Estimation of the Bennett mandibular immediate side shift in Iraqi full mouth rehabilitation patients (An in vivo study)

Ma'an Rasheed Zakaria, B.D.S., M.S., Ph.D. [(1)]

ABSTRACT

Background: Controversy exists concerning the presence and amount of the Bennett mandibular immediate side shift among patients and whether it is necessary to accommodate for it in adjustable articulators. The aim of this study was to register and calculate the amount of any immediate side shift (ISS) present in patients requiring full mouth rehabilitation.

Materials and methods: 3- dimensional condylar movements of 50 Iraqi TMD-free patients were recorded using a stereographic fully adjustable articulator system during protrusion, left and right eccentric mandibular movements. Protrusive angles of each patient were verified to figure out the suitable fossa analog for each case. The thickness of each right and left premade fossa analog selected was measured with a vernier caliper and was tightly secured in the articulator fossa compartment. Functionally-generated path recordings were performed using custom-made intraoral clutches. Bennett ISSs, verified by the stereographic system in the molded fossae, were measured using the vernier caliper. The final right and left ISSs were estimated by subtracting the thickness of the blank fossa analog from that of the molded one. The final ISSs were recorded and statistically compared.

Results: Stereographic recordings of eccentric mandibular movements revealed ISSs within all patients involved in this study. The ISSs varied among the patients and bilaterally within them. Their average values ranged between 0.80 mm for females and 1.68 mm for males, showing significant statistical differences between them but with no relevancy to age advancement. Mean values of ISSs of males' and females' mandibular left joints were more than those recorded by their right joints.

Conclusion: Verifying the mandibular ISS in the molded fossae is an essential step to efficiently rehabilitate full mouth cases; thus it would be helpful to use a fully adjustable articulator system to restore complicated cases since very minor intraoral occlusal adjustments might be required for the finished restorations prior to the final cementation.

Key words: Bennett Immediate side shift, fossa analog, rehabilitation. (J Bagh Coll Dentistry 2014; 26(4):54-62).

INTRODUCTION

The Bennett immediate side shift (ISS), or transtrusion of the mandible, is defined as "a thrust of the mandible in a generally horizontal direction"; it is regulated by the anatomic configuration of the glenoid fossa or capsular ligament on the nonworking side of the skull and it is activated by muscle action during mandibular lateral excursive movements [(1)].

The ISS has been considered the most important factor in determining pos-terior fossa depth and width and the contour of the palatal cavities of the maxillary anterior teeth. The greater the extent of the ISS, the more palatal concavity should be provided in the anterior teeth to permit their harmonious functioning without locking in the posterior occlusion [(2,3)].

About 80% of the adult population exhibits ISS to some degree. It can occur unilaterally or bilaterally, and may differ in the amount and degree of angulation from one side of the skull to the other. When present, ISS occurs when the nonworking condyle moves from its centric position in the fossa during a lateral excursive movement of the mandible. The condyle moves medially against the medial and superior walls of the fossa (mediotrusion of the non-working condyle). The degree and amount of the movement is determined by the shape of the fossa, the looseness of the capsular liga-ment, and contraction of the muscles, primarily the pterygoids [(4)].

For this reason, it's extremely important that the articulating surfaces be in strict harmony with this side shift. Any discrepancy in this harmony could result in the most destructive lateral forces encountered in a mal-articulation [(5)]. Side shift can vary in the amount of the total horizontal movement anywhere from 0.2 mm to more than 2.5 mm. Beyond this point the condyle moves forward, downward, and inward against the medial and superior walls of the fossa [(1)]. Because the ISS influences the horizontal and vertical elements of occlusion, it must be recognized and taken care of during the diagnosis and treatment planning stage of patients having major restorative procedures performed, and sometimes for occlusal corrections by selective grinding. If the side shift is ignored, the restorations may end up with an occlusal pattern that does not function with that movement, and may result in built-in occlusal interferences leading to occlusal disharmony [(6)].

The shape of the condyle would directly affect the nature of the Bennett shift of the mandible.

(1)Retired Professor. Department of Conservative Dentistry. College of Dentistry, University of Baghdad

Investigating the shapes of the frontal projection of thousands of mandibular condyles revealed that a subject with an angular condyle functioning in an angular fossa would move his mandible inferiorly to a noticeable degree when making a lateral shift, whereas a person with a flat condyle would not necessarily drop inferiorly at all during the lateral side shift [7].

Using a pantograph, the ISS is measured on the horizontal plane orbiting path record and is expressed in units of tenths of a millimeter. This value is almost always less than 2 mm [8].

It was reported that although the pantograph has been extensively used in research and clinical practice, the value of the programmed articulator would only be realized if the transfer of graphic information to the articulator was accurate. In a study, it was found that with experienced dentists, the error in ISS following on pantographic tracing was 0.16 mm while it reached 0.40 mm with the inexperienced dentists. Such errors were rated significant in top wall articulator settings which would greatly affect the occlusal configuration of fixed restorations. The authors' explanation for that difference was attributed to the relative magnification of the graphic tracings in which the scribed lines of the ISS are usually short and appear sensitive to the dentists' experience [9].

Stereographic techniques have a decided advantage in the use of the 3-dimensional recordings (functionally gene-rated path). All border pathways can be programmed into the condylar guidance, including protrusive-lateral movements. The instrument can be used in combination with customized anterior guidance procedures [10].

Controversy exists concerning the complexity of the articulator to accurately simulate mandibular movements. It was estimated that restorations constructed with fully adjustable articulators require 5% intraoral adjustment whereas those made using semi-adjustable articulators would require 50% and restorations made with simple hinge articulators would require 95% since using them had led to occlusal discrepancies in the final restorations which have to be corrected in the mouth in addition to being a time-consuming procedure [11].

It was concluded that it should be realized that ISS cannot be simulated by slot track semi-adjustable articulators and significant errors in cusp positions and groove orientation of posterior teeth may result [12].

Most semi-adjustable articulators lack adjustments for the ISS and inter-condylar distance (ICD) besides that no provision for motion analog curved path-ways is present. Limitations are inherent in these articulators because of the inability to accurately duplicate the posterior determinants of occlusion. It has been reported that in order to minimize the errors of straight-line semi-adjustable articulators in the horizontal plane, additional clearance should be made distal to the occlusal groove on mandibular molar teeth [13].

The use of complete gnathological instruments (fully adjustable articulators) for patients having bucco-lingual wear facets on the posterior teeth with rounded central fossae has been stressed on since most adult participants possessed them. Lateral eccentric prematurities were rated as one basis for occlusal pathoses [14].

Patients with excessive Bennett movement and little or no anterior guidance present the greatest challenge in occlusal rehabilitation procedures because the cusp movement pathways of their posterior teeth are very shallow and the elimination of eccentric interferences can be very difficult. The completely adjustable articulators would be most helpful for these patients [15].

The importance of estimating the ISS during dental restorative therapy especially in extensive occlusal rehabilitation cases has been stressed since the incorrect ISS measurement can cause occlusal error which occurs because the ISS takes place early in mandibular laterotrusion, producing lateral movement of the posterior teeth before dis-occlusion has occurred. If the fossae width of teeth don't accommodate for the lateral motion of opposing cusps, occlusal deflective contacts on facio-lingual cusp inclines will result [3]. The TMJ Deluxe fully adjustable articulator system provides for fossa molding of the patient's fossae, unlike the slot-track, straight-line path semi-adjustable articulators [15].

A stereographic articulator has been considered one of the simplest "fully adjustable" instruments to use for full mouth rehabilitation cases and has been also ranked an excellent articulator for fabricating dentures. The intraoral clutches are stabilized by the central bearing point and all recordings are made intraorally within the central area of the bases which is an advantage over pantographic devices that frequently have a tendency to tilt the denture base with the weight of the external appendages in addition to the difficulty and time-consumed in attempting to set the fully adjustable articulator according to the pantographic tracings [16].

In addition, it has been noted that electronic pantographs and electronic axio-graphs are not within the reach of the general practitioners besides that they are of high price values and are limited to teaching and research institutes [17].

It is worthy to mention that careful diagnosis, thorough treatment plans, and meticulous buildup of full mouth rehabilitation cases can avoid creating TMDs specially when legal claims concerning TMDs have been increased over the years, a fact which necessitates that evidence-based knowledge in the field of TMD diagnosis and treatment must be fulfilled [18].

MATERIALS AND METHODS

Fifty adult patients (25 females and 25 males) aged 30 to 65 years participated in this study. They required extensive occlusal rehabilitation treatment due to either generalized loss of incisal and occlusal morphology due to attrition and faceting of teeth, extensive defective restorations, or multiple missing teeth, associated with moderate or severe OVD collapse.The patients were free from any TMDs and TMJ problems and were recruited from those seeking fixed prosthodontic work at the department of conservative dentistry, College of Dentistry, University of Baghdad. The criteria for patients' selection concentrated on the status of being healthy with no oral pathology or history of TMJ pain or dysfunction according to the multiaxial Research Diagnostic Criteria for TMDs (RDC/TMD) [19]. Full series of periapical X-rays and a panoramic radiograph were taken for each patient. Clinical examination for each patient included masticatory muscles' palpation, maximal opening of the mouth measured from the incisal surfaces of the anterior teeth using the vernier caliper (less than 40 mm indicated muscle spasm), mandible deviation upon opening represented as a sudden jerk to one side, condyles' pain or crepitus verification during mouth opening and closing by applying anterior and superior pressure against both condyles with tips of index fingers inserted in the auditory meatus.

For each patient, two sets of maxillary and mandibular irreversible hydro-colloid impressions (Tropicalgin Chromatic, ZhermackSpA, Italy) were made and converted into stone casts. Centric jaw relationship was made using Aluwax (Aluwax Dental Products Co, Michigan, USA) following Dawson's technique.[16] Terminal mandibular hinge axis location was performed using the TMJ kinematic face-bow(TMJ Instrument Co, Inc, USA) [20].

The Face-bow record was transferred to the TMJ Deluxe Model T-7 fully adjustable articulator (TMJ Instrument Co, Inc, USA), and the ICD of each patient was determined and the condyle posts of the articulator were locked at the determined measurements [21]. The maxillary cast of the patient was mounted on the maxillary member of the articulator then the mandibular cast was mounted on the mandibular member of the articulator according to the patient's centric jaw relationship record.

Extra-oral clutches construction was done following the manufacturer's instructions. The maxillary clutch was returned intraorally followed by the mandibular clutch. The clutches were checked for the studs' clearance located in the maxillary clutch when the mouth was closed. Adjustments in the vertical opening were made by the central bearing screw located in the mandibular clutch.

Each clutch was secured on the patient's teeth with light body silicone impression material (Indurent Gel, Zhermack SpA, Italy) placed inside the clutch which was transferred to the patient's mouth who was asked to bite on the mandibular clutch so that the two clutches were firmly seated.

Intraoral stereographic recording of mandibular border movements for each patient was carried out in the following manner. With the patient sitting in a recline position, a trial recording was made to ensure that the patient could make reproducible border movements. Under the operator's guidance, three right lateral, three left lateral, and one protrusive movements were performed to constitute a recording starting from the centric position with the central bearing screw of the mandibular clutch riding on the disk at the center of the maxillary clutch, and its studs at least 1.5 mm from the mandibular clutch surface. The mandibular clutch was removed from the mouth; a mix of TMJ acrylic resin (TMJ Instrument Co, Inc, USA) was placed in four patties facing each stud of the maxillary clutch (Fig.1). When the resin reached its dough stage, the mandibular clutch was placed inside the mouth and the patient was directed to move the mandible into the various border movements by holding the mandible with the operator's thumb and index fingers, starting with small circles of movement from the retruded position (Fig.2).

Figure 1: Acrylic resin patties placed on mandibular clutch platform.

Figure 2: Intraoral stereographic recording of mandibular border movements.

When the acrylic resin was set, the clutches were removed from the mouth. On the lathe wheel, one third of the border resin material of the patties was trimmed by stone wheel in a way that the cuts would be tapered away from the recorded area to avoid any contact with the maxillary clutch except its studs and central bearing screw in any intraoral movement during refining the studs' pathways. When the acrylic resin was set and the patient had completed the movements, the recording should have app-eared with four completely cleared Gothic arch forms. The recorded pathways were lubricated with petroleum jelly and the clutches were reinserted in the mouth. The patient was asked to refine the recording with the cutting studs until comfortably smooth protrusive, right, and left lateral movements were made (Fig.3).

Figure 3. Stereographic clutches after completion of the 3-dimensional recording.

Examining the recorded Gothic arch tracings on the mandibular clutch platform, pointed tracings indicated no sign of any ISS (Fig.4). On the other hand, the Gothic arch would have a flat shape instead of pointed indicating the presence of an ISS (Fig.5).

Figure 4 and 5: The recorded Gothic arch tracings on the mandibular clutch platform.

With both clutches inside the patient's mouth, the patient was guided to bite in terminal hinge position, i.e. in the points of each Gothic arch tracing, then a piece of soft impression compound was placed in the clutch notches and in between them. The clutches were then mounted on the TMJ articulator (Fig.6).

Figure 6: Upper and lower clutches mounted on the TMJ articulatorfor fossa molding.

The TMJ Instrument Manufacturing Co. has created five color-coded fossa ana-logs with curved paths in 5-degree protrusive variations (28, 35, 40, 45, 50°), (Fig. 7).

Figure 7: Premade color-coded fossa analogs.

In order to verify the fossa analog degree suitable for fossa molding of each full occlusal rehabilitation case, a protrusive inter-occlusal record was registered for each patient using Aluwax.

The mandibular cast was mounted to the maxillary cast, which was previously mounted on the upper articulator member according to the kinematic face-bow registration, using the terminal hinge centric inter-occlusal record.

In order to verify the protrusive angle of each patient to figure out the exact fossa analog degree which should be used for fossa molding for that case, two square shaped transparent hard plastic protractors having a scale ranging from (0-60°) were attached to the articulator outside each of its fossa compartment in such a way that the protractor was close to the condyle stylus. The condyle pin was located at the center of the protractor in the terminal hinge position (Fig.8).

Figure 8: The condyle pin located at the protractor center.

Placing the protrusive inter-occlusal record in position between the maxillary and mandibular casts, the angle of eminentia was observed by sighting the center of the condyle pin through the transparent protractor and the protrusive angle for each patient was recorded so that the exact fossa analog suitable for that case could be selected for fossa molding.

The thickness of each right and left selected premade fossa analog was measured with the vernier caliper (Buffalo Dental Mfg Co, USA) at the most posterior side of its temporal plate near its intersection with its rear wall (Fig.9).

Figure 9: Measuring the premade fossa analog.

Two prefabricated plastic fossa analogs selected by the above described technique were tightly secured in the TMJ articulator fossa compartment. The height of contour of the condyle ball was checked to fit into the fossa box. With the incisal pin of the articulator being removed, the recording studs were checked to follow their respective paths specially the anterior studs which shouldn't leave the recorded surface. TMJ resin was mixed and let to set up to dough stage then a small portion of it was placed inside each fossa box. The condyle balls were sprayed with the silicone release agent.

In order to mold the articulator fossae, the index finger of each operator's hand was placed on the posterior corner of the maxillary clutch and the thumbs on its lower anterior aspect. The other fingers grasped the mandibular attached clutch on the posterior border. Without touching the top member of the articulator, sufficient downward pressure was applied with the thumb and forefingers to assure continuous contact of the studs with the recording. The studs were drawn over the recordings in protrusive, right and left lateral border movements to form the fossae. Several passes over the recordings were made until the resin was set (Fig.10).

Figure 10: Fossa molding on the TMJ articulator.

The upper member of the articulator was detached in order to examine each fossa path (Fig.11).

Figure 11: Molded fossa analog formed the stereographic technique.

Excess acrylic resin was trimmed especially that which extended beyond the posterior wall of the fossa so that the upper member could arc back completely. The final refined fossae were ready for immediate side shift calculation (Fig.12).

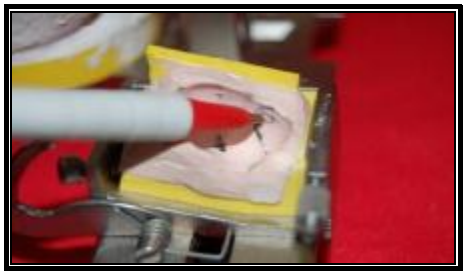

Figure 12: Pointing at the immediate side shift.

The molded fossa analogs were classified according to each patient. The Bennett ISSs verified by the stereographic system in the molded fossae were measured using the vernier caliper with an accuracy of $\pm$ 0.01 mm (Fig.13). The final right and left ISSs were verified by

subtracting the thickness of the blank fossa analog from that of the molded one.

The arithmetic mean values of all different records were computed and subjected to statistical analyses.

Figure 13: Measuring of mandibular immediate side shift.

RESULTS

Regarding the immediate side shift (ISS), Table (1) represents a higher mean average for males (1.68 mm) compared to the females (0.80 mm).

Table 1: Descriptive statistics of the (ISS) of females & males in mm.

Average ISS Groups	Mean	SD	Min.	Max.
Female	0.80	0.32380	0.18	1.43
Male	1.68	0.56275	0.90	2.75
Total	1.24	0.63520	0.18	2.75

The ANOVA test and Student's t-test (Tables2&3) revealed statistically high significant differences between the ISSs of malepatients compared to those of females.

Table 2: ANOVA test results of the (ISS).

Average ISS	SOS	Df	M.S.	F	Sig.
Between Groups	9.654	1	9.654	45.802	0.000 HS
Within Groups	10.117	48	0.211		
Total	19.770	49			

Table 3: Group Statistics (Student's t-test) results of the average (ISS).

Average ISS	Mean	SD	t-test	P-value	Sig.
Female	0.80	0.32	-6.768	0.000	HS
Male	1.68	0.56			

The left TMJs of females (0.84 mm) and males (1.76 mm) ISS group mean values were greater than the right ones (0.75 mm & 1.59 mm), while the means of males (1.68 mm) were higher than the females (0.80 mm) in general scoring a difference of 0.88 mm (Table 4). Mean ISSvalues of both sexes of left TMJs equaled to 1.30 mm while those of the right TMJs were 1.17 mm.

Table 4: Descriptive group mean values of right & left joints

ISS (mm)	Female			Male		
	Right	**Left**	**Mean**	**Right**	**Left**	**Mean**
	0.75	0.84	0.80	1.59	1.76	1.68

DISCUSSION

In this study, the amount of ISS has been found to vary among patients and bilaterally within them. The ANOVA and Student's t-tests revealed highly significant differences between the mean ISS of male patients compared to those of the female patients. Factors responsible for such variance in the mandibular ISS could be related to the hypertension of masticatory muscles and the strain of the TMJ area [22] in addition to the markedly variation of the sizes and shapes of regional muscle attachments among subjects and the different displacement patterns in specific muscles where the movements of each muscle part differs according to variations in the size and shape of insertion areas [23].

The presence of the ISS in all studied patients requiring full mouth rehabilitation has supported previous beliefs that the ISS is a result of adaptive morpho-functional changes in the fossae due to occlusal interferences and/or other forces applied to the joints.[1] Another responsible factor for the variation of ISS between patients could be the stretch in the ligaments of the articular capsule of the rotating (working) condyle being a consequence of the contraction of the medial pterygoid muscle on the orbiting side resulting in medial movement of the orbiting condyle, causing the rotating condyle to move out until the slack in its articular capsule is consumed.[8]

The results of this current study revealed that the mean ISS value of the female patients was 0.80 mm and was 1.68mm for the males which didn't coincide with those of Gibbs et al. [24] (0.40 mm) and Beardet al.[25] (0.36 mm) who found no differences between the female and male subjects with an increase in the ISS with age; such findings were different from the current study in which ISS differences existed between the sexes and no relevancy of ISS was correlated with the increase of age of the patients. On the other hand, it coincided with Roads et al. [8] conclusions that the ISS value is almost always less than 2.0 mm and with Solnit and Curnutte [1] observations that the side shift may vary from 0.2 mm to 2.5 mm condyle.

Bellanti and Martin [26] reported that only 13% of the examined subjects demonstrated voluntary ISS of more than 0.20 mm while in this study, 100% of the patients scored voluntary ISS values greater than 0.20 mm.This study results also didn't go along with their findings since only 30% of the subjects demonstrated an ISS of the mandible in their study. In addition, their subjects' ages ranged between 15 years to above 30 years (authors didn't mention the maximum age). On the contrary, the man-dibular ISS was present in all patients included in this study.

This increase in the range of ISS in this study compared to other studies could be explained that possibly through the years of mastication and parafunctional habits, a remodeling of condylar form, a stretching of temporomandibular ligaments or an incoordination of muscles could have accounted for it.[25]

In this study, the means of the left ISS of both female and male patients (0.84 & 1.76 mm) were greater than the means of the right ISS (0.75 & 1.59 mm). This finding supports the observations of Turp et al. [27] who related the observed discrepancy to a functional difference of the left and right inferior heads of the lateral pterygoid muscle. Other potential reasons for the observed discrepancy in the maximum lateral excur-sion are differences in the TMJ anatomy, the preferred side of mastication, and occlusal (mediotrusive) interferences**.** [27]

In this study, the mean ISS values of both sexes of the left condylar side (1.30 mm) were close to dos Santos and Ash [28] study values (1.08 mm) but the right side ISS mean values (1.17 mm) were significantly more than theirs (0.25 mm). The increased ISS (due to lack of occlusion) can't be assumed which may indicate that the ISS is more constant throughout life than previously believed and therefore, loss of occlusion as a suspected cause of variance in ISS was not substantiated [29].

Applying the functionally genera-ted path technique indicated that no intraoral occlusal adjustment would be necessary for the finished restorations since a precise reproduction of the dynamic jaw motion had led this system to possess the potential to improve the accuracy of the prosthetic teeth occlusion.[30] It was concluded that for patients with less than 0.75 mm ISS, chair side correction of the errors in the horizontal plane is possible, but for patients with an ISS greater than 2 mm, the error is clinically unacceptable and difficult to correct. For such reasons, articulators should have mech-anical equivalents to represent border movements because patients function to border positions during mastication and the need for incorporating ISS into articulator move-ments is essential [30].

Bellanti and Martin [26] concluded that some consideration must be given to the necessity of using an articulator system that would reproduce the occurrence of ISS within patients. They further reported that the presence of mandibular ISS increases the potential for working and nonworking side tooth contacts which poses a problem for the restorative dentist because of the difficulty of controlling occlusal contacts in dental restorations. The findings of this study strongly agree with such remarks.

Finally, the results of this study strongly support the importance of using a fully adjustable articulator system which can precisely record different mandibular border movements in restoring full mouth rehabilitation cases, especially when all the four quadrants are involved with or without abnormal deviation of the mandible so that crowns which a dentist has to grind excessively on, teeth that feel high, bridges that don't fit, can be avoided [31]. This became obvious in the finished full mouth rehabilitation cases of the involved patients in this study, since very minor intraoral occlusal adjustments were needed for the finished restorations.

The conclusions that cab be drawn from this study are:

1. Bennett mandibular ISS varied among patients and bilaterally within them and significant differences were present between the mean values of males and those of females with no relevancy to the increase in age.
2. Since all patients requiring full mouth rehabilitation treatment exhibited ISSs in this study, the necessity of an articulator which incorporates mechanical equivalents to represent mandibular border movements specially the ISS is one that can serve clinical purposes satisfactorily specially that minor intraoral occlusal adjustments were required for the finished restorations.
3. Verifying the mandibular ISS in the molded fossae is an important step to efficiently construct complicated prosthodontic cases.

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