Height of mandibular basal bone in dentate and edentulous subjects

Qiufei Xie, Juhani Wolf, Kari Soikkonen and Anja Ainamo

Departments of Prosthetic Dentistry and Dental Radiology, Institute of Dentistry, University of Helsinki, Helsinki, Finland

Xie Q, Wolf J, Soikkonen K, Ainamo A. Height of mandibular basal bone in dentate and edentulous subjects. Acta Odontol Scand 1996;54:379–383. Oslo. ISSN 0001-6357.

Age-related differences in the height of the mandibular basal bone were compared between young and old dentate subjects and between dentate and old edentulous subjects by means of panoramic radiographs. The distances of the mental foramen and mandibular canal from the lower border of the mandible, when measured, showed the mandibular basal bones in old dentate and in old edentulous men to be higher than those of young dentate men in the molar region ($P < 0.05$). The height of the basal bone below the mental foramen was smaller in old edentulous women than in young and old dentate women ($P < 0.05$). A slight bone deposition along the lower border of the mandible in the molar region seems to take place with increasing age. The mental foramina of edentulous women move toward the lower border of the mandible as a result of alveolar bone resorption. □ *Aging; mandibular canal; mental foramen; panoramic radiography*

Qiufei Xie, Institute of Dentistry, PO Box 41 (Mannerheimintie 172), FIN-00014 University of Helsinki, Finland

Studies on dry human skulls and on living individuals have elucidated the growth of the adult craniofacial skeleton (1–3). Changes in size and shape of facial bones and the continuing eruption of teeth have been observed to occur throughout adult life (1–11).

On the basis of a longitudinal investigation, Behrents (3) concluded that growth of craniofacial bones continues into the oldest age. Increase in vertical dimensions of the maxilla and mandible was obvious in comparisons of cephalograms taken at different ages. However, it is impossible to show whether increase in distance from the cementoenamel junction to the lower border of the mandible (LBM) is a result of bone deposition on the LBM or of the eruption of teeth.

In several studies on ancient populations (100–1800 AD), slight bone deposition on the lower border of the mandible in the molar region has been documented (4, 5, 8, 9). A change in the quality of food and probably also in the speed of attrition of teeth has occurred since those days, at least in industrialized countries. Therefore, on the basis of findings in ancient populations the conclusion cannot be reached that similar bone deposition occurs along the LBM in human beings today.

The mandibular canal has served to distinguish the alveolar process from the basal bone in several studies using radiographs (8–10) and is generally accepted as a stable reference structure in the dentate mandible (4, 5, 8–10). The mental foramen is also a landmark for the basal bone when dry skulls and living patients are studied (12, 13). Härle (14) and Reich & Gade (15) noted that the position of the mandibular canal remained unchanged in the atrophic mandible. A contrary result has, however, been found by Ulm et al. (16). They indicated, in a study of edentulous mandible sections, that the distance of the canal from the lower border of the mandible decreased significantly in patients with a severely resorbed alveolar ridge. Soikkonen et al. (17) reported the mental foramen to be situated significantly lower in edentulous women with severely resorbed mandible than in dentate women. The position of the mandibular canal was also lower, but not significantly.

The aims of the present study were to discover whether any difference existed in the height of the mandibular basal bone between young and old subjects and to assess the basal bone in edentulous subjects in comparison with that of dentate subjects.

Materials and methods

Two groups of dentate subjects, young and old, and one group of edentulous elderly subjects were examined. The young dentate group comprised 131 subjects with a mean age of 27 (range, 18–38) years, 63 male and 68 female; the old dentate group comprised 91 persons with a mean age of 65 (range, 52–81) years, 46 male and 45 female. Fourteen old dentate persons came from the sample of the dental survey of the Helsinki Aging Study (HAS) made in 1990–91. The rest of the old dentate persons and all the young dentate subjects came from the patient pool of the Institute of Dentistry, University of Helsinki. The edentulous group also came from the sample of the dental survey of HAS and consisted of 128 elderly subjects with an edentulous mandible and a mean age of 80 (ages: 76, 81, and 86) years, 32 male and 96 female. Panoramic radiographs of these subjects were taken with a PM 2002 CC panoramic machine (Planmeca Co., Helsinki, Finland).

Criteria for selection of the radiographs of young dentate subjects were as follows: 1) subjects aged 18–38

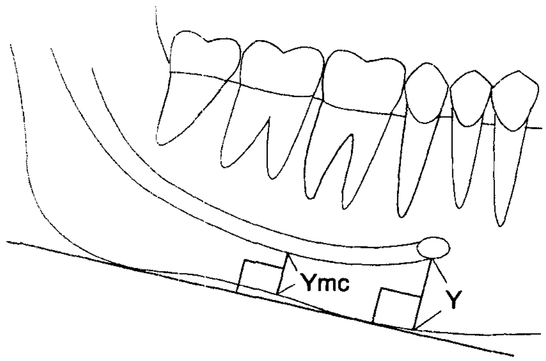

Fig. 1. Measured distances. Y = distance from lower margin of the mental foramen to lower border of the mandible; Ymc = distance from lowermost point of the mandibular canal (in relation to lower border of the mandible) to lower border of the mandible. Y and Ymc measurements were made on both sides of mandible.

years; 2) at least 28 teeth present and in normal occlusion; 3) radiologic images of anatomic landmarks such as the border of mandible, the lower border of mandibular canal, or the mental foramen being distinct at least on one side; 4) no gross distortion of images of mandible and maxilla; and 5) space between maxillary and mandibular teeth forming an approximately horizontal space or a gentle arch with the midpoint lower than the ends (18).

Because of the difficulty in finding old persons with full dentition, the criteria for old dentate subjects were as follows: 1) subjects older than 50 years; 2) teeth present at the anterior or at the posterior measurement site; and 3) at least 20 occluding teeth left. The other criteria were those stated above as points 3–5.

Radiographs of the edentulous subjects were selected on the basis of points 3 and 4 in the first criterion list, and the image of the edentulous mandible had to be slightly U-shaped.

Measurements were made at four sites in each mandible, at the mental foramen, and at the lowermost point of the mandibular canal (where the canal was closest to the LBM) on both sides. The distance measured from the lower margin of the mental foramen to the LBM was defined as Y, and the distance between the lowermost point of the canal and the LBM as Ymc (Fig. 1). A line was drawn tangential to the most inferior points at the mandibular angle and the lower border of the mandibular body. All the measurements were made perpendicular to this tangential line (Fig. 1).

To ensure consistency, one investigator (Q. Xie) was responsible for selecting all the panoramic radiographs and performing the measurements. The mental foramen was not visible in 15 cases of 262 young dentate mandible halves, 5 of 182 old dentate mandible halves, and 37 of 256 edentulous mandible halves (including 35 mandible halves, in which the mental foramen was completely resorbed due to severe reduction in the residual ridge). The corresponding figures for the lower

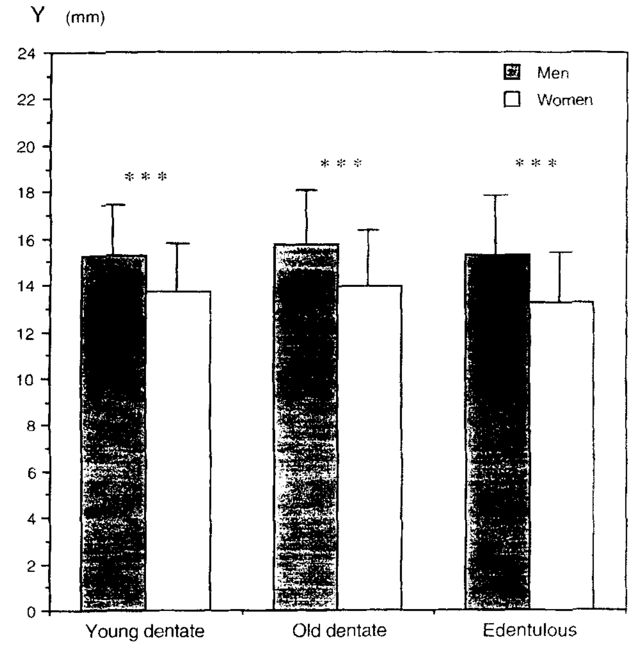

Fig. 2. Means of the Y distance (see Fig. 1 for definition) in the young dentate and old dentate subjects and edentulous people. Statistical evaluation with unpaired t test. *** $P < 0.001$.

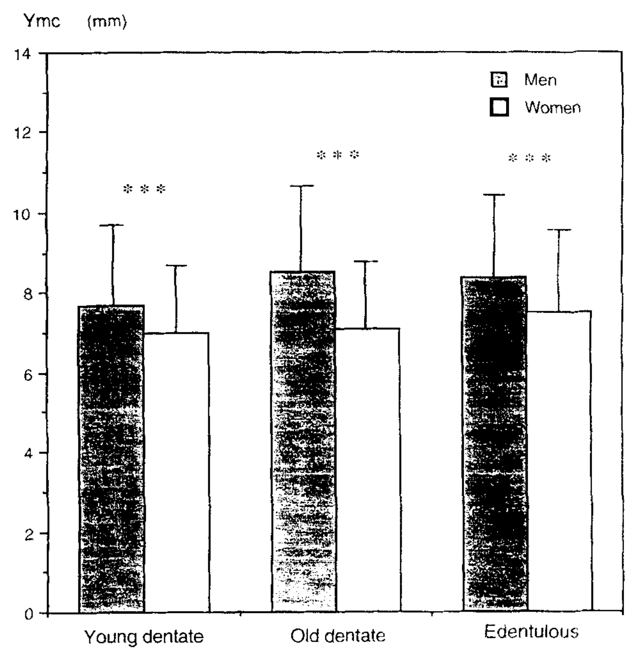

Fig. 3. Means of the Ymc distances (see Fig. 1 for definition) in young dentate and old dentate subjects and edentulous people. Statistical evaluation with unpaired t test. *** $P < 0.001$.

border of the mandibular canal were 34, 47, and 78, respectively.

Each radiograph was viewed on a standard light box. After all lines and points to be measured were drawn on

Table 1. Means (mm) and standard deviations (s) of measurements from the lower margin of the mental foramen to the lower border of the mandible (Y) and from the lowermost point of the mandibular canal to the lower border of the mandible (Ymc) in young and old dentate groups and the edentulous group

	Y				Ymc			
Group	No.	Mean	Range	s	No.	Mean	Range	s
Men								
Young dentate	115	15.3	10.3–19.5	1.8	103	7.7	2.9–12.3	1.8
Old dentate	89	15.7	11.5–21.5	2.1	70	8.5*	4.6–12.7	2.2
Edentulous	61	15.3	8.9–19.7	2.3	55	8.4†	5.3–15.6	2.0
Women								
Young dentate	132	13.7	8.0–18.3	1.8	125	7.0	3.7–11.8	1.6
Old dentate	88	13.9	8.1–19.9	2.2	65	7.1	3.2–11.0	1.6
Edentulous	158	13.2‡	7.0–18.6	2.2	123	7.5†	2.6–12.0	2.0

No. = number of measurements. Statistical evaluation with the unpaired t test: * $P < 0.05$ between young and old dentate men; † $P < 0.05$ between young dentate and edentulous persons; ‡ $P < 0.05$ between young dentate and edentulous women, and between old dentate and edentulous women.

the films with pencil, the radiographs were scanned, digitized, magnified, and measured with a UMAX UC-1200S scanner (UMAX Data System Inc., Hsinchu, Taiwan) and an IBM PC-compatible computer.

Of the radiographs, 10% were randomly selected and re-marked and re-measured after an interval of 1 month for an intraexaminer test.

Statistical analyses of the results were performed by means of the StatView + Graphics package (Brain-Power, Inc., Calabasas, Calif., USA). Since there was no significant difference in the measurements between the two sides of the mandible, the data were pooled for further analysis. An unpaired two-tailed t test was performed to compare differences in means between the men and women, and among the three groups. A paired two-tailed t test was used for testing statistical significance of intraexaminer difference. The statistical significance level $\alpha = 0.05$ was used.

Results

The men had a higher mandibular basal bone than the women both during early and late adulthood and in edentulousness ($P < 0.001$; t test) (Figs. 2 and 3).

The old dentate men had a significantly greater ($P < 0.05$; t test) distance (Ymc) between the lowermost point of the mandibular canal and the LBM than the young dentate men (Table 1). A corresponding difference was also found between the edentulous and the young dentate men ($P < 0.05$; t test). However, the absolute mean differences were small, less than 1.0 mm. There was no significant difference in the distances (Y) from the lower margin of the mental foramen to the LBM among the three groups of men.

The differences among the three groups of women were small. The edentulous women had a slightly greater distance between the lowermost point of the mandibular canal and the LBM than did the young dentate women ($P < 0.05$; t test), but no significant difference was found between the old and young dentate women (Table 1). The measurement (Y) between the lower margin of the mental foramen and the LBM in the edentulous women was significantly smaller than in the other two groups of women ($P < 0.05$; t test) (Table 1).

The mean of the difference in the re-measurements was 0.05 mm ($s = 0.57$), which was not statistically significant in the test of intraexaminer error.

Discussion

In the present study we used those selected panoramic radiographs in which the lower margin of the mental foramen and the lower border of the mandibular canal could be located. To avoid interexaminer error, only one investigator was responsible for performing the measurements. Our previous study demonstrated that a slight misalignment of the head (within the range of ±5° tilt and ±5 mm shift in the sagittal plane) in a PM 2002 CC panoramic machine caused only 1.0% and 1.8% differences in vertical measurements at the sites of the lower first molar and the mental foramen made from the panoramic radiographs (19). Moreover, no significant difference was found in the intraexaminer test; the deviation (0.57 mm) of re-measurement was much smaller than the deviations (1.6–2.3 mm) of distances between the mental foramen and the LBM and between the mandibular canal and the LBM among the subjects studied. Therefore, our measurements can be considered reliable.

The finding of this study that the mandibular basal bone in the molar region was higher in the old dentate and edentulous men than in the young dentate men, and that a slight increase in the basal bone could be shown in the edentulous women at this point, seems to indicate that a vertical increase in the mandibular basal bone occurs with age. This is in agreement with earlier studies by Newman & Levers (4), Levers & Darling (5), and Whittaker et al. (7–9). The amount of difference in mandibular base bone was 1.4 mm during 40 years in the study by Whittaker et al. (9) and 0.8 mm during 36 years in dentate men in the present study. This smaller amount of bone deposition in contemporary people than in ancient people is probably a result of modern refined food and different eating habits. According to our findings, the lower border of the mandible in the molar region is a structure that is still not a static even in contemporary people.

The growth of bone during adulthood is controlled by multiple factors (20). Sexual hormones, such as androgen and estrogen, contribute to the development of a morphologic difference in craniofacial skeletons between the genders and even to a different velocity of growth in later adulthood. The speed of bone growth in adult women is lower than that in men (3). In postmenopausal women the deficiency of estrogen speeds up resorption in bone and may affect the deposition process. Local control factors such as the masticatory muscles and bite force play an important role in craniofacial skeletal change (21); tension is traditionally believed to induce bone formation (20). Since the mandible functions as a lever (22), contraction of the jaw elevator muscles such as the masseter and medial pterygoid muscle during normal chewing movements may cause a small amount of tension along the LBM in the molar regions. In general, men have stronger masticatory muscles and greater bite force than women, and molars have a greater bite force than premolars and incisors. The sexual hormones and the various strengths of the force of the masticatory muscles together may explain the difference in increase in the height of the mandibular basal bone between genders. The lower bite force in the premolars than in the molars may be the reason for the lack of a significant increase in basal bone in either sex at the site of the mental foramen.

In the present edentulous group we did not measure the height of the mental foramen in 35 (32 in the women and 3 in the men) edentulous mandibular halves, because they were atrophic mandibles, wherein the mental foramina were completely resorbed so that the mandibular canal reached to and was exposed on the crest of the residual ridge. In some of the edentulous mandibles measured, the mental foramen was observed in a semi-ovoid form and was located at the top of the residual ridge (17). The decreased height (Y) of the mandibular basal bone at the site of the mental foramen in the edentulous women is probably caused by the opening of the mental canal having moved towards the base of the mandible due to progress of alveolar bone resorption, since no age-related difference was found in the dentate women. This reduction did not reach a level of significance in the edentulous men, probably because of the smaller number of subjects and their smaller degree of resorption than for the women. The decreased height (Y) of mandibular basal bone indicates that in elderly edentulous subjects, especially in elderly edentulous women, the mental foramen moves toward the lower border of the mandible as a result of resorption.

No significant reduction in the average distance from the lowermost point of the mandibular canal to the LBM was found in the edentulous men. This was in accordance with the findings of Härle (14) and Reich & Gade (15) and in contrast to the finding of Ulm et al. (16). Further analysis of the association of residual ridge resorption with the mandibular canal will be performed in our continuing study.

It can be concluded that slight bone deposition seems to occur along the lower border of the mandible in the molar region with age in contemporary people, particularly in men. The mental foramina of edentulous women move toward the lower border of the mandible as a result of alveolar bone resorption.

References

1. Israel H. Evidence for continued apposition of adult mandibular bone from skeletalized materials. J Prosthet Dent 1979;41:101–4.
2. Ainamo A, Ainamo J, Poikkeus R. Continuous widening of the band of attached gingiva from 23 to 65 years of age. J Periodont Res 1981;16:595–9.
3. Behrents RG. Growth in the aging craniofacial skeleton. Monograph 17. Craniofacial Growth Series. Ann Arbor (MI): University of Michigan, Center for Human Growth and Development, 1985:107.
4. Newman HN, Levers BGH. Tooth eruption and function in an early Anglo-Saxon population. J R Soc Med 1979;72:341–50.
5. Levers BG, Darling AI. Continuous eruption of some adult human teeth of ancient populations. Arch Oral Biol 1983;28: 401–8.
6. Ainamo A, Ainamo J. The dentition is intended to last a lifetime. Int Dent J 1984;34:87–92.
7. Whittaker DK, Parker JH, Jenkins C. Tooth attrition and continuing eruption in a Romano-British population. Arch Oral Biol 1982;27:405–9.
8. Whittaker DK, Molleson T, Daniel AT, Williams JT, Rose P, Resteghini R. Quantitative assessment of tooth wear, alveolar-crest height and continuing eruption in a Romano-British population. Arch Oral Biol 1985;30:493–501.
9. Whittaker DK, Griffiths S, Robson A, Roger-Davies P, Thomas G, Molleson T. Continuing tooth eruption and alveolar crest height in an eighteenth-century population from Spitalfields, east London. Arch Oral Biol 1990;35:81–5.
10. Smith P, Wax Y, Adler F. Population variation in tooth, jaw, and root size: a radiographic study of two populations in a high-attrition environment. Am J Phys Anthropol 1989;79:197–206.
11. Danenberg PJ, Hirsch RS, Clarke NG, Leppard PI, Richard LC. Continuous tooth eruption in Australian aboriginal skulls. Am J Phys Anthropol 1991;85:305–12.
12. von Wowern N, Stoltze K. Pattern of age related bone loss in mandibles. Scand J Dent Res 1980;88:134–46.
13. Cawood JI, Howell RA. A classification of the edentulous jaws. Int J Oral Maxillofac Surg 1988;17:232–6.
14. Härle F. Die Lage Des Mandibularkanals im zahnlosen Kiefer (English abstract). Dtsch Zahnaerztl Z 1977;32:275–6.
15. Reich R, Gade R. Zur Verletzungsgefahr des Nervus alveolaris inferior bei der Implantationschirurgie des Unterkeifers anhand anatomischer Untersuchungen (English abstract). Dtsch Zahnaerztl Z 1983;38:126–8.
16. Ulm CW, Solar P, Blahout R, Matejka M, Watzek G, Gruber H.

Location of the mandibular canal within the atrophic mandible. Br J Oral Maxillofac Surg 1993;31:370–5.
17. Soikkonen K, Wolf J, Ainamo A, Xie Q. Changes in the position of the mental foramen as a result of alveolar atrophy. J Oral Rehabil 1995;22:831–3.
18. Packota GV, Hoover JN, Neufeld BD. A study of the height of intact alveolar bone on panoramic radiographs of adult patients. J Prosthet Dent 1988;60:504–9.
19. Xie Q, Soikkonen K, Wolf J, Mattila K, Gong M, Ainamo A. Effect of head positioning in panoramic radiography on vertical measurements: an in-vitro study. Dentomaxillofac Radiol 1996; 25:61–6.
20. Enlow DH, editor. Facial growth. 3rd ed. Philadelphia: W B Saunders Company, 1990:229, 238.
21. Schumacher GH. Factors influencing craniofacial growth. In: Normal and abnormal bone growth: basic and clinical research. Prog Clin Biol Res 1985;187:3–22.
22. Oyen OJ. Masticatory function and facial bone growth and development. In: Enlow DH, editor. Facial growth. 3rd ed. Philadelphia: W B Saunders Company, 1990:282.

Received for publication 22 December 1995
Accepted 11 April 1996