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Measurement of labio lingual bone thickness in the interforaminal region of the mandible, to facilitate safe implant placement- An In vitro study

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Abstract
Aim: *To measure the labio-lingual bone thickness in the mandibular interforaminal region to facilitate safe implant placement in patients of Indian origin.*
Materials and Methods: *Labio-lingual bone thickness was measured at 16 points in the interforaminal region of mandibles from 20 cadavers, in vitro, using Dial gauge tester.*
Results: *Mean thickness ranged from 9.23 to 11.80 mm with a minimal value of 5.542mm in the midline region. No significant difference was noted between dentate and edentulous specimens. This confirms that the loss of tooth has no influence on the basal process of the mandible.*
Conclusion: *The thinnest region is medially located and is narrower than the minimum required for a 3.75 mm diameter endosseous implant. Hence special attention is needed during surgical procedure to avoid lingual cortical breach and subsequent hemorrhage.*
Keywords: *Labio lingual bone thickness, mandibular implant safety.*

Introduction

Dental implants are an excellent alternative for the rehabilitation of edentulous patients, and have high success rates. Although implant placement is not a highly complex procedure[1,] complications such as paresthesia, edema and hemorrhages have been reported[1-4]. Hemorrhages, sub lingual edema and tongue elevation are complications related to implant surgical procedures in the anterior region of the mandible[5,6]. These complications are potentially relevant because they may result in obstruction of the upper airway,[7-9]. The most frequent cause of these complications is vascular injury[7]. Anterior mandibular (interforaminal) region is important in implant applications as it serves a basis for neurovascular bedding and holds the prosthesis for patients.

The mental foramen (MF) is an important landmark when considering placing implants in the interforaminal region of the mandibular arch. Regarding the horizontal relationship between the MF to the lower teeth, many studies have shown that the most common site is below the second premolar [1]. In terms of the size of the MF, it is reported that the average size is 4.6-mm horizontally and 3.4-mm vertically[1]. There is extensive literature on measurement of the labio-

lingual bone thickness in the mandibular interforaminal region[7] However, racial characteristics or racially-based anatomical limitations have not been considered in these studies and measurements were not made at many points in the mandibular interforaminal region. The aim of this in vitro cadaveric study was to measure the labio-lingual bone thickness in the mandibular interforaminal region with the aim of facilitating safe implant placement in patients of Indian origin.

Materials and Methods

Twenty cadavers of Indian descent (19 men and 1 woman), providing 20 mandibles, were used from the collection at the Department of Anatomy, Calicut Medical College, Kerala. The ages ranged from 50 to76 years (average, 66 years). Eight of the mandibles were dentulous at the interforaminal region (dentulous group) and the other12 were edentulous (edentulous group). Cadavers with disorders that might have influenced the reliability of the study were excluded from study. In each specimen, the mandible was detached from the cadaver and completely exposed.

Landmarks and Measurements

To measure the labio-lingual bone thickness of the mandibular interforaminal region, a line was drawn between the right and left mental foramina (interforaminal line) parallel to the mandibular inferior margin (Figure 1). The mid-sagittal plane was defined as the plane passing through the following 3 points:

• Mid-point of the interforaminal line

• Mid-point of the mandibular inferior margin (gnathion)

• Highest point in the centerof the mental spine.

The interforaminal line was equally divided into 4 sections on both sides of the mid sagittal plane. The lines between the interforaminal line and the mandibular inferior margin were also equally divided into 4 sections to create a grid-like pattern on the mandibular interforaminal region. The mid-sagittal plane was assigned a value of 0, equidistant vertical lines for both sides were drawn as 1 to 4, and the horizontal lines for both sides were designated A, B, C and D. Bone thickness measurement points were measured with a *dial gauge tester* (figure2*)*. On the labial side the points were determined at each point of intersection by the defined vertical and horizontal lines. Measurement points on the lingual side were defined as the points on the lingual side corresponding to measurement points on the labial side where labio-lingual bone thickness was maximum at the same height as measurement points on the labial side (each level of A, B, C and D), when the measured mandible was placed on a flat table and the measured axes were parallel with the table. Linear distances (labio-lingual bone thicknesses) between defined points on the labial and lingual sides were measured using calipers (Mitutoyo, Kanagawa, Japan). There were a total of 16 measurement points of labio-lingual bone thickness on each side (left or right) because the mid-sagittal plane formed the boundary between bilateral points.

The labio-lingual bone thicknesses of both the dentate and edentulous groups were measured using the same methods described above. All mandibular specimens were also examined to investigate the existence and location of the mandibular lingual foramen in the lingual median region.

The implant systems included in the study were.

1. The Branemark system
2. lmZ-Dental Implant System
3. Spectra System
4 .Integral system
5. Astra system
6 .Immediate load implant system
7. Bone fit system
8. Corevent system
9. Sterioss System

From all the above systems of Implant, the implant diameter of each system was obtained (Table I) and compared with the results of Labio-Lingual bone thickness in the mandibular interforaminal region.

Observations and Result

The data obtained in edentulous groups are tabulated in Table 2 and dentulous group in Table 5**.** The mean Labio-Lingual bone thickness in

edentulous group ranged from 5.542mmto 8.534mm with minimum thickness of 5.542mm at point l-A near the mid sagittal plane (Table 3). The mean labio lingual bone thickness in dentulous group ranged from 5.668mm to 8.255mm with minimum value of 5.668mm at point 2A (Table 4). The maximum labio_lingual bone thickness was found in point 4-C near the canine region.

No significant difference in labio-lingual bone thickness at each site between dentulous and edentulous groups was noted. The minimum and maximum diameter of implant in each system ranges from 3.5mm to 6.8mm. (Table I)

The lingual foramen in the mandibular median region was observed in 14 of 20 mandibles (70%). In these specimens the lingual foramen was located in the area of point l-C or 1-D.

Statistical Analysis

The available data from each group was recorded. The mean, the minimal values and the maximum values of the labio-lingual bone thickness at each measurement site are calculated. The differences between the dentulous and edentulous groups were analyzed by Anova or F test (table6).

Table 1

	SYSTEMS	Min:diameter in mm	Max:diameter in mm
1	The Branemark system	3.70	5.50
2	lmZ-Dental Implant System	3.50	4.25
3	Spectra System	3.50	4.50
4	Integral system	3.25	4.00
5	Astra system	3.50	4.00
6	Immediate load implant system	5.80	6.80
7	Bone fit system	3.75	5.75
8	Corevent system	3.50	5.50
9	Sterioss System	3.50	6.50

Figure 1

Figure 2

Dial gauge tester with mandible

Table 2

Specimen	Point	1	2	3	4
1	A	5.609	5.596	7,76	7.968
	B	5,565	5.937		7.719
	C	5, 744	6,31	8. 165	8,629
	D	5.704	6.551	8,096	0302
2	A	5.433	5.69	7,709	7.540
	B	5.431	5,973	6.387	6.943
	C	5,68	5.921	8.108	440
	D	5765	6.109	8.019	8.309
3	A	5.557	5.572	7.52	7.781
	B	5.698	5.891	6.588	6.515
	C	5.761	6.591	8.191	8.573
	D	5.756	6.7i	8.029	8.452
4	A	5.534	5.532	7.54	7.840
	B	5.748	6.018	6.611	d. 129
	C	5.649	5.791	&767	8.498
	D	5.716	5.98	8.081	8.215
5	A	5.543	5.641	7.623	7.681
	B	5.382	5.90B	6.556	7.091
	C	5.251	6.209	8.179	8.589
	D	5.742	6.659	8.056	8.397
6	A	5.522	6.091	7.844	7.760
	B	5.427	5.926	6.58	8.091
	C	5.778	6.014	8.976	8.486
	D	5,729	6,046	8,052	8.273
7	A	5.534	5.566	7.765	7.812
	B	5.693	5.994	6.723	7.491
	C	5.731	6.999	8.145	8.511
	D	5.776	6.491	8.034	8.355
8	A	5.608	6.22	7,766	7.719
	B	5.567	5.919	6.548	7.189
	C	5.719	5.309	8.129	8.551
	D	5. 695	6.276	8.071	8.310

Labio lingual bone thickness in edentulous mandible

Table 3

		SLL	
A	1	5.542500019	MINIMUM
B	2	5.738500118	
C	3	7.790875053	
D	4	7.762625217	
A	1	5.563875198	
B	2	5.955749989	
C	3	6.603374958	
D	4	7.395374775	
A	1	5.664374828	
B	2	6.143000126	
C	3	8.832150046	
D	4	8.534375191	MAXIMUM
A	1	5.735374928	
B	2	6.354000092	
C	3	8.054750443	
D	4	8.327124596	
		8.534375191	

Mean, minimum & maximum values in edentulous mandible.

F(9,112)=16.07; P<0000

Table 4

		SLL	
A	G_1:1	6.236917	
A	G_1:2	5.668417	
A		7.021167	Minimum
A	G_1:4	7.542583	
B	G_1:1	6.3365	
B	G_1:2	5.75725	
B	G_1:3	6.265167	
B	G_1:4	7.02125	
C	G_1:1	6.358917	
C	G_1:2	6.02225	
C	G_1:3	7.555083	
C	G_1:4	8.255333	Maximum
D	G_1:1	6.57725	
D	G_1:2	6.034333	
D	G_1:3	7.308833	
D	G_1:4	8.045584	

Mean values, 1 dependent variable.;

Mean, minimum & maximum values in dentulous specimens

Table 5

Specimen	Point	1	2	3	4
1	A	5.439	5.996	6.0380	6.902
	B	5.685	5.977	7.708	7.547
	C	5.764	6.11	8. 019	8.301
	D	5.553	5.555	7.527	7.789
2	A	5.361	5.56	7.761	7.817
	B	2.74	5.692	5.995	6.726
	C	5.645	6.521	8.143	8.514
	D	5.717	6.41	8.039	8.353
3	A	5.548	5.645	7.628	7.681
	B	5.387	5.538	6.556	7.019
	C	5.786	6.231	2.179	8.580
	D	5.744	6.621	8.054	8.397
4	A	5.603	6.219	7.76	7.713
	B	5.568	5.519	6.549	7.124
	C	5.719	5.391	8.128	8.358
	D	5.696	6.279	8.073	8.374
5	A	5.605	5.991	7.762	7.963
	B	5.563	5.538	6.781	7.963
	C	5.742	6.391	8.168	8.620
	D	5.701	6.751	8.109	8.308
6	A	5.432	5.696	7.09	7.541
	B	5.482	5.99	6.389	6.990
	C	5.687	5.939	8.109	8.434
	D	5.768	6.19	8.018	8.301
7	A	5.559	5.17	7.523	7.789
	B	5.559	5.898	6.524	6.508
	C	5.763	6.597	8.191	8.571
	D	5.751	6.768	8.025	8.450
8	A	5.536	5.334	7.948	7.849
	B	5.748	6.613	6.614	8.197
	C	5.647	5.71	8.709	8.490
	D	5 719	5.929	8.081	8.212

	A	5.545	5.658	7.629	7.683
	B	5.38	5.989	6.556	7.019
	C	5.758	6.208	8.172	8.386
9	D	5.741	6.651	8.051	8.584
	A	5.52	6.078	7.849	7.762
	B	5.429	5.52	6.586	8.019
	C	5.774	6.095	8.901	8.480
10	D	5.722	6.081	8.054	8.277
	A	5.531	5.569	7.763	7.811
	B	5.699	5.993	6.721	7.481
	C	5.733	6.929	8.143	8.519
11	D	5.778	6.971	8.039	8.254
	A	5.654	6.348	6.017	7.516
	B	5.567	5.55	6.489	8.035
	C	5.71	5.783	5.98	7.981
12	D	5.695	6.392	6.214	6.980

Labio lingual bone thickness in dentulous mandible.

Table 6

ANOVA, to compare the two groups
1-mandible, 2-horizontal, 3- vertical

	df	MS	df	MS				
	Effect	Effect	Error	Error	F	p-level		
Mandible	1	0,580916	288	0.436204	1.331753	0.24945	Not significant	
Horizontal	3	9.565144	288	0.436204	21.92813	8.09E-13		
Vertical	3	71.04736	288	0.436204	162.8763	0		
12	3	0,037478	288	0.436204	0,085919	0.967708		
13	3	6.712008	288	0.436204	15.3873	2 6E-09		
23	9	1.818734	288	0.436204	4.169455	4.49E-05		
123	9	0.085927	288	0.436204	0.196989	0.99383		

No significant difference between labio lingual bone thicknesses within the two groups was seen.

All horizontal, vertical effects and their interactions were eliminated.

Discussion

The labio-lingual bone thickness was measured between the mental foramina and the mandibularinferior border using the mental foramina, the gnathion, and the mental spine as anatomical landmarks, because these are easy to define clinically. In addition, the height and width of the mandibular symphysis and mental foramen region down to the lower mandibular border are not affected by bone resorption due to tooth loss, as reported by Cawood et al.[14] Also, there are no marked differences between individuals.[4] In this study, no significant difference was observed in the labio-lingual bone thickness between the dentulous and edentulous groups. The loss of teeth, as expected, had no influence on the basal process of the mandible. With the use of the above anatomical landmarks, measurement error in labio-lingual bone thickness was less than 10% of SD for all specimens (n = 10) in this study. Therefore, the measurement method used in this study is considered to be precise and reliable.

Frodel et al reported that the bone surrounding an osseointegrated implant should be at least 1 mm thick[10] .In other words, labio-lingual thickness in the mandible has to be at least 5.75 mm for implant placement of a Brånemark System of 3.75 mm diameter. In the Japanese specimens, a minimal labio-lingual bone thickness at points 1-A and 1-D of less than 5.75 mm was found. Therefore, perforation may occur when a 3.75 mm diameter endosseous implant is placed in this mandibular median region. However, most complications due to perforation of mandibular lingual cortical bone were encountered in the canine and first premolar areas, according to previous studies.[1-6] Bone thickness in the canine to first premolar area was greater than 5.75 mm in this study. Two cases were reported to be of Caucasian origin.[5,6] Other reports of complications have come from America-1 Israel-2 Sweden-3 and the Netherlands-4 and almost always referred to Caucasians.

In the comparisons made in one study, Japanese people are thinner in both the mean and minimal values than Europeans in the region of the mandibular symphysis (corresponding to point 1-A in this study). However, in the first premolar region (corresponding to point 3-A in this study), European people are mostly thinner in both the mean and minimal values than the Japanese people — the minimal value in the first premolar region was 4 mm or 5 mm. Therefore, when an endosseous implant with a 3.75 mm diameter is placed, it seems

that the Europeans have a higher possibility of perforation of the lingual cortical bone in the interforaminal canine and first premolar region as compared with findings in this study.

Regarding damage to the arteries with the possibility of serious complications after perforation ofthe mandibular lingual cortical bone, Hofschneider et al mentioned that damage to the sublingual artery or the submental artery might cause severe bleeding.[7] These researchers used 17 central European cadavers and investigated the incidence, localization, and diameter of these arteries with the objective of preventing hemorrhagic complications. Tepper et al examined lingual vascular canal penetration in the mandible of 70 central European people using CT scans.[7] These researchers observed at least 1 lingual perforating bone canal in the mandibular median region in all patients.

In addition, they examined the contents of bone canals in the median region of 2 cadaveric mandibular specimens and recognized them to be branches from the sublingual artery and accompanying vein. McDonnell et al examined the incidence of foramina in the lingual mid-line of 314 dried mandibles, the majority originating in eastern India, with a small number being of Australian Aboriginal origin.17. These researchers reported that lingual foramina existed in 311 specimens and the branches of sublingual arteries penetrated into the lingual foramina from the dissection of 28 wet specimens. Even for the Japanese specimens in this study, lingual foramina were observed on 7 of 10 mandibles and all were located in the mandibular median region. Therefore, for Asians, special attention is needed to ensure placement of 3.75 mm diameter endosseous implants into the mandibular median region because the lingual cortical bone might be perforated and cause damage to the branches of the sublingual arteries.

In a previous study of Yuki uchinda et al in 2005 regarding the measurement of labio lingual bone thickness in Japanese cadaveric mandibular inter froraminal region observed a minimum thickness of 5.23 mm in midline. They also found that presence of mandibular lingual foramen in 70% of their samples studied.

Conclusion

This study concluded that the maximum thickness in the mandibular interforaminal region is at the midline region (5.542 mm).So special attention is required for placement of implant at the median region, otherwise the lingual cortical bone might be perforated and might cause damage to the branches of sublingual arteries of accompanying veins, which may lead to hemorrhagic complications. The margin of error is minimal.

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