Clinical Report

Age Affects Alveolar Bone Height and Width in Patients Undergoing Dental Implant Treatment: Findings from Computed Tomography Imaging

Shungo Ichiki, Hirotaka Muraoka, Naohisa Hirahara, Kotaro Ito, Hiroyuki Okada and Takashi Kaneda

1) Department of Radiology, Nihon University School of Dentistry at Matsudo, Matsudo, Japan
2) Department of Oral Pathology, Nihon University School of Dentistry at Matsudo, Matsudo, Japan

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Abstract: Dental implants may help improve the general health and quality of life in older adults with tooth loss. Accurate assessment of the alveolar bone is key to implant treatment. Several studies have examined the value of jaw morphology diagnostic imaging; however, few studies have evaluated age-related changes in alveolar bone height and width using computed tomography (CT) scanning. The purpose of this study was to assess age-related changes in alveolar bone height and width using CT scans of patients undergoing dental implant treatment. We analyzed CT scans of 1960 sites in 655 cases (225 men, 430 women; age range, 20-85 years; mean age, 60.96 years) obtained from June 2016 to December 2018. The mean alveolar bone height and width were the outcomes of interest. The participants were dichotomized by age into groups of 20-64 and 65-85 years. Alveolar bone height and width were classified into six groups by site; the values were examined by age. Analyses were performed with the Mann-Whitney U test and Spearman correlation coefficients. Statistical significance was established at P<0.05. The height of the upper anterior (P<0.001), upper premolar (P<0.001), upper molar (P<0.01), lower anterior (P<0.01), lower premolar (P<0.05), and lower molar (P<0.01) sites, and the width of the upper anterior (P<0.01), upper premolar (P<0.01), and upper molar (P<0.01) sites in the alveolar bone were significantly associated with age. The present findings suggest that the decline in upper alveolar bone height and width and lower alveolar bone height is associated with aging in the present cohort. These findings suggest that older people may require implant treatment that is predicated on bone grafting.

Key words: Age-related change, Computed tomography, Alveolar bone

Introduction

Developed countries are facing aging populations. Aging is a process associated with chronological age; older adults are defined as those aged ≥65 years. The United Nations Population Division forecasts that the proportion of the population aged ≥65 years in developed countries may increase from 14.3% in 2000 to 25.9% in 2050. The changing demographics and associated tooth loss are likely to affect the future demand for dental care services. Tooth loss and oral disease in older adults are public health challenges, and dental implant treatment is becoming increasingly common worldwide for patients with tooth loss.

Dental implants help reduce the risk of dysfunction in people who have lost their teeth and may improve their overall health and quality of life. Dental implant treatment requires that the dentist knows the exact height, width, and contour of the alveolar bone and the relationship between the maxillary sinus and the mandibular canal. Failure to accurately assess these parameters may lead to complications, including inferior alveolar nerve injury and maxillary sinus membrane perforation.

Pantomography and computed tomography (CT)-based examinations are often used to assess morphology, mandibular quality, and post-operative progress in clinical practice. CT scanning may be particularly helpful in accurate three-dimensional evaluation of jawbone morphology due to its excellent spatial resolution. Previous studies have shown that implant treatment without suitable alveolar bone height and width is unlikely to be effective. In addition, previous studies have shown that older age may increase the risk of implant failure. In fact, older patients are more likely than their younger counterparts to experience implant failure, highlighting the importance of accurate radiographic assessment of alveolar bone morphology ahead of any implant treatment. However, few previous studies have examined the alveolar bone height and width in different age groups.

The present study aimed to assess age-related changes in alveolar bone height and width, using CT scan findings from 665 patients (1960 clinical sites) who received a dental implant.

Materials and Methods

This was a retrospective cohort study, approved by the ethics committee, Nihon University School of Dentistry at Matsudo (No. EC19-010) and conducted in accordance with the 1975 Declaration of Helsinki (2013 revision). This study examined CT findings from 1960 clinical sites (Upper anterior 286 sites, upper premolar 366 sites, upper molar 417 sites, lower anterior 206 sites, lower premolar 266 sites, and lower molar 419 sites) in 655 patients (225 men, 430 women; age range, 20-85 years; mean age, 60.96 years) undergoing dental implant treatment at Nihon University School of Dentistry at Matsudo, Matsudo, Japan.
the Nihon University School of Dentistry Hospital, Matsudo, Japan, between June 2014 and December 2018. The exclusion criteria were tooth sockets due to extraction procedures (n=331) and severe metal artifacts in imaging (n=154).

Data acquisition

CT scans were acquired with an Aquilion 64 system (Canon Medical Systems Corp. Otawara, Japan), which is a multi-detector row CT (MDCT) unit, with Ziostation (Ziosoft, Newark, CA) as the workstation. Imaging parameters included tube voltage of 120 kV, tube current of 100 mA, and helical pitch of 41 s/rotation; bone display images were used. The MDCT images were displayed on the workstation, and the height and width of the alveolar bone were measured on the screen, using the distance measurement function. The distance was measured twice by two radiology specialists (SI, 4 years of experience; HM, 9 years of experience) blinded to the age of the patients; the average value was used in subsequent analyses. The alveolar bone height was measured using the differences in values obtained between the alveolar bone crest and the floor of the maxillary sinus, the crest of the alveolar bone and the floor of the nasal cavity, and the crest of the alveolar bone and the mandibular canal (Fig. 1). Bone width was measured as the maximum distance between the buccal and lingual sites of the alveolar crest cortical bone (Fig. 2). These methods were adapted from Sekiya et al.11

Statistical analysis

In this study, patients were dichotomized into two age groups (20-64 and 65-85 years) based on the World Health Organization Elderly Classification.1 The alveolar bone height and width were examined at the upper anterior (20-64;132 sites and 65-85 years;154 sites), upper premolar (20-64;167 sites and 65-85 years;199 sites), upper molar (20-64;145 sites and 65-85 years;272 sites), lower anterior (20-64;102 sites and 65-85 years;104 sites), lower premolar 20-64;134 sites and 65-85 years;132 sites), and lower molar sites (20-64;203 sites and 65-85 years;216 sites). Between-group comparisons of the alveolar bone height and width were performed using the Mann-Whitney U test. Spearman’s correlation coefficient (ICC) values were interpreted as follows: 0–0.2, 0.21–0.39, 0.40–0.59, 0.60–0.79, 0.80–0.90, and >0.90 indicated slight, minimal, weak, moderate, strong, and perfect agreement, respectively.12 These

Table 1. Alveolar bone height by site per age group

| Age groups (years) | Height (mm) |
|--------------------|-------------|
|                    | 20-64       | 65-85       | P-value |
| Upper              |             |             |         |
| Anterior           | 16.3±3.5    | 14.1±3.7    | <0.001  |
| Premolar           | 12.9±4.1    | 10.8±4.5    | <0.001  |
| Molar              | 7.7±3.9     | 6.2±3.6     | <0.01   |
| Lower              |             |             |         |
| Anterior           | 19.4±3.7    | 17.4±4.4    | <0.05   |
| Premolar           | 14.4±3.7    | 12.7±3.3    | <0.01   |
| Molar              | 12.6±3.8    | 10.3±4.2    | <0.001  |

Table 2. Alveolar bone width by site per age group

| Age groups (years) | Width (mm) |
|--------------------|-------------|
|                    | 20-64       | 65-85       | P-value |
| Upper              |             |             |         |
| Anterior           | 4.5±1.7     | 3.9±1.5     | <0.001  |
| Premolar           | 5.9±1.7     | 5.2±1.7     | <0.05   |
| Molar              | 7.4±2.9     | 8.5±2.7     | <0.001  |
| Lower              |             |             |         |
| Anterior           | 4.4±1.2     | 4.3±1.7     | 0.46    |
| Premolar           | 6.1±1.8     | 6.4±2.1     | 0.16    |
| Molar              | 7.1±2.3     | 7.4±2.7     | 0.43    |
analyses were performed with SPSS (version 21.0; IBM Armonk, NY). P-values of < 0.05 were considered statistically significant.

Results

The ICC value was 0.785, indicating moderate agreement between the two observers regarding all height and width measurements of the alveolar bone. Table 1 presents the alveolar bone height and width values by site per group. There were significant differences between groups in height estimates of the upper anterior, upper premolar, and lower molar sites (P<0.001), and the upper molar, lower anterior, and lower premolar sites (P<0.05). There were also significant differences between groups in width estimates of the upper anterior and molar sites (P<0.001), and in the upper premolar site (P<0.05). There was no significant difference in lower alveolar bone width between groups (P>0.05).

Figure 3. Scatter plot showing the relationship between the diameter of upper alveolar bone and age.

Figure 4. Scatter plot showing the relationship between the diameter of lower alveolar bone and age.
Correlations between age and alveolar bone height and width per site are presented in Fig 3. Age was negatively correlated with the height of the upper anterior, upper premolar, upper molar, lower anterior, lower premolar, and lower molar sites. Age was positively correlated with upper molar site width. No correlation was found between age and lower molar width.

Discussion

The present study examined the alveolar bone height and width in each site of interest, stratified by age; these parameters differed between patients aged ≤65 years and those aged >65 years. The width of the upper molar alveolar bone in patients aged ≥65 years was significantly greater than that in those aged <65 years. Lower alveolar bone width was similar in both groups.

As life expectancy is increasing worldwide, the duration of periodontal disease is also increasing in older adults\(^\text{13,14}\). Therefore, the rates of both tooth loss and alveolar bone loss are expected to continue to increase\(^\text{15}\). Generally, losing a tooth causes irreversible resorption of the alveolar bone over time. The presence of sufficient alveolar bone in the upper and lower jaws is essential for the success of dental procedures such as placement of dental implants and dentures.

The height and width of the alveolar bone are the most important factors that affect long-term efficacy in dental implant treatment. Failure rates of implants shorter than 9 mm tend to be higher than those of longer implants, regardless of implant manufacturer, design, surface characteristics, or type of application\(^\text{16-19}\). Root form implants with 4-mm crestal diameter usually require ≥6 mm of bone width to ensure sufficient bone thickness and blood supply around the implant, helping achieve long-term retention. Therefore, the baseline alveolar bone height and width should approximate 12 mm and 6 mm, respectively, to accommodate the ideal treatment plan\(^\text{20,21}\). Previous studies have reported alveolar bone height and width deficiencies in many parts of the upper and lower jaws\(^\text{22}\). Similarly, in this study, there was a decrease in alveolar bone height and width in most areas. However, the upper molar sites showed a tendency toward greater alveolar bone width. In general, residual ridge resorption is more rapid in the lower premolar and lower molar regions than in the lower anterior region of the mandible because of the lower position of the reversal line in the posterior region\(^\text{22}\). These changes in the upper molars may depend on the morphology of the maxillary molar base that is wider than that of the lower jaw.

These findings suggest that aging is associated with tooth bone loss and that most older adults may be deficient in bone height and width. These findings also suggest that bone augmentation is required in most older adult patients. These findings may be relevant to clinical practice. In general, bone augmentation is more predictable in width than in height; in cases of inadequate width before implant placement, bone grafting may be used to create an optimal site for restorative implantation\(^\text{22,23}\).

A limitation of our study was its single-center retrospective nature, which may limit the generalizability of the present findings. In addition, we could not examine patients whose imagining findings were affected by impairment resulting from metal artifacts. Prospective studies with long follow-up periods are required to validate the present findings.

In conclusion, the current findings suggest that aging affects the height and width of the upper alveolar bone, with the greatest effect on height, indicating that older adults may not be able to receive implant treatment without also receiving a bone graft.

Conflict of Interests

The authors have declared that no COI exists.

References

1. World Health Organization. World report on ageing and health. WHO Press, 2015
2. Hashimoto K and Tabata K. Population aging, health care, and growth. J Popul Econ 23: 571–593, 2010
3. Jung JH, Choi BH, Jeong SM, Li J, Lee SH and Lee HJ. A retrospective study of the effects on sinus complications of exposing dental implants to the maxillary sinus cavity. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 103: 623–625, 2007
4. Juodžkalys G, Wang HL, Sabalys G, Sidlauskas A and Galindo-Moreno P. Inferior alveolar nerve injury associated with implant surgery. Clin Oral Implants Res 16: 183–190, 2013
5. Moy PK, Medina D, Shetty V and Aghaloo TL. Dental implant failure rates and associated risk factors. Int J Oral Maxillofac Implants 20: 569–577, 2005
6. Fukai K. Oral Health for Achieving Healthy Longevity in an Aging Society Evidence and Policy. Int J Oral Health 13: 52-57, 2017
7. Ettinger RL and Mulligan R. The future of dental care for the elderly population. J Calif Dent Assoc 27: 687–692, 1999
8. Bryant SR and Zarb GA. Outcomes of implant prostodontic treatment in older adults. J Can Dent Assoc 68: 97–102, 2002
9. Chung SK, Wei LJ, Douglass CW and Dodson TB. Risk factors for dental implant failure: A strategy for the analysis of clustered failure-time observations. J Dent Res 81: 572–577, 2002
10. Montes CC, Pereira FA, Thomé G, Alves EDM, Acedo RV, de Souza JR, Melo ACM and Trevilatto PC. Failing factors associated with osseointegrated dental implant loss. Implant Dent 16: 404–412, 2007
11. Sekiya K, Sekiya K, Kaneda T, Sekiya K, Mori S and Sakayanagi M. Assessment of alveolar bone height and width using 64-MDCT examination for dental implants. Jpn Oral Implant 24: 115-121, 2009 (in Japanese)
12. Koo TK and Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. J Chiropr Med 15: 155–163, 2016
13. Kanasi E, Ayilavarapu S and Jones J. The aging population: Demographics and the biology of aging. Periodontol 2000 72: 13–18, 2016
14. Sternberg SA and Gordon M. Who are older adults? Demographics and major health problems. Periodontol 2000 16: 9–15, 1998
15. Ellen RP. Periodontal disease among older adults: what is the issue? Periodontol 2000 16: 7–8, 1998
16. Albrektsson T, Brånemark PI, Hansson HA and Lindstrom J. Osseointegrated titanium implants. Requirements for ensuring a long lasting, direct bone to implant anchor age in man. Acta Orthop Scand 52: 155–170, 1981
17. Lekholm U, Ericsson I, Adell R and Slots J. The condition of the soft tissues at tooth and fixture abutments 89 supporting fixed bridges: A microbiological and histological study. J Clin Periodontol 13: 558–562, 1986
18. Breine U and Brånemark PI. Reconstruction of alveolar jawbone. An experimental and clinical study of immediate and preformed autologous bone grafts in combination with osseointegrated implants. Scand J Plast Reconstr Surg 14: 23–48, 1980
19. Eufinger H, Konig S and Eufinger A. The role of alveolar ridge width in dental implantology. Clin Oral Invest 1: 169–177, 1997
20. Misch CE. Available Bone and Dental Implant Treatment Plans. In: J.Hard Tissue Biology V ol. 30(4): 383-388, 2021
21. Misch CE. Treatment Plans for Partially and Completely Edentulous Arches in Implant Dentistry. In: Contemporary Implant Dentistry, ed by Misch CE, Mosby, St. Louis, 2008, pp 406-418.

22. Romano PR, Caton JG and Puzas JE. The reversal line may be a key modulator of osteoblast function: observations from an alveolar bone wound-healing model. J Periodontal Res 32: 143–147, 1997

23. Chiapasco M, Casentini P and Zaniboni M. Bone augmentation procedures in implant dentistry. Int J Oral Maxillofac Implants 24 Suppl: 237–259, 2009

24. Pramstraller M, Farina R, Franceschetti G, Pramstraller C and Trombelli L. Ridge dimensions of the edentulous posterior maxilla: a retrospective analysis of a cohort of 127 patients using computerized tomography data. Clin Oral Implants Res 22: 54–61, 2011
