ORIGINAL ARTICLE

Movements of Mandible Before and After Prosthodontic Treatment: A Clinical Study

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ABSTRACT

Background: The range of mandibular movements as well as the changes happening before and after prosthodontic treatment were not studied to set a norm in Indian individuals. Present study determined the range of mandibular movements viz, protrusion, movements measured at the mandibular first molar region both on right and left side at working and non-working sides, movements measured in the incisor region while performing lateral excursions, active and passive opening movements in prosthodontically treated and untreated individuals.

Material and Methods: The sample consisted of 160 prosthodontically untreated and 80 treated individuals. The Morphometric and mandibular movement parameters were first measured in the untreated individuals and then in the treated individuals with digital vernier caliper directly and using putty indices. Then the comparison was made between the two by applying statistical analysis. The test used was two-way analysis of variance.

Results: A norm could be formulated both for morphometries related to mandible, mandibular arch and mandibular movements. The mandibular movements get restricted after prosthodontic treatment.

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INTRODUCTION

Human dentition is put to test during function especially during mastication. Mastication requires a 'harmonious contact between teeth of the opposing arches both in static and dynamic phase. Occlusal contact during the dynamic phase is dictated by the mandibular movements and controlled by the temporomandibular joints (TMJ). Dynamic aspects of human temporomandibular articulation and particularly the morphologic and functional variations were studied by Ricketts.[1] The range of normal variations in morphology, function and correlation of certain functions of denture with the behavior of the TMJ were one of the areas of investigation.

Posselt[2] elucidated the shape and dimension of the contact area of movement of the anterior measuring point and that of condyles in dentate individuals. The extreme positions of the anterior measuring point were united by straight lines and thereby an impression was obtained of the outline, size and shape of the areas of movement. Thus, the distance between retruded and protruded contact position was determined and was in the range of 10.5 mm to 12 mm. The distance between extreme right and left lateral positions was found to be 19.5 mm to 22.5 mm.[2] Gibbs *et al*.[3] studied functional movements of the mandible with the objective to provide an accurate and extensive data of jaw motion and maxilla mandibular relationship during chewing which could enable articulator specifications to be made, and to determine the manner and degree in which differing states of occlusion effect jaw motion during chewing. It was found that in sagittal view the total lateral motion at the condyle was 1.5 mm and the working side condyle was nearly stationary.[3] However, numerical values of mandibular movements were rarely documented with a view to formulate a norm. An operator is often very confused and fails in decision making to determine the normalcy of mandibular movements and thereby in diagnosing the abnormality of the functioning masticatory apparatus. There is no Indian standard that provides information on the normal range of mandibular movements. These circumstances served as the need of the present study which was designed to be conducted on both prosthodontically treated and untreated individuals belonging to Bangalore to determine the morphometric values such as intercondylar distance, distance between intercondylar axis and axis connecting mesio incisal angles of the mandibular central incisors, distance between intercondylar axis and axis connecting mesiobuccal cusps of

the mandibular molars and inter mandibular molar distance related to mandible and mandibular arch.

MATERIALS AND METHODS

Present study was conducted in the Department of Prosthodontics, M R Ambedkar Dental College and Hospital, Banglore after obtaining approval of the institutional ethical committee and informed consent from all the particpants subsequent to explaining the procedure in detail. Total of 240 (160 prosthodontically untreated and 80 treated) individuals with non-contributing systemic history were selected amongst the patients visiting the OPD of M R Ambedkar Dental College and Hospital, Banglore. Only those individuals, who had normal tempomandibular joint function and were without any crepitus, or any deviation during mandibular movements, were selected for the study.

Methodology: Prosthodontically untreated subjects were divided into four groups according to the age viz., Group I: 21-30 yrs, Group II: 31-40 Yrs, Group III: 41-50 yrs, Group IV: 51-60 yrs. Similarly, prosthodontically treated individuals were also divided into four groups according to the type of treatment viz., Group A: Complete dentures (CD), Group B: Removable Partial dentures (RPD), Group C: Fixed partial dentures (FPD), Group D: Single Crowns. The morphometric and mandibular movement parameters were first measured in the untreated individuals and then in the treated individuals with digital vernier caliper directly and using putty indices. Methodology for the present study was based on study protocol as suggested by Rivera-Morales *et al*.[4]

Parameters Recorded: The following parameters were recorded; *Mandibular intercondylar distance - measured between outer poles*; *Distance between the inter condylar axis and the axis connecting the mesiobuccal cusps of the mandibular first molars* (Fig. 1); *Distance between the intercondylar axis and the axis connecting the mesiobuccal cusp of the mandibular first molars* (Fig. 2) and; *Distance measured between intercondylar axis and the axis connecting mesioincisal angle of mandibular central incisor* (Fig. 3).

In order to measure the above parameters, the subject was seated in the dental chair in an upright position without head

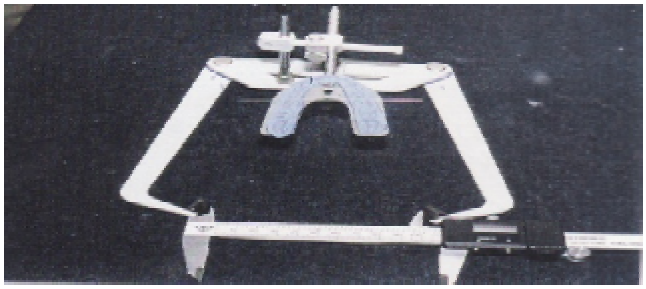

Figure 1: Intercondylar distance measured between outer poles.

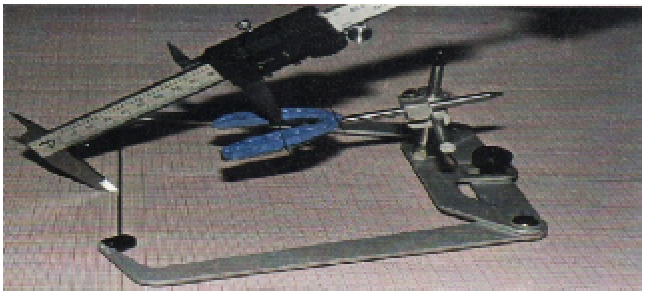

Figure 2: Distance measured between intercondylar axis and the axis connecting mesiobuccal cusp of mandibular first molar.

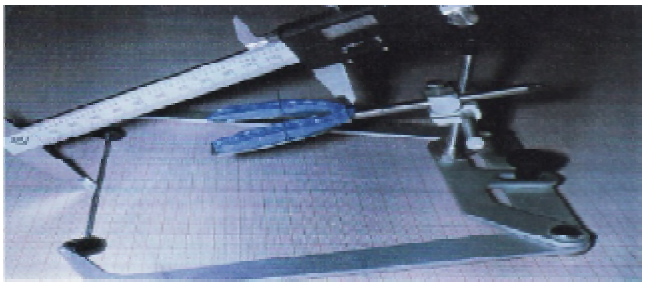

Figure 3: Distance measured between intercondylar axis and the axis connecting mesioincisal angle of mandibular central incisor.

support so as not to influence the position of the mandible. Face bow fork (SAM II axioquick recorder.) was then painted with a silicone adhesive on one surface and after drying, silicone putty impression material was placed. This was then positioned on the mandibular arch (Fig. 4), and the subject was instructed to close the mouth, gently biting on the fork. Care was taken to keep the interocclusal distance to a minimum so that translatory movements of the mandible could be avoided. After the curing of the impression material, the fork was removed and the excess material extending to the undercut areas was cut off using a sharp blade. The fork was then reseated in the mouth. Then SAM II ear piece face bow was positioned, connecting the fork and the external auditory meatus. Now the position of the adjustable arms in relation to the fixed arm of the face bow was marked with an indelible pencil to enable repositioning at a later stage for measurements of the distance between the adjustable arms of the face bow. The assembly is then removed and readjusted to the original

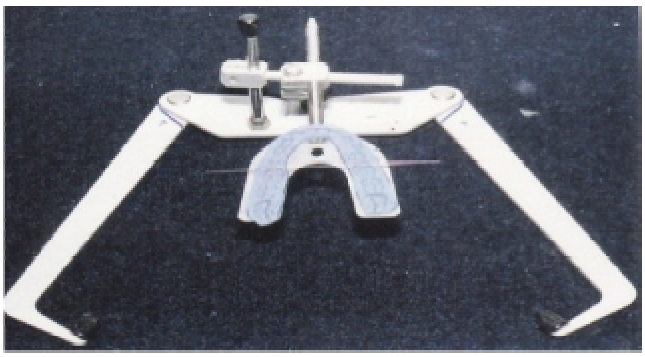

Figure 4: Position of adjustable arms marked in relation to the fixed arms of elbow.

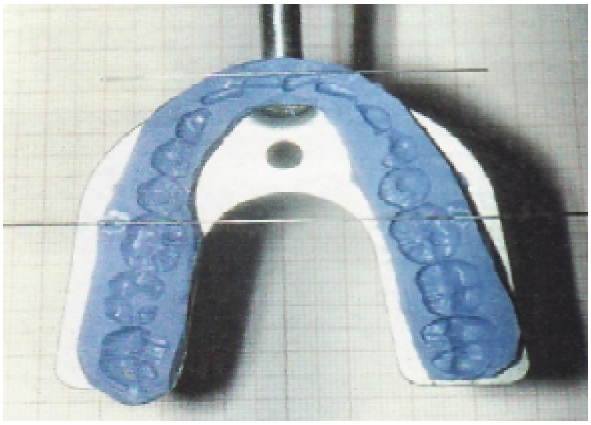

Figure 5: Distance measured between the mesiobuccal cusps of mandibular first molar.

dimensions. A 2 mm thick straight stainless steel wire was positioned between the ear plugs and the midpoint was marked on it. One stainless steel wire of 0.5 mm diameter was placed over the mandibular first molars connecting the mesiobuccal cusp tips. A similar wire was placed over the mandibular incisors connecting the mesioincisal angles (Fig. 5). The entire assembly was then placed over a graph paper co-inciding the intercondylar axis with a bold line. From this, ear plug positions and the centralization could be verified (Fig.6). The distance from the axis to the wire fixed over the molars was measured at the centre using the digital vernier caliper. Similarly the distance from the axis to the incisors was also measured. From the distance calculated, 13 mm was reduced because the intercondylar axis is positioned 13 mm anterior to the external auditory meatus. The intermolar distance was then measured from the mesiobuccal cusp of right mandibular molar to the mesiobuccal cusp of left mandibular molar on the cast. Two points, one on each were marked on both the cusp. A curved stainless steel wire was placed over the cast touching both the cusps so as get the marks duplicated on the wire. Later the wire was straightened and the distance between the points was measured with the help of vernier caliper. Intercondylar distance was measured using the same face bow. Hinge axis points were marked on the skin on the both sides of the face. The points were marked

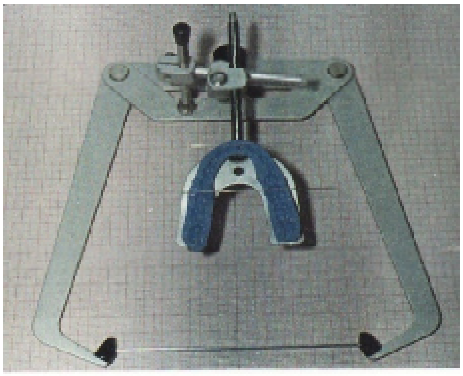

Figure 6: Facebow assembly placed on graph paper for centralization.

13 mm anterior to the posterior most point of the tragus in the cantho-meatal line and verifying it further by palpation. The ear pieces were positioned tightly on the points marked. Positions of the adjustable arms were marked and the face bow was removed. After repositioning the face bow, intercondylar distance was measured between the ear pieces.

The next parameters measured were the range of movement of the mandible viz. *passive opening* and *active opening*, *extreme protrusive* movement and *lateral excursive* movements.

Figure 7: Measuring passive opening.

Figure 8: Measuring active opening.

The subject was seated in the dental chair in an upright position without head support. Vertical overlap was measured at the central incisor region using the digital vernier caliper. For this purpose a mark was made on the mandibular central incisors at the level of the incisal edge of the maxillary incisors in the intercuspal position. Then the subject was instructed to open the mouth and the inter incisal distance was measured (Fig. 7). The subject was again asked to open further as far as he could and opening was measured (Fig. 8). The measurement of the vertical overlap was added to the measurements obtained on opening, and the actual opening was calculated. The former measurement was considered as passive opening and the latter as active opening.

Protrusive movement: First the subject was asked to close in intercuspal position. A vertical line was drawn on the maxillary second premolar, extending it down to the mandibular premolar (Fig. 9). Then the subject was instructed to protrude to the maximum and the extent of protrusion was marked on the maxillary tooth against the mark present on the mandibular tooth. After this, silicone putty was mixed and placed over the mandibular and maxillary central incisors covering the labial and lingual surfaces, and the subject was asked to close in intercuspal position (Fig. 10). The impression material was united and molded to form a singular mass. After curing, the index was removed. A vertical line was then marked with an indelible pencil on the labial surface, 3 mm away from the midline. The index was reseated to get the copy of the marking on the inner surface of the index (Fig. 11). Along this line the index was sectioned vertically (Fig. 12). Similarly another index was prepared in the protrusive position verifying simultaneously the extent of protrusion by looking at the markings made on the posterior teeth. This index was also sectioned as mentioned earlier. The range of motion was measured between incisal tips. The displacement in the horizontal plane alone was considered for the measurement.

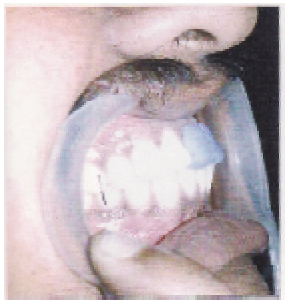

Figure 9: Vertical line drawn on the maxillary second premolar extending it down to mandibular second premolar with putty index made in incisor region.

Figure 10: Extent of index drawn on the maxillary teeth with putty index made in incisor region.

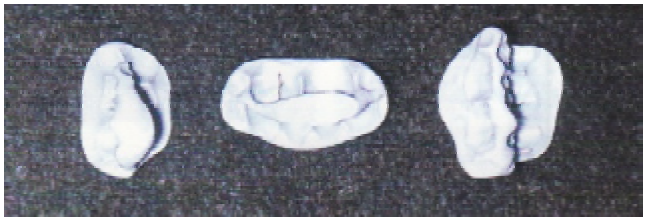

Figure 11: Markings made on the teeth are copied on the inner surface of indices.

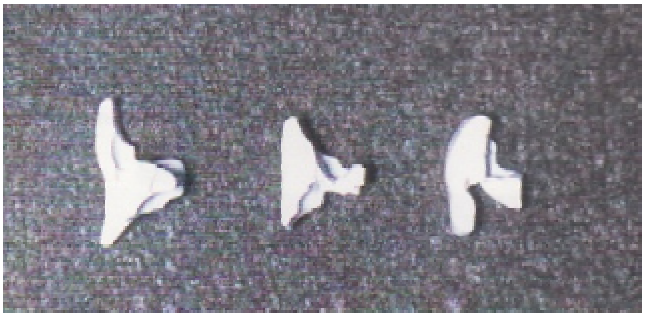

Figure 12: Indices sectioned along the line marked.

Lateral excursive movement: Subject was instructed to make extreme right side and left side movements of the mandible with minimum opening. Vertical lines were marked on maxillary central incisors 3mm away from the midline and this was extended to the mandibular teeth (Fig. 13). Then the subject was instructed to make extreme left side movement. Holding on to that position the distance between the vertical lines were measured (Fig. 14). Two measurements were thus obtained and it was averaged to calculate the excursive movement at the incisor region. After this, the lines present on the mandibular incisors were projected to the maxillary teeth in the extreme position. This was used to ascertain the positions during the preparation of the indices. Indices were made on working and non-working sides in the first molar region. Silicon putty impression material was placed over the first molar region on both sides and the subject was instructed to close in maximum intercuspal position (Fig. 15). The material was manipulated to cover the buccal surfaces of the maxillary

Figure 13: Vertical lines were marked on maxillary central incisors 3mm away from the midline and this was extended to the mandibular teeth.

Figure 14: Distance between the vertical lines were measured on left lateral excursion.

Figure 15: Putty indices made in intercuspal position.

Figure 16: Indices made on the working and nonworking sides.

and mandibular first molars completely. Once the material was cured the indices were removed and the lines were marked on the buccal surfaces of the maxillary molars corresponding to the mesiobuccal cusp tips. The indices were reseated to get a copy of this line on the inner surface to serve as an aid in sectioning the indices (Fig. 16). Similarly an index was made on the working side when the subject made an extreme movement corresponding to the lines marked previously on the anterior teeth. For the same movement an index was made on the non-working side keeping the working side index in position. For these indices also, lines were marked on the maxillary buccal surfaces of molars corresponding to the mesiobuccal cusp tips and were copied on the indices as an aid in sectioning. Similarly indices were made when the subject performed an extreme movement to other side. The movement of the mandible in horizontal plane was measured between the maxillary and the mandibular cusp tips. After this total mediolateral movement of the mandible at lower right and left first molar level was calculated by adding working side movement and non-working side movement. Similarly total mediolateral movement of the mandible at incisor level was also calculated.

Statsitical Analysis: The values obtained for the different parameters were tabulated for prosthodontically untreated as well as prosthodontically treated individuals. Mean and standard deviation values were calculated for different groups and according to the sex distribution. The data were analyzed using 'F' test (two way analysis of variance) for comparison between groups and between sexes. For comparing treated and untreated individuals student't' test was used.

RESULTS

A norm could be formulated both for morphometries related to mandible, mandibular arch and mandibular movements. Morphometric values of the prosthodontically untreated and treated individuals were compared (Table 1 and 2). In general it was observed that mandibular movements get restricted when an individual undergoes prosthodontic treatment. Range of mandibular movements is less in treated individuals than that of untreated ones. There was statistical no significant differences in morphometry between the two groups. Intercondylar distance and intermolar distance were found to be significantly different in both the groups but numerically the difference is very negligible. The distance measured between the intercondylar axis to the mandibular central incisor and mandibular first molars were not significantly different.

DISCUSSION

The actual movements of the mastication were recorded by still and motion picture photography in a study conducted by Schweitzer.[5] The length of the functional opening stroke was usually not more than one half to three-fourth that of maximal opening. The functional envelope of motion was much smaller and well within the borders of the total envelope of motion. One of the early documentations on mandibular movements made by Posselt[2] had given a graphic illustration of the range of mandibular movements. Initial evaluations were mainly centered on opening and closing movements and later the excursive movements were also included. For precise measurements, advanced tools like jaw motion

Table 1: Comparison of the morphometric parameters between prosthodontically untreated and prosthodontically treated groups

Morphometric parameters	Mean ± S.D. (in mm)		t Value	p Value
	Untreated (n=160)	Treated (n=80)		
Intercondylor distance	116.67 ± 1.22	118.67 ± 0.33	14.96	P < 0.0001
Distance between intercondylor axis and central Incisors	97.10 ± 2.19	96.97 ± 1.29	0.49	P > 0.05 (N.S)
Distance between intercondylor axis Connecting mandibular first molars	73.74 ± 2.18	73.35 ± 1.03	1.52	P > 0.05 (N.S)
Intermandibular molar distance	45.08 ± 1.18	44.62 ± 1.26	2.52	P < 0.05

Table 2: Comparison between the parameters of mandibular movements in prosthodontically untreated and treated individuals (in mm)

Mandibular movements measure	Mean ± S.D.		t Value	p Value
	Untreated (n=160)	Treated (n=80)		
Protrusion	7.60 ± 0.53	6.13 ±0.31	22.68	p < 0.00001
Working side-Right (lllrnolar region)	4.38 ± 0.61	4.18 ± 0.14	9.04	p < 0.00001
Working side - Left (do)	4.34 ± 0.13	4.28 ± 0.11	2.00	p < 0.05
Non-working side - Right (do)	3.79 ±0.28	3.64 ± 0.12	4.60	P < 0.001
Non-working side - Left (do)	3.63 ± 0.47	3.71 ± 0.08	1.50	p > 0.05 (N.S)
Anterior right lateral movement	7.24 ± 0.33	6.18 ± 0.21	25.30	p < 0.00001
Anterior left lateral movement	7.18 ± 0.50	6.27 ± 0.20	15.64	p < 0.0001
Passive opening	38.97 ± 0.82	37.98 ± 0.74	9.09	p < 0.001
Active opening	51.94 ± 0.44	51.26 ± 0.03	8.96	P < 0.001
Total medio lateral movement at	-	-	-	-
- Lower right first molar region	8.17 ± 043	7.69 ± 0.32	8.86	p < 0.001
- Lower left first molar region	7.89 ± 0.60	7.79 ± 0.16	1.48	p > 0.05 (N.S.)
- Incisor region	14.38 ± 0.78	12.46 ± 0.40	20.65	p < 0.00001

tracking, sonography of the TMJ, occlusal contact recording and electromyographic recordings of jaw muscles were described by Ekfeldt.[6] Evaluation of mandibular movements will definitely provide an insight into the functioning of temporomandibular joints. The use of devices for quantitatively measuring mandibular motion has recently become more common in scientific and clinical use.[7]

While performing the clinical screening of prosthodontic patients, an operator is very often confused to determine the normalcy of function because of the lack of normal values of the mandibular movements ascertained for Indian individuals. As there is no data available to measure and compare mandibular movements, it has become difficult for the clinician to determine whether the movement is normal or not. The effect of prosthodontic treatment on the mandibular movements is also not ascertained because of the paucity of data. Realizing the importance and the appreciating the reality, it was decided to formulate a data pertaining to normal mandibular movements. The present study was designed in this context, and our view was only to find out range of mandibular movements in treated groups irrespective of treatment rendered. Patients were divided into treated and untreated groups to make a comparison of the results obtained in treated individuals with that of normal standard that is obtained from untreated individuals and thus to check the effects of prosthodontic treatment on mandibular musculature and therefore the mandibular movements. The mean value of intercondylar distance measured in untreated individuals was 116.67± 1.22 mm. However in treated individuals it was 118.67 ± 0.33 mm. The distance between intercondylar axis and mandibular central incisors was 97.1 ± 2.19 mm in untreated individuals and 96.97 ± 1.29 mm in treated individuals. Intermandibular molar distance was 45.08 ± 1.18 mm in untreated individuals and 44.62 ± 1.26 mm in treated individuals. It can be observed that while the intercondylar distance is higher in treated individuals, the intermolar distance is higher in untreated ones. The intercondylar distance measurements obtained in the study are comparable to the values given by Moyers.[8]

As mentioned earlier mandibular movements were studied under different headings. Both hinge type and translatory movements were included. Direct measurement was done with the vernier calipers for protrusion and for lateral excursive movements measured at the incisor region. For all other movements indices were made using silicon putty and measurements were done after appropriately sectioning it. The indices were fairly accurate, but it had limitations on the translating side in the molar region because it could not individualize the lateral movement from the forward and downward components. But the possibility of an error creeping into is not significant because this method is designed to be copied in clinical situations. Hence, the values obtained in this study will have clinical relevance because the values will serve as a norm for comparison.

Protrusive movement was measured at the incisor region using two putty indices, one made at intercuspal position and other at maximum protrusive position. In normal individuals males showed higher protrusive value when compared to that of females. No such difference was seen in treated individuals. While comparing the age groups maximum protrusion was expressed by group III (41-50 yrs) both in males and females.

Considering the entire sample, protrusion in untreated subjects was computed as 7.60 ± 0.53 mm whereas in treated ones it was only 6.13 ± 0.31 mm. This difference was highly significant when statistical methods were applied.

Lateral excursive movements were measured at the first molar region and in the incisor region. In the molar region it was measured both on the left and the right side. And in each side it was measured when the molar performed the working function and the non-working function. The working side movement in untreated subjects was 4.38 ± 0.61 mm on the right side and 4.34 ± 0.13 mm on the left side. The non-working side movements on the right and left were 3.79 ± 0.28 mm and 3.63 ± 0.47 mm respectively. The reduction in values for the non-working side is due to the limitation in including the forward and downward components of movements. In treated individuals the working side movement on right and left were 4.18 ± 0.14 mm and 4.28 ± 0.11 mm. The non working side movement on right and left were 3.64 ± 0.12 mm and 3.71 ± 0.08 mm. Except the non-working left side movement, all the other values showed a significant reduction in case of the treated individuals. Total mediolateral movement was calculated in the first molar region by the addition of working side and non working side movement that have taken place at one site. A reduction in values was seen in treated individuals.

The lateral movements measured in the anterior region for the right lateral movement was 7.24 ± 0.33mm and for left lateral movement was 7.18 ± 0.50 mm. In the treated individuals these values have come down to 6.18 ± 0.21 mm and 6.27±0.20 mm at a statistically significant level. The total mediolateral movement measured in incisor region was 14.38 ± 0.78 mm in normal individuals whereas it has significantly reduced in treated individuals expressing the value of 12.46 ± 0.40 mm.

Opening was measured interincisally in order to compute the actual opening. The vertical overlap was first identified and it was added to the opening measured between the maxillary and mandibular incisor tips. Initially the individual was asked to make a passive opening and later to make an active opening within the tolerance limit. The passive opening in normal individuals was 38.97 ± 0.82 mm and active opening was 51.94 ± 0.44 mm. In prosthodontically treated individuals it was 7.98 ± 0.74 mm and 51.26 ± 0.73 mm respectively. Here also the reduction in opening observed in treated individuals was statistically significant but numerically within one millimeter. Passive opening was marginally more in females but in active opening no such difference was noticed in the case of normal individuals. In treated individuals the difference between groups was not significant. Considering the entire study population, opening was slightly less in the treated group at a statistically significant level.

Numerical values on mandibular movements were provided by Posselt,[2] Robert[9] and Clark *et al.*[10,11] The values given by Posselt[2] were derived from a graphic representation and hence it was augmented more than the actual values. Clinically we may not be able to make use of those values. The values given by Roberts[9] are based on the data obtained from diseased individuals. Clark *et al*.[10,11] has recorded opening of 50.33 mm, right lateral excursion of 12.9 mm and protrusion of 9.1 mm measured in the anterior region. The data was obtained from the subjects belonging to California.[10,11] A norm could be formulated both for morphometries related to mandible, mandibular arch and for mandibular movements. The values obtained are relevant to individuals belonging to Bangalore and nearby areas. Opening and lateral movements can be measured directly in the incisal region using a pair of vernier calipers. In order to measure the excursive movements in the posterior region and the protrusion in the anterior region, putty indices can be made which is a simple procedure that can be performed in a dental clinic. Thus, it can be concluded that prosthodontic treatment in general has a restrictive effect on mandibular movements.

REFERENCES

1. Ricketts RM. Variations of the temporomandibular joints as revealed by cephalometric laminagraph. Am J Orthod 1950; 36: 877-98.
2. Posselt Ulf. Movement areas of mandible. J Prosthet Dent 1957; 7: 375-85.
3. Gibbs CH, Messerman T, Reswick JB, Derda HJ. Functional movements of the mandible. J Prosthet Dent 1971; 26: 604-20.
4. Rivera-Morales WC, Goldman BM, Richard S, Jackson VS. Simplified to measure mandibular range of motion. J Prosthet Dent 1996; 75: 56-9.
5. Schweitzer JM. Masticatory function in man. J Prosthet Dent 1961; 11: 625-47.
6. Ekfeldt A, Karlsson S. The changes of masticatory movement characteristics after prosthodontic rehabilitation of individuals with excessive tooth wear. Int J Prosthodont 1996; 9: 539-45.
7. Soboïeva U, Laurioà L, Slaidioà A. Jaw tracking devices—historical review of methods development. Part I. Stomatologija. 2005; 7: 67-71.
8. Moyers RE. Hand Book of Orthodontics 4th ed, Year Book Medical Publisher Inc, London. 1998; p. 294.
9. Robert CA, Tallents RH, Espeland MA, Handelman SL, Katzberg RW. Mandibular range of motion versus arthrographic diagnosis of the temporomandibular joints. Oral Surg Oral Med Oral Pathol. 1985; 60: 244-51.
10. Clark GT, Lynn P, Clark GT. Horizontal Plane Jaw movements in controls and clinic patients with temporo mandibular disfunction. J Prosthet Dent 1986; 55: 730-35.
11. Clark GT, Tsukiyama Y, Baba K, Simmons M. The validity and utility of disease detection methods and of occlusal therapy for temporomandibular disorders. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997; 83: 101-6.