

Anthropometric Analysis of the Human Mandibular Cortical Bone in Indian Population as Assessed by Dental Computed Tomography (DentaScan)

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ABSTRACT

Aim: Anatomic variations based on ethnicity, gender, and age play a pivotal role in designing surgical techniques, although the majority of them are based on anthropometric data of the Caucasian population. The study aimed to assess the cortical thickness, width, and height of Indian mandibles using DentaScan; to determine their relationship with age and gender, and to focus on their surgical implications in the Indian population.

Materials and methods: A prospective cross-sectional study conducted at the Department of Dentistry comprised of 100 DentaScans (males and females; 21–50 years) indicated for orthodontic therapy, impacted wisdom tooth surgery, and immediate dental implants. Subjects were equally divided into two age groups (21–35 and 36–50 years). DentaScan assessment of mandibular cortex, width, and height was conducted at symphysis, parasymphysis, and the body region. Student's *t*-test was used to derive comparisons between genders and age groups. *p* value ≤ 0.05 was considered statistically significant.

Results: Thicker posterior cortices, wider mandibles, and greater height were found in males. Thicker symphysis was found in younger females. Older subjects demonstrated thicker upper third cortices at parasymphysis and body, and wider upper third mandibles anteriorly. Younger subjects displayed thicker lower third cortices at parasymphysis; wider lower third mandibles anteriorly and upper third posteriorly; and greater height at symphysis. Younger females and all males exhibit safer anterior and posterior sites, respectively. Older females with smaller mandibles require more careful treatment planning.

Conclusion: Within the limitations of the study, it can be concluded that anthropometric differences in mandibular cortical bone are important decisive parameters that provide baseline data for designing a "gender- and age-specific" treatment plan for mandibular surgeries in the Indian population.

Clinical significance: Considering the heterogeneity of mandible based on ethnicity, gender, and age; and since variations demand adaptation in surgical techniques, anthropometric baseline data of the Indian mandibular cortex serve as a useful reference guide for the surgeons and provide opportunities for standardized norms for designing a "gender- and age-specific" treatment plan for mandibular surgeries in Indian population.

Keywords: Anthropometry, Cortical bone, DentaScan, Mandible, Oral and maxillofacial surgery.

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INTRODUCTION

The shape of the mandible in hominins has been documented to have evolved at a faster pace than any other primate clade.¹ This rapid pattern of shape evolution has been accredited to the shared characteristics among australopithecines and species of the genus *Homo* in regards to habitat preferences, body size, patterns of sexual dimorphism, diet, and food processing behavior.¹ There is no denying the fact that craniofacial anatomy including the mandible has demonstrated significant differences among races and ethnic groups.² Aging plays an important factor for craniofacial morphology and development as dentofacial dimensions have been validated to continue to change throughout adulthood and the pattern of these changes may be race-specific.³

As mandible being one of the most anatomically varied structures of the body, influenced by ethnicity, gender, and physiological process of aging, mandibular surgeries necessitate knowledge of internal and external morphology and consequent modification in their approaches. Oral and maxillofacial surgeries like mandibular osteotomies, dental and orthodontic implants, tooth disimpaction surgeries, open reduction and internal fixation, jaw resections, orthognathic surgeries, genioplasties, and distraction osteogenesis demand detailed analysis of the involved

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and uninvolved sections of the jaw and teeth to place the osteotomy cuts with utmost precision.

Most of the surgical techniques have been based on anthropometric data of the Caucasian population. There has been a serious paucity of mandibular anthropometric data for the

Indian population especially in regards to cortical bone thickness. Anthropometric assessment to determine average measurements and proportional variance of the bony cortex along with width and height in different age groups and gender is decisive for successful surgical outcomes, as it directly contributes to the preservation of neurovascular bundles, healthy bony tissue, and tooth structures in the vicinity.

Traditionally, cadaveric examination, plain radiography, and conventional computed tomography (CT) have been the mainstay for mandibular anthropometry and evaluation of the oral and maxillofacial region. The last two decades have witnessed some important anthropometric studies of human cadaveric mandibles examining cortical bone thickness among different age groups and ethnicities.⁴⁻⁸ For instance, evaluation of variation in trabecular density and cortical thickness as per age and dental status;⁴ variation in buccal and lingual cortical bone thickness in the anterior and posterior mandible;⁵ variation of cortical bone thickness in mandibular canal region and its implication for sagittal split osteotomies; and variation in lateral cortical bone thickness in the region of the mental foramen.^{7,8} These methods have always been technique sensitive with increased probability of loss of specimen or bony shrinkage; more susceptible to human error and predominantly, with limited sample size. Intraoral periapical and orthopantomographic views provide a two-dimensional radiographic assessment, completely lacking the third labio/buccolingual dimension. Conventional CT although provides a comprehensive imaging experience, yet is deficient in yielding a distinct bony window of tooth-bone cross-section and a more precise submillimeter scale.

The advent of spiral and cone-beam computed tomography (CBCT) has certainly transformed the imaging trends. Although CBCT technology renders a reduced amount of radiation exposure, yet its limited availability and accessibility still pose a major obstacle for its routine usage in many Indian cities including ours. Alternatively, the technique of dental CT, also called DentaScan, represents a specific investigation protocol and a software program that includes the acquisition of axial scans of the jaw with the highest possible resolution and curved and orthoradial multiplanar reconstructions. It allows the mandible to be imaged in axial, panoramic, and cross-sectional planes.⁹ DentaScan has presented itself with cost-effective X-ray tubes, high-quality flat panel detector systems, and powerful personal computers. All the aforementioned characteristics along with its easy availability at the government medical hospital in our city made this technique more practical and affordable for the patients in our study.

Henceforth, the present study aimed to obtain anthropometric baseline data of the Indian population by measuring and analyzing the thickness of the human mandibular cortex along with width and height using DentaScan technology; to determine the variation and relationship of these parameters with age and gender; and to focus on their surgical implications for designing an "age- and gender-specific" treatment plan for mandibular surgeries in Indian population.

MATERIALS AND METHODS

This is a prospective cross-sectional study and was conducted at the Department of Dentistry at a premium medical college and tertiary healthcare center in Jaipur, Rajasthan, India, between December 2019 and March 2020. The study was conducted after

taking approval from the Institutional Ethical Committee and written informed consent from the participants.

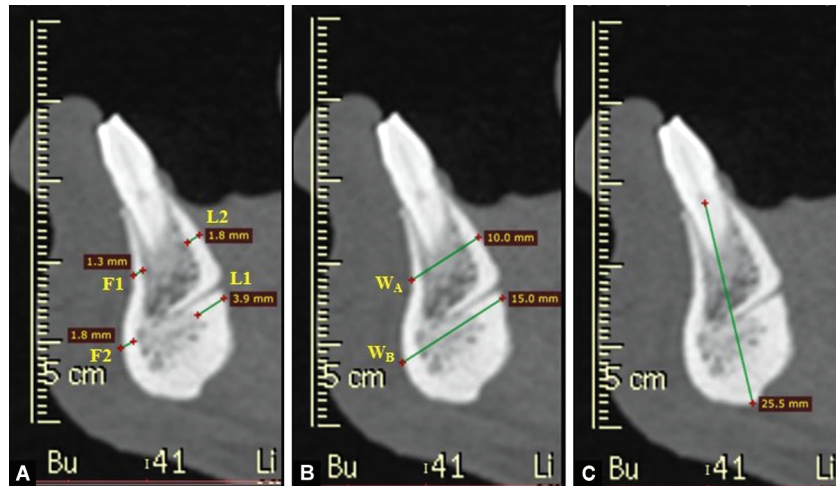
The sample size as calculated with the precision/absolute error of 5% and a type I error of 5%, consisted of 100 DentaScans obtained from patients requiring treatments, such as, orthodontic therapy, impacted wisdom tooth surgery, and immediate dental implant placements. Both males and females, with symmetric mandibles, complete dentition (with and without third molars), and no retained deciduous teeth were included in the study. Patients with partial or complete edentulous arches were excluded owing to a tendency for alveolar ridge resorption.¹⁰ Patients with bony and periapical pathology; conditions affecting musculoskeletal development like temporomandibular joint disorders; periodontal disease; diabetes mellitus; past mandibular surgery and pregnancy were excluded from the study. A total of 100 patients met the inclusion criteria ranging from 21 to 50 years. They were divided into two age groups (21–35 and 36–50 years) of 50 patients each.

Images were obtained using Lightspeed Volume CT [General Electric (GE) Health Care, Milwaukee, WI, USA] with DentaScan technology [General Electric (GE) Health Care, Milwaukee, WI, USA]. Subjects were placed in a supine position and the scans were completed with axial orientation parallel to the mandibular occlusal plane. The multislice scanner was set at 120 kVp (kilovoltage peak) and 120 mA (milliamperes). High-resolution images of the mandible with 1.0 mm thick axial slices at 1 mm slice interval and 512 × 512 matrix were obtained. The effective dose was 8.16 mSv (millisieverts).

This axial scan data were transferred to the advantage workstation (AW) for post-processing and reconstruction using DentaScan software. The archived data in the form of Digital Imaging and Communications in Medicine (DICOM) format were saved in a compact disc (CD) and transferred to a laptop computer. Digital imaging and communications in medicine images were then viewed and assessed with the help of Radiant DICOM Viewer software (version 5.5.1, Medixant, Poland).

Due to variation in structure and functional adaptation of different parts of the mandible, a total of five mandibular cross-sectional/paraxial views were selected for each patient: one at symphysis (S) between two central incisors, two at parasymphysis (P) distal to canine (right and left), and two at the body (B) region distal to the first molar (right and left). Each cross-section (Fig. 1) was measured for cortical bone thickness at four sites: the upper buccal third (F1), lower buccal third (F2), lower lingual third (L1), and upper lingual third (L2); the height (H) of the mandible by a line drawn perpendicular to the mandibular plane at the approximate center of cross-section; and width of the mandible by two lines drawn perpendicular to the height at two sites, respectively: upper width (W_A) at one-third and lower width (W_B) at two-thirds of the total height. Each measurement was named according to the side and anatomic site of the mandible. For example, SF1 referred to the upper buccal cortical width at symphysis and RBL1 referred to the lower lingual cortical width at the right body. Similarly, LPW_A referred to the upper width of the mandible at left parasymphysis and RBH refers to the height of the mandible at the right body region. The measurements were documented and saved using Microsoft Excel software (Microsoft Corporation, USA; Version 2010).

Data were presented as mean ± standard deviation (SD) and statistical analyzes were done using Student's *t*-test for each anatomical landmark to derive comparisons between genders and age groups. As the study was done on a 95% confidence level, a *p* value ≤0.05 was considered statistically significant. Statistical



Figs 1A to C: Measurement of (A) Cortical bone thickness; (B) Mandibular width; (C) Mandibular height. Abbreviations: F1: Upper buccal third; F2: Lower buccal third; L1, Lower lingual third; L2, Upper lingual third; W_A , Width at upper one-third; W_B , Width at lower one-third; Bu, Buccal; Li, Lingual

Package for Social Sciences (SPSS) software [International Business Machines (IBM), USA; Version 18] was used for analysis.

Measurements were obtained by two examiners (chief and co-investigator). The inter- and intraobserver bias was overcome by calculating intra- and interobserver errors and comparing the results with Lin's concordance correlation. A concordance score of 1 indicated perfect repeatability. One hundred measurements from 10 randomly selected patients were repeated between a time duration of 1 month. Concordance score for intraobserver reliability ranged from 0.995 to 0.999 (mean score was 0.997). Concordance score for interobserver reliability between the two examiners ranged from 0.977 to 0.994 (mean score was 0.985). The scores indicated nearly perfect reliability.

RESULTS

The study is comprised of 53 males and 47 females. 21- to 35-year olds included 27 males (54%) and 23 females (46%) whereas 36- to 50-year olds included 26 males (52%) and 24 females (48%).

Cortical Bone Thickness

In 21- to 35-year olds, the upper buccal cortex demonstrated maximum thickness at the body region (2.74 ± 0.52 mm) which gradually declined to its half (1.36 ± 0.31 mm) at the symphysis. The lower buccal cortex was thickest at the parasymphysis (2.80 ± 0.77 mm) with a slight decrease at the body and reached its minimum at the symphysis (1.36 ± 0.31 mm). The lower lingual cortex displayed maximum thickness at the parasymphysis (3.17 ± 0.81 mm) and was thinnest at the body region (1.81 ± 0.64 mm). The upper lingual cortex was thickest at parasymphysis (2.12 ± 0.52 mm) and declined to its minimum at the symphysis (1.68 ± 0.44 mm) with an intermediate thickness of 1.8–1.9 mm at the body. Females displayed thicker buccal and lower lingual cortices at the symphysis with a maximum average increment of 1.29 mm at the lower buccal site as compared to males. Younger males had thicker cortices as compared to younger females at the upper lingual site of the symphysis, lower buccal parasymphysis, and upper buccal body region. As summarized in Table 1, the aforementioned gender comparisons were statistically significant ($p \leq 0.05$).

36–50-year olds demonstrated the thickest upper buccal cortex at the body (2.89 ± 0.74 mm), reducing to almost half at the symphysis (1.41 ± 0.26 mm). Both thickest (2.83 ± 0.79 mm) and thinnest (2.08 ± 0.71 mm) lower buccal cortex was reported at the body region. Contrastingly, the lower lingual cortex demonstrated maximum thickness at symphysis (2.82 ± 1.07 mm) reducing to its minimum at the body (1.78 ± 0.45 mm), whereas the upper lingual cortex was thickest at the body (2.28 ± 0.64 mm) and thinnest at the symphysis (1.79 ± 0.34 mm). As summarized in Table 1, older males exhibited thicker buccal and lower lingual cortices as compared to older females at the body region which was statistically significant ($p \leq 0.05$).

On comparing the age groups (Fig. 2), younger subjects displayed significantly thicker lower buccal ($p = 0.057$) and lower lingual cortices [$p = 0.002$ (right); $p = 0.000$ (left)] at parasymphysis as compared to the older mandibles. The upper buccal cortex ($p = 0.046$) at parasymphysis and upper lingual cortex at the body [$p = 0.015$ (right); $p = 0.011$ (left)] were significantly thicker in the older age group.

Mandibular Width

The upper one-third of the mandibles was widest at the body (21–35 years: 12.89 ± 0.71 mm; 36–50 years: 11.82 ± 1.89 mm) which drastically declined at the symphysis (21–35 years: 6.43 ± 0.97 mm; 36–50 years: 6.44 ± 0.78 mm). Contrarily, the lower third was widest at the symphysis (21–35 years: 14.49 ± 2.51 mm; 36–50 years: 13.38 ± 3.11 mm) and reduced to a minimum at the body (21–35 years: 9.12 ± 0.90 mm; 36–50 years: 9.15 ± 1.37 mm). Younger males had wider mandibles (both upper and lower third) anteroposteriorly as compared to young females ($p \leq 0.05$) (Table 2). Older males had wider mandibles as compared to older females at all sites ($p \leq 0.05$) (Table 2).

As per age comparisons, younger subjects had a wider lower third at the symphysis ($p = 0.030$) and parasymphysis ($p = 0.052$) and thicker upper third at the body [$p = 0.005$ (right); $p = 0.020$ (left)] as compared to the older age group. The latter demonstrated wider upper third of the mandible at the parasymphysis region [$p = 0.000$ (right); $p = 0.005$ (left)] (Fig. 3).

Table 1: Summary of mandibular cortical bone thickness at four different sites at symphysis, parasymphysis, and body regions in groups I and II based on gender

Group	Site	Gender	Number	Mean (mm)	Standard deviation	p value
I	SF1	Male	27	1.36	0.31	0.0015*
		Female	23	1.63	0.41	
I	SF2	Male	27	1.36	0.31	0.0013*
		Female	23	2.65	0.88	
I	SL1	Male	27	2.63	0.80	0.0491*
		Female	23	2.96	0.80	
I	SL2	Male	27	1.99	0.46	0.0199*
		Female	23	1.68	0.44	
I	RPF2	Male	27	2.80	0.77	0.0413*
		Female	23	2.40	0.55	
I	LPF2	Male	27	2.80	0.73	0.0485*
		Female	23	2.43	0.54	
I	RBF1	Male	27	2.74	0.52	0.0239*
		Female	23	2.39	0.54	
I	LBF1	Male	27	2.69	0.53	0.0221*
		Female	23	2.34	0.52	
II	RBF1	Male	26	2.89	0.74	0.0169*
		Female	24	2.44	0.53	
II	RBF2	Male	26	2.83	0.79	0.0009*
		Female	24	2.08	0.71	
II	RBL1	Male	26	2.13	0.52	0.0434*
		Female	24	1.85	0.43	
II	LBF2	Male	26	2.77	0.85	0.0036*
		Female	24	2.09	0.71	
II	LBL1	Male	26	2.08	0.56	0.0443*
		Female	24	1.78	0.45	

* $p \leq 0.05$

Abbreviations: group I, 21–35 years; group II, 36–50 years; S, symphysis; P, parasymphysis; B, Body; R, right; L, left; F1, upper buccal third; F2, lower buccal third; L1, lower lingual third; L2, upper lingual third

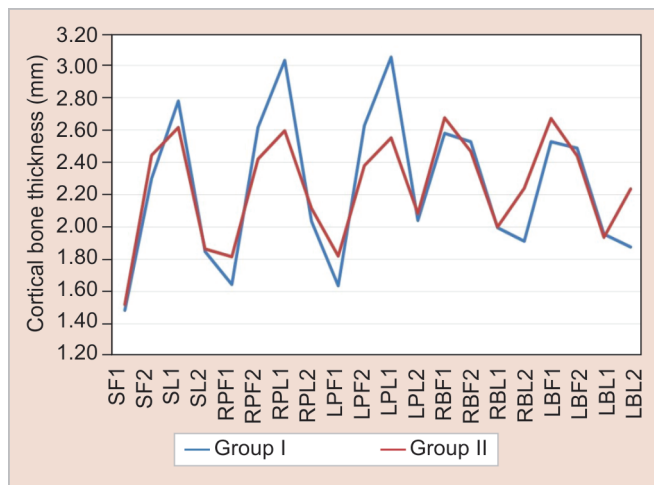


Fig. 2: Mandibular cortical bone thickness at four different sites at symphysis, parasymphysis, and body regions in two different age groups (I and II). Abbreviations: S, symphysis; P, parasymphysis; B, body; R, right; L, left; F1, upper buccal third; F2, lower buccal third; L1, lower lingual third; L2, upper lingual third

Mandibular Height

In 21–35-year olds, a modest decrease in height of the mandible was reported from symphysis (29.94 ± 2.14 mm) to body region (26.41 ± 1.84 mm) with male mandibles demonstrating significantly greater height as compared to females ($p < 0.05$) (Table 3). In 36–to 50-year olds, maximum height was observed at parasymphysis (28.77 ± 3.74 mm) which gradually decreased at the body (26.20 ± 4.26 mm), although gender variation was not significant in the older subjects (Table 3).

Age-wise, the younger mandibles displayed significantly greater height (28.74 ± 2.31 mm) at the symphysis as compared to the older age group with an average difference of 1.26 mm ($p = 0.036$) (Fig. 4).

DISCUSSION

Human mandibular anthropometry presents itself as an area of intrigue, investigation, and implication especially for treatment planning in oral and maxillofacial surgery and oral implantology. As per our knowledge, the present study stands first in evaluating the dimensional variance in cortical bone thickness, width, and height

Table 2: Mandibular width at two different sites at symphysis, parasymphysis, and body regions in groups I and II based on gender

Group	Site	Gender	Number	Mean (mm)	Standard deviation	p value
I	SW _A	Male	27	7.27	1.00	0.0044*
		Female	23	6.43	0.97	
I	SW _B	Male	27	14.49	2.51	0.0034*
		Female	23	12.71	1.48	
I	RPW _A	Male	27	7.90	0.70	0.0000*
		Female	23	6.67	0.91	
I	RPW _B	Male	27	13.49	1.81	0.0002*
		Female	23	11.50	1.71	
I	LPW _A	Male	27	7.63	1.06	0.4371
		Female	23	7.32	1.66	
I	LPW _B	Male	27	13.19	2.25	0.7954
		Female	23	13.00	2.87	
I	RBW _A	Male	27	12.89	0.71	0.0000*
		Female	23	10.80	0.96	
I	RBW _B	Male	27	11.15	1.09	0.0000*
		Female	23	9.12	0.90	
I	LBW _A	Male	27	12.67	0.78	0.0000*
		Female	23	10.80	0.95	
I	LBW _B	Male	27	11.01	1.07	0.0000*
		Female	23	9.27	1.03	
II	SW _A	Male	26	7.30	1.08	0.0023*
		Female	24	6.44	0.78	
II	SW _B	Male	26	13.38	3.11	0.0279*
		Female	24	11.50	2.77	
II	RPW _A	Male	26	9.05	1.20	0.0001*
		Female	24	7.49	1.33	
II	RPW _B	Male	26	12.89	2.71	0.0269*
		Female	24	11.23	2.43	
II	LPW _A	Male	26	9.05	1.31	0.0002*
		Female	24	7.51	1.34	
II	LPW _B	Male	26	12.87	2.68	0.0273*
		Female	24	11.25	2.36	
II	RBW _A	Male	26	11.81	1.87	0.0010*
		Female	24	10.14	1.49	
II	RBW _B	Male	26	10.71	1.54	0.0004*
		Female	24	9.15	1.37	
II	LBW _A	Male	26	11.82	1.89	0.0016*
		Female	24	10.24	1.43	
II	LBW _B	Male	26	11.05	2.24	0.0018*
		Female	24	9.27	1.49	

* $p \leq 0.05$

Abbreviations: group I: 21–35 years; group II: 36–50 years; S, symphysis; P, parasymphysis; B, body; R, right; L, left; W_A, width at upper one-third; W_B, width at lower one-third

of Indian mandibles among gender and age groups with the largest sample of 100 live subjects using dental CT.

The findings in our study regarding cortical bone thickness are concurrent with the study conducted by Swasty et al. who assessed mandibular cortex using CBCT in the Caucasian population.¹¹ Older Indian subjects in our study with the thinnest lower buccal cortex at the body region are the one exception. Thickening of the lower lingual cortex and narrowing of upper buccal

cortical plates at symphysis can be accredited to the masticatory forces of tension and compression, respectively, coupled with superimposed torsional and bending stresses.⁵ Similar findings were observed in Neanderthal mandible from France, whereby the relationship between dental wear and cortical bone distribution was investigated.¹² In accordance with our study, Katranji et al. also reported the thinnest buccal plate in the mandibular anterior dentate region while planning dental implant surgeries.⁶

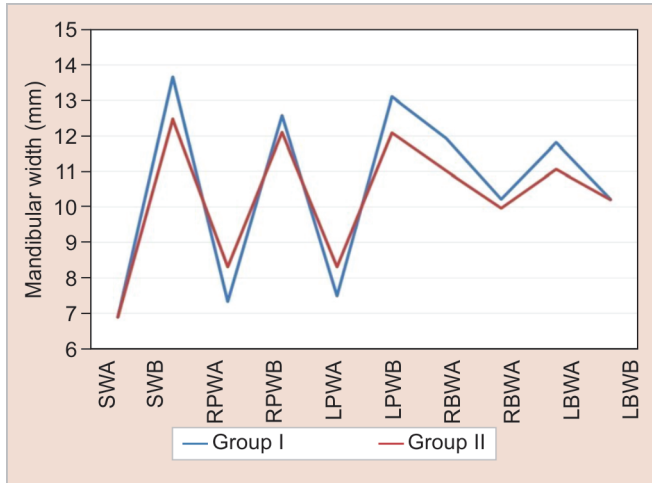


Fig. 3: Mandibular width at two different sites at symphysis, parasymphysis, and body regions in two different age groups (I and II). Abbreviations: S, symphysis; P, parasymphysis; B, body; R, right; L, left; W_A, width at upper one-third; W_B, width at lower one-third

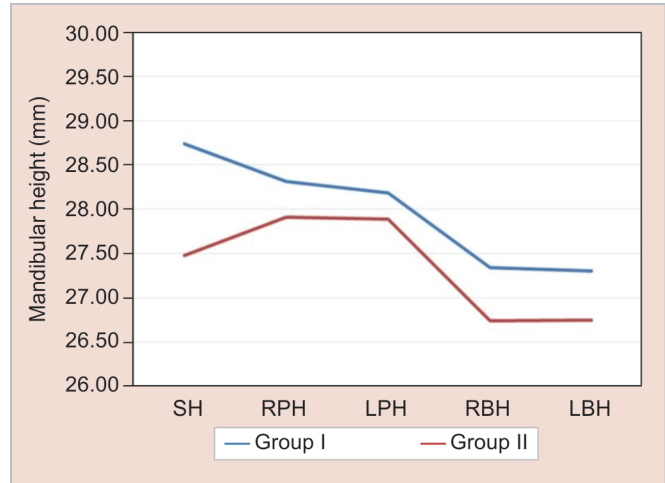


Fig. 4: Mandibular height at two different sites at symphysis, parasymphysis, and body regions in two different age groups (I and II). Abbreviations: S, symphysis; P, parasymphysis; B, body; R, right; L, left; H, mandibular height

Table 3: Mandibular height at symphysis, parasymphysis, and body regions in groups I and II based on gender

Group	Site	Gender	Number	Mean (mm)	Standard deviation	p value
I	SH	Male	27	29.94	2.14	0.000011*
		Female	23	27.33	1.61	
I	RPH	Male	27	29.21	1.91	0.000285*
		Female	23	27.26	1.61	
	LPH	Male	27	29.08	1.96	0.000405*
		Female	23	27.13	1.67	
I	RBH	Male	27	28.11	1.94	0.002448*
		Female	23	26.43	1.76	
	LBH	Male	27	28.06	1.89	0.003125*
		Female	23	26.41	1.84	
II	SH	Male	26	28.02	3.39	0.2556
		Female	24	26.89	3.57	
II	RPH	Male	26	28.75	3.72	0.0849
		Female	24	27.00	3.31	
	LPH	Male	26	28.77	3.74	0.0702
		Female	24	26.93	3.30	
II	RBH	Male	26	27.23	3.98	0.3846
		Female	24	26.21	4.24	
	LBH	Male	26	27.25	3.99	0.3742
		Female	24	26.20	4.26	

* $p \leq 0.05$

Abbreviations: group I: 21–35 years; group II: 36–50 years; S, symphysis; P, parasymphysis; B, body; R, right; L, left; H, mandibular height

Thicker posterior cortical plates in all Indian males and thicker anterior cortical plates in younger females can be attributed to a cumulative effect of variation with age and sexual dimorphism. An increase in thickness with age can be assigned to the fact that aging not only increases mandibular bone density but also leads to a consolidation of bone and thickening of cortices, as substantiated by Kingsmill and Boyde.⁴ Role of mastication and functional stresses in combination with the type of facial growth pattern has also been validated as important factors causing variation in cortical bone thickness. Short-faced subjects are characterized with thicker

mandibular cortex as compared to hyperdivergent facial patterns that demonstrate thinner cortices.^{13,14}

From a clinical standpoint, the thickness of buccal cortical plates can determine the positioning of orthodontic anchorage implants; placement of monocortical screws; genioplasties and sagittal split osteotomies. The minimum cortical bone thickness of 1 mm has a direct correlation with an increase in primary stability of the anchorage implants.^{15,16} As per our findings, thicker buccal cortices in Indian males at the body region as compared to females are potentially safer sites for optimum stability of orthodontic

implants. These are also in accordance with the studies conducted by Al-Jaf et al.,¹³ Niwlikar et al.,¹⁷ and Al-Hafidh et al.¹⁸ In regards to sagittal split osteotomies, vertical bone cutting depth with an intact safe zone can be better achieved in males than females as per the recommended value of 5 mm in the first molar buccal region,⁷ although there were no significant age-related changes in the buccal cortex at the body region in our study. At parasymphysis, lower buccal cortices in younger Indian males and upper buccal cortices in older subjects can be considered as safer sites for monocortical screw placement with the least risk of injury to tooth roots and nerve. These anatomic sites are also concurrent with the studies conducted by Carlos de Souza Fernandes et al.⁸ and Al-Jandan et al.¹⁹

Younger Indian females can achieve better stability at buccal and lower lingual cortical plates at the symphysis favoring internal fixation in cases of fractures and genioplasty. A 2-mm cortical thickness could provide optimum stability of monocortical screws in the treatment of fractures, but it could not be sufficient for plate support particularly in cases of chin advancement genioplasties because of traction and recurrences caused by musculature inserted in the lingual cortex.²⁰ Thicker buccal and lingual cortices at the symphysis can serve the bicortical function of the screws providing enhanced stability.

According to the study conducted by Miyamoto et al.,²¹ the initial stability during dental implant installation was found to be influenced more by the cortical bone thickness than the implant length. Henceforth, thicker cortices at various mandibular sites favor successful dental implant placements and may also help in dictating the possibility of immediate loading which is one of the most popular concepts, thereby reducing the duration of treatment.

Mandibular width in our study shows a similar trend as advocated by Swasty et al. in their CBCT assessment of Caucasian mandibles.¹¹ Invariably across all ages and gender, the anteroposterior variation between the upper and lower width of the mandible can be predisposed to its horseshoe shape in combination with masticatory forces.^{5,22} According to our study, the mandibles of Indian men and women change differently with increasing age, particularly in women where there may be a marked reduction in the alveolar bone mass owing to various physiological and endocrinological factors. Osteoporosis and menopause are regarded as important cofactors for bone resorption in aging women.^{23–25} Since subjects with bone pathologies were excluded in our study, smaller mandibles in older Indian women can be attributed to the latter. Nevertheless, a physiological age-related decrease in the bone mass in an otherwise healthy mandible, cannot be overlooked. Wider mandibles have also been validated in cases of larger cross-sectional areas of temporalis and masseter muscles; subjects with stronger bite forces and those suffering from bruxism.²⁶ Additionally, dolichofacials and subjects with hyperdivergent facial patterns tend to demonstrate smaller alveolar thickness and bone width.^{27,28} From a clinical perspective, bone width assessment is an indispensable tool for dental implant therapy, hence should be dealt with proper attention and careful treatment planning, especially in older Indian females.

Younger Indian males demonstrate significantly greater anterior height as compared to younger females; thus substantiating a valid parameter for sexual dimorphism, as also evidenced by Chimurkar et al. in their cadaveric evaluation.²⁹ Orthopantomographic examination has also verified higher values of a basal bone component of mandibular height in males and the increased

tendency of bone resorption and reduced bone height in post-menopausal women.^{30,31} Endocrinological (androgens and estrogen) and local factors (masticatory and bite forces) as previously described play an important role in craniofacial skeletal variance leading to morphological differences in bone height.³⁰ In regards to age-related changes, symphysis displays a statistically significant reduction in bone height on age advancement. Various studies have also described facial pattern and skeletal malocclusion as important factors affecting bone height at the symphysis. Subjects with skeletal class III relationship and hypodivergent individuals tend to exhibit an increased anterior bone height.^{20,28}

Clinically, bone height serves as an important parameter for treatment planning of dental implants, vertical cut osteotomies, and internal fixation by miniplate osteosynthesis. Height assessment can be useful in predicting the length of dental implants in the safe zone, thereby safeguarding vital structures, such as, mental and inferior alveolar nerves in the posterior mandible, which already showcases a relatively smaller bone height. As per the current data, we infer that dental implants of greater length can be preferred in younger Indian males at the symphysis as compared to other subjects and anatomical sites. Immediate placement of implants during tooth extraction is advisable to avoid significant age-related alveolar ridge resorption and bone height reduction.¹⁰ Champy's technique provides ideal lines of osteosynthesis for optimum stability but they tend to overlap tooth structures and nerves posing a significant amount of risk. Ellis documented root injuries with 6-mm screws especially in female patients with minimal mandibular height.³² Indian females especially the older age group require better attention and more careful bone height assessment.

In conjunction with mandibular cortical bone, width, and height, DentaScan assessment of the position of mental foramen and inferior alveolar nerve canal are important parameters for pre-surgical treatment planning in dental implants, orthognathic surgeries, and evaluation of mandibular invasion in cases of malignancies.^{33,34} Although not included in the present study, anthropometric assessment of the latter by dental CT has been prospected in the future.

CONCLUSION

Considering the heterogeneity of the human population regarding complex and varied anatomical structures, such as, mandible; the influence of ethnicity, gender, and age; and since anatomic variations demand adaptation in the application of surgical techniques, anthropometric assessment of mandibular cortex, width, and height provides important baseline data of Indian population that serves as a useful reference guide for the surgeons; and provides opportunities for standardized norms for designing a "gender and age-specific" treatment plan for mandibular surgeries in Indian population.

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