the region of the interest. The BA/TA ratio was calculated based on bone area divided by tissue area.

A Mann-Whitney U-test was used for comparisons between the lateral incisor-canine and median regions. A p value less than 0.05 was considered to indicate a significant difference.

Results

For vertical distance, the lateral incisor-canine region was 21.6±6.6 mm and the medial region was 21.8±5.9 mm, while for maximum width, that of the lateral incisor-canine region was 11.7±1.3 mm and of the medial region was 13.4±1.2 mm. BA/TA in the lateral incisor-canine region was 36.1±7.2% and in the medial region was 47.7±11.9% (Table. 1).

The vertical distance of the lateral incisor-canine region between the medial region was not significantly different. In contrast, maximum width and BA/TA of alveolar bone for those regions was significantly different (Fig. 2).

Discussion

The McGill consensus statement presented at McGill University, Montreal, in 2002 declared that overwhelming evidence shows that a 2IP-IOD should be the first choice for treatment of an edentulous mandible[1]. Thereafter, in 2009, the York consensus statement was released in support for and to follow-up the McGill statement[2,3]. For a 2IP-IOD procedure, implants are placed around the lateral incisor and canine region of the mandible[4,5]. More recently, a 1IP-IOD procedure has been used for an edentulous mandible to reduce the cost of treatment as well as invasiveness of the surgical procedure, with the implant placed in the anterior midline of the mandible[4,6]. In the present study, morphological measurements were performed to compared the prognostic value of 1IP-IOD and 2IP-IOD.

The average size of the crown width of the central incisor, lateral incisor, canine, first premolar and second premolar in Japanese individuals were reported to be 5.4, 6.1, 6.7, 7.1,

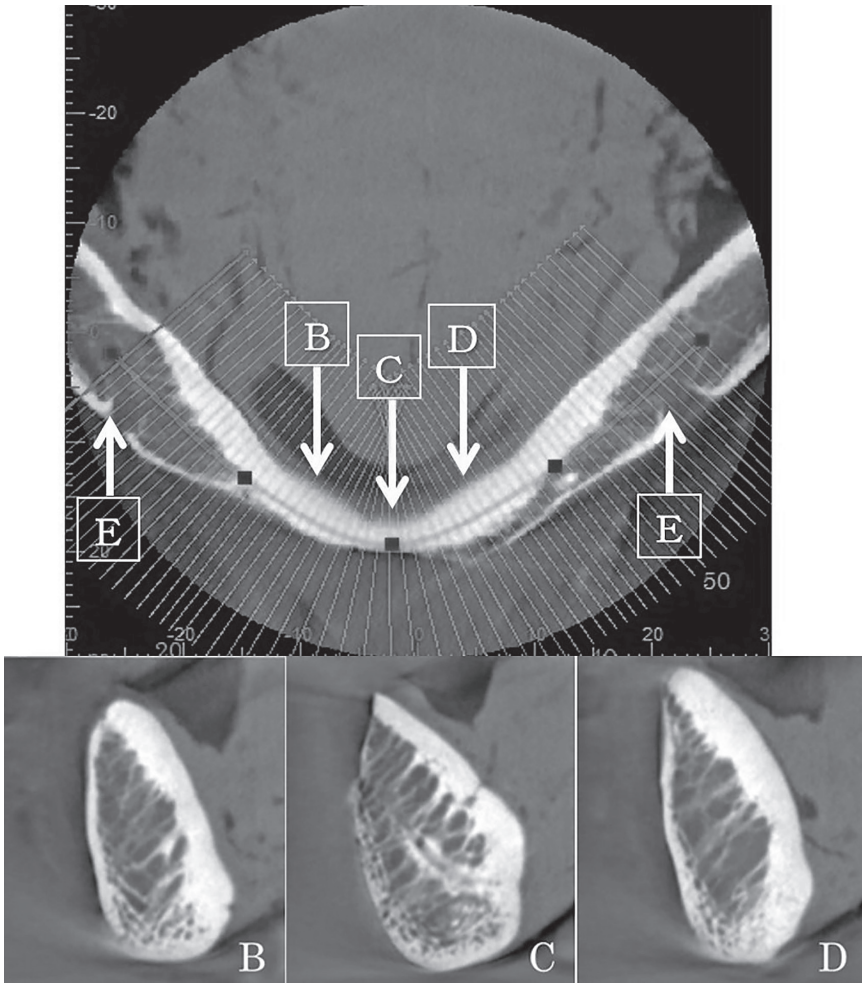

Fig. 1 Region of interest

A. Horizontal slice image of alveolar bone of anterior region
The region of interest was set as the mental spine and 40% of the front area between the mental spine and mental foramen
B. MPR image of right-side lateral incisor-canine region
C. MPR image of medial region
D. MPR image of left-side lateral incisor-canine region
E. Mental foramen

Table 1. Measurement results

	Vertical distance (mm)	Maximum width (mm)	Bone area per tissue area BA/TA(%)
Lateral incisor-canine region	21.6±6.6	11.7±1.3	36.1± 7.2
Medial region	21.8±5.9	13.4±1.2	47.7±11.9

and 7.4 mm, respectively[8]. The mental foramen exists in the interval between the premolar teeth, and midway between the upper and lower borders of the mandible body[9]. The region of implant placement for a 2IP-IOD is the lateral incisor-canine region. Thus, for our analysis, the area on CBCT images, including 40% of the front between the medial line and mental

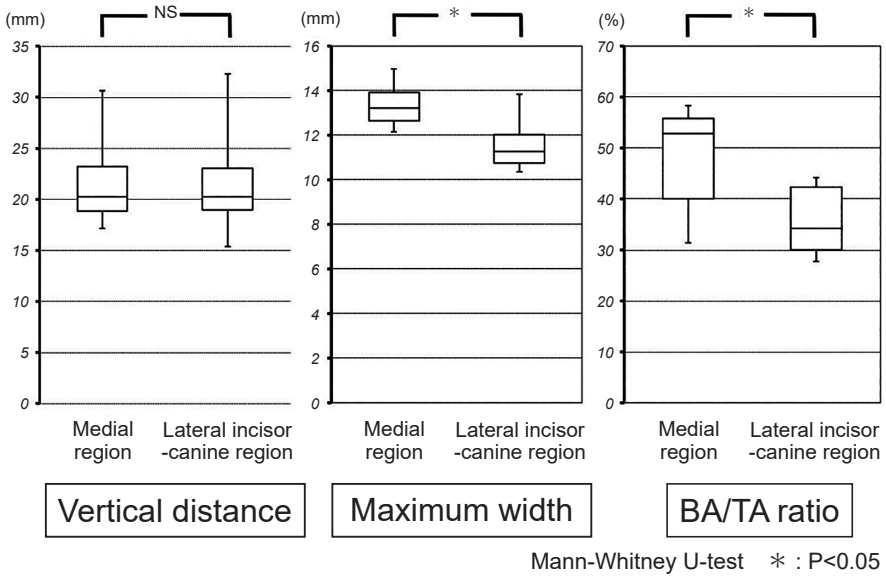

Fig. 2 Measurement results and statistical differences

foramen, was set as the lateral incisor-canine region. A previous *in vitro* study that used locator attachment to evaluate movement of an implant overdenture with different numbers of implants showed that rotation of the implant overdenture during mastication with anterior teeth was increased in cases with a 2IP-IOD as compared to 1IP-IOD and 3IP-IOD cases[4]. Also, a clinical study showed that retention force increases in cases with ball attachments as compared to Dolder bars and magnet attachments used in overdenture prosthetic treatments[5]. Patients prefer bar and ball type attachments rather than a magnetic attachment[10], though selection of the attachment system has effects on implant overdenture stability. In a study that quantified cortical bone parameters in mandibles using CBCT, cancellous bone was found to be significantly thicker in incisor as compared to canine regions[11]. Furthermore, the thickness of the anterior region of the mandible varies in each patient[12].

In the present study, a comparison of the morphometry of the mandible in the incisor-canine and medial regions showed no significant difference for vertical distance. The maximum widths of the mandible and bone area per tissue area, i.e., BA/TA, were found to be greater in the medial region than the incisor-canine region of the mandible (Fig. 2). In the alveolar part of the mandible, alveolar bone becomes atrophied following tooth extraction[13], while it has also been shown that trabecular bone in the alveolar ridge of the mandible undergoes structure remodeling until 12 months after tooth extraction[14]. At the mandibular symphysis, the two halves of the mandible unite and ossification proceeds towards the midline[9]. It has been shown that bone requires stimulation to maintain its mass[13]. Also, a previous study that used CBCT images reported that the genial tubercle is longer in males than females[15]. In the present study, the BA/TA ratio of cancellous bone was greater in the medial region than in the lateral incisor-canine region of the mandible. Furthermore, the lingual foramen exists on the lingual side of the mandibular cortical bone in the midline[16], from which blood vessels

pierce the mandible [17]. Quantification of not only bone quantity but also understanding of the pathway of the vascular supply to the mandible are necessary prior to implant placement in the medial region of the mandible. The present morphological measurements of the mandible showed that bone width and BA/TA are greater in the medial side of the mandible.

Conclusion

For placement of an implant overdenture, the present results showed that the medial region of the mandible is more variable than the lateral-canine region. Furthermore, the existence of thick cancellous bone in the medial region suggests a promising implant load capability.

Compliance with ethical standards
Conflicts of interest : None to declare

References

1) Feine, J.S., Carlsson, G.E., Awad, M.A., Chehade, A., Duncan, W.J., Gizani, S., Head, T., Heydecke, G., Lund, J.P., MacEntee, M., Mericske-Stern, R., Mojon, P., Morais, J.A., Naert, I., Payne, A.G., Penrod, J., Stoker, G.T., Tawse-Smith, A., Taylor, T.D., Thomason, J.M., Thomson, W.M. and Wismeijer, D. : The McGill consensus statement on overdentures. Mandibular two-implant overdentures as first choice standard of care for edentulous patients. Gerodontology. **19** ; 3-4 2002.
2) Thomason, J.M., Feine, J., Exley, C., Moynihan, P., Müller, F., Naert, I., Ellis, J.S., Barclay, C., Butterworth, C., Scott, B., Lynch, C., Stewardson, D., Smith, P., Welfare, R., Hyde, P., McAndrew, R., Fenlon, M., Barclay, S. and Barker, D. : Mandibular two implant-supported overdentures as the first choice standard of care for edentulous patients--the York Consensus Statement. Br. Dent. J. **22** ; 185-6 2009.
3) Thomason, J.M., Kelly, S.A., Bendkowski, A. and Ellis, J.S. : Two implant retained overdentures –a review of the literature supporting the McGill and York consensus statements–. J. Dent. **40** ; 22-34 2012.
4) Oda, K., Kanazawa, M., Takeshita, S. and Minakuchi, S. : Influence of implant number on the movement of mandibular implant overdentures. J. Prothet. Dent. **117** ; 380-385 2017.
5) Naert, I., Alsaadi, G. and Quirynen, M. : Prosthetic aspects and patient satisfaction with two-implant-retained mandibular overdentures: a 10-year randomized clinical study. Int. J. Prosthodont. **17** ; 401-10 2004.
6) Passia, N., Wolfart, S. and Kern, M. : Ten-year clinical outcome of single implant-retained mandibular overdentures-A prospective pilot study. J. Dent. **82** ; 63-65 2019.
7) Schneider, C.A., Rasband, W.S. and Eliceiri, K.W. : NIH image to Image J : 25 years of image analysis. Nat Methods. **9** ; 671–675 2012.
8) Fujita, T. : Textbook of dental anatomy 22nd Ed. ; 47-78 Kanehara& Co., Ltd Tokyo 1995.(in Japanese)
9) Evans, B.T. Infratenporal and pterygopalatine fossae and temporomandibular joint. In : Gray's anatomy (Ed., Standring S.) 41st Ed. ; 534-555 Elsevier Livingstone 2016.
10) Cune, M., van Kampen, F., van der Bilt, A. and Bosman, F. : Patient satisfaction and preference with magnet, bar-clip, and ball-socket retained mandibular implant overdentures: a cross-over clinical trial. Int. J. Prosthodont. **18** ; 99-105 2005.
11) Velásquez, H., Olate, S., Díaz, C., Navarro, P., Borie, E. and de Moraes, M. : Quantitation of mandibular symphysis bone as source of bone grafting : Description in class I and class III skeletal conditions. J. Oral Implantol. **43** ; 211-7 2017.
12) McAndrew, B.P. and Strauss, R.A. : Delayed muscle detachment after genial tubercle advancement in patient with obstructive sleep apnea. J. Oral Maxillofac. Surg. **58** ; 1040-3 2000.
13) Berkivitz, B.K.B, Oral cavity. In : Gray's anatomy (Ed., Standring S.) 41st Ed. ; 507-533 Elsevier Livingstone 2016.
14) Tanaka, M., Yamashita-Mikami, E., Akazawa, K., Yoshizawa, M., Arai, Y. and Ejiri, S. : Trabecular bone microstructure and mineral density in human residual ridge at various intervals over a long period after tooth extraction. Clin. Implant Dent. Relat. Res. **20** ; 375-83 2018.
15) Nejaim, Y., Moreira, D.D., Fernandes, A.B.N., de Souza, M.M.G., Groppo, F.C. and Haiter, Neto, F. : Evaluation of the morphology of the

genial tubercle using cone-beam computed tomography. Br. J. Oral Maxillofac. Surg. **56**；155-6 2018.
16) Liang, X., Jacobs, R., Lambrichts, I. and Vandewalle, G.：Lingual foramina on the mandibular midline revisited. A macroanatomical study. Clin. Anat. **20**；246-51 2007.
17) Xie, L., Li T., Chen, J, Yin D., Wang, W. and Xie, Z.：Cone-beam CT assessment of implant-related anatomy landmarks of the anterior mandible in a Chinese population. Surg. Radiol. Anat. **41**；927-934 2019.

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