Revista Odontológica Mexicana
Facultad de Odontología
Vol. 16, No. 2 ● April-June 2012
pp 80-87
ORIGINAL RESEARCH

Vestibular crown relief measurement in normal occlusion arches

Medición del relieve coronal vestibular en arcadas con oclusiones normales

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ABSTRACT

Masticatory system function is related , among other aspects, to occlusal configuration characteristics. Through the years, different occlusion concepts have been described until reaching the functional occlusion concepts that we nowadays use. Common characteristics of ideal or normal occlusion have been established. Nevertheless, in our days, several authors agree upon the concept that occlusal characteristics are specific to each individual. The aim of this study was to determine vestibular crown characteristics of both arches by means of dental crown rotation measurements . The study was conducted in a specific Mexican population not subjected to orthodontic treatment and considered normal. Dental crown rotation was measured in 110 models. Use was made of an appliance and an attachment which allowed measurement of dental surfaces with the aid of a laser beam. Results show a similar pattern in left and right side rotations of a same region (upper and lower jaw). All average rotations of lower teeth measured between -1° and 1°. Average rotation of upper jaw teeth ranged from -2° to 8.5°. In both upper and lower regions, central, lateral and canine teeth presented a negative average rotation; premolars and molars presented a positive average rotation. Upper and lower molars presented greater standard deviation. This study reached the conclusion that, due to variations observed in crown rotation, it is not appropriate to standardize its values to conduct orthodontic treatments. It is more convenient to use appliances individually tailored for each patient.

RESUMEN

La función del sistema masticatorio se encuentra relacionada entre otros aspectos con las características de la configuración oclusal. Se han descrito a través de los años diferentes concepciones de la oclusión, hasta llegar a los conceptos de oclusión funcional actualmente utilizados. Se han establecido características comunes de oclusiones consideradas ideales o normales, sin embargo en la actualidad diversos autores concluyen que las características oclusales son específicas de cada individuo. El objetivo de este estudio fue determinar el relieve coronal vestibular de ambas arcadas a través de la medición de la rotación de las coronas dentales presentes en una población mexicana sin tratamiento de ortodoncia con una oclusión considerada normal. En 110 modelos de estudio se midieron las rotaciones de las coronas dentales. Se utilizó un aparato y un aditamento que permiten la medición de superficies dentales empleando un rayo láser. Los resultados muestran un patrón similar en las rotaciones entre el lado derecho e izquierdo de una misma región (mandibular y maxilar). Todas las rotaciones promedio de los dientes de la mandíbula midieron entre -1° y 1°. En cambio, la rotación promedio de los dientes maxilares fluctuó entre -2° y 8.5°. En ambas regiones, el central, el lateral y el canino tuvieron una rotación promedio negativa a diferencia de los premolares y molares que presentaron una rotación promedio positiva. Los molares superiores e inferiores presentaron mayor desviación estándar. Se concluye que debido a la variación observada en la rotación coronal no es adecuado estandarizar sus valores para realizar los tratamientos de ortodoncia, por lo que la utilización de aparatología con prescripción individualizada es más conveniente.

Key words: Labial surface, crown rotation, normal occlusion, individually tailored treatment.
Palabras clave: Superficie labial, rotaciones coronales, oclusión normal, prescripción individualizada.

INTRODUCTION

Occlusion is the fundamental basis for Orthodontics, and, in general terms, of Dentistry as a whole. Obtaining adequate occlusion must be the treatment`s objective. All implications comprehended in obtaining a normal or ideal occlusion must be taken into consideration.[1]

In the course of the first attempts to describe occlusal configurations, Edward Angle[2] lists occlusal relations based on the position of the first molar; this method stirred great interest in the subject of occlu-

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sion. Many research projects were conducted with the aim of explaining the complexity of occlusion.

Current concepts of what constitutes normal or ideal occlusion are based on studies which include neuromuscular and morphologic aspects which have been found to influence the position of teeth in their arches. These are related to the functional stability of occlusion.[3]

Normal or ideal occlusion is related to the functioning of the Masticatory System, and this is related to many factors, among others, vestibular crown architecture of the arches which includes crown rotations. Andrews deems dental rotations as being the fourth key to occlusion, he mentions that in ideal occlusion there must be absence of crown rotations.[4,5]

In the course of his research he measured, within the scope of vestibular crown architecture, crown prominence and contour in upper and lower arches, and thus established their values. These values were used as a basis for bracket construction in his Straight Arch Appliance. Nevertheless, in spite of taking into consideration and granting great importance to crown rotations, he did not identify variations in angle values. He allotted them a constant value of 0° in relation to the vestibular crown architecture.[6]

Several authors, like Ricketts,[7] Alexander,[8] Bennet and McLaughlin[9] and Kesling[10] among several others, continued applying Andrews concepts in the development of different technique with pre-adjusted appliances, omitting variations in prescription values for crown rotation.

In the course of developing his philosophy, Dr Roth took into consideration variations in crown rotations. Therefore, within his system, bracket prescription included standardized average values.[11-13]

Several studies have reported varied anatomy in teeth. These dental crown morphology variations might affect the site of bracket placement, or even the exact expression of the prescription, which is reflected into first and third degree movements. This fact has been duly noted, and has led to the current question of whether it is convenient to place individually tailored brackets, specifically manufactured according to the anatomical characteristics and physiological circumstances of each individual.[14]

The aim of the present study was to measure dental crown rotation variability, within the bounds of vestibular crown architectural relief, in a particular Mexican population with normal or ideal occlusion, as well as to determine which factors like tooth, region or side, explain the aforementioned variability.

MATERIALS AND METHODS

The present observationally-oriented study was performed on 110 plaster dental casts, taken by students of the National School of Dentistry, National University of Mexico. Inclusion criteria were the following: patients had to be Mexican born from Mexican parents, of both genders (37 male and 73 females), age ranking from 18 to 25 years. With no prior prosthetic or orthodontic treatment and presenting occlusion considered normal (Angle`s Class I in molar and canines),

Figure 1. Appliance used for dental surface measurement with the aid of goniometers and laser beam (Patent 264310).

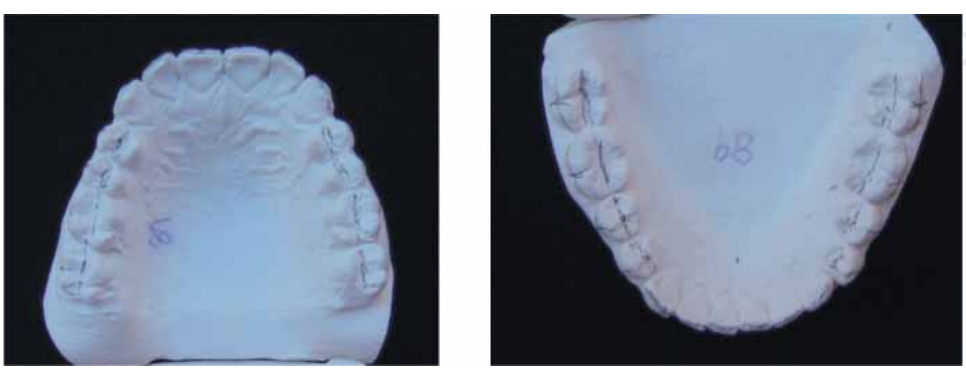

Figure 2. Drawing of groove and incisal ridge on every crown of study models.

1 to 2 mm horizontal overbite 1 to 3 mm vertical overbite, <1.5 crowding, as well as no clinical proof of temporomandibular articulation problems.

In all study models, clinical crown rotation of 28 teeth were measured; from central incisor to second molar, in both sides (right and left), in both regions (upper and lower jaw). A random procedure was observed to decide upon measurement sequence for the model, arch, side and tooth. One single, previously determined individual, performed all measurements.

Figure 3. Tracings of coordinates established by FACC and FAP.

Dental crown vestibular surfaces were measured to establish crown rotation. For this purpose, an appliance was used with a device designed to record measurements of a given surface of the dental crown vestibular side. Accurate measurement of the crown rotation was achieved with the assistance of a goniometer as well as laser beams. (Patent 264310) *(Figure 1)*.

To perform measurements, the incisal edge and groove or central pit of each crown were marked *(Figure 2)*.

At a later point, Edgewise 0.022 inch, 100 mesh. GAC International Inc NY USA standard brackets were placed on the dental crown vestibular side. Before bracket placement, in all dental crowns, a two reference coordinate designed by Andrews was drawn: the facial axis of the clinical crown (Facial Axis Clinical Crown, FACC) and its middle point, called Facial Axis Point (Facial Axis Point, FAP) *(Figure 3)*.

Brackets were adapted, and on the wings, a flat and thin lamina (0.02 mm thick) was glued in a parallel position to the base of the bracket. This device was used to record crown rotation *(Figure 4)*.

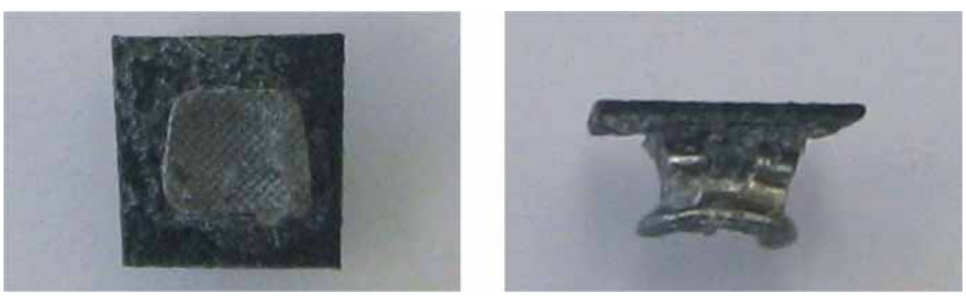

Figure 4. 0.2 mm lamina adapted to bracket wings.

Figure 5. Placement of bracket with respect to reference guides.

In all teeth, brackets were adhered to the crowns with silicon (GAC International, Inc, NY, USA). The guides of the aforementioned coordinates were used as reference *(Figure 5)*.

Before recording crown rotation the study models s occlusal plane was guided so as to rest in a position parallel to the horizontal plane.

To perform the aforementioned procedure, the measurement appliance used, included a device which allowed to hold the model in a base, and perform tri-dimensional movements, in such a way as to guide the occlusal plane in a parallel position to a laser beam which thus determined the horizontal plane *(Figure 6)*.

At a later point, another laser beam was projected on the groove or central pit of each posterior tooth to be measured. On anterior teeth it was projected on the incisal border. The measurement was superposed to the previously drawn line. At this position, the goniometer recorded 0 degrees *(Figure 7)*.

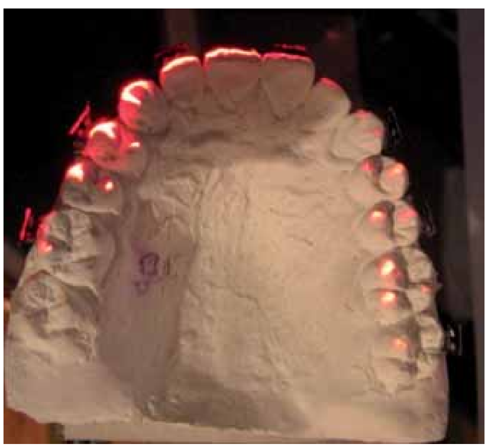

Figure 6. Occlusal plane guided in parallel position to the horizontal plane.

At a later point, the model slides and the laser beam were adjusted, so as to have the laser light fall upon the ridge of the lamina to the bracket wings. The laser beam reflected upon the graduated templates of the goniometers, which then recorded the crown rotation with respect to the anatomical architectural relief of the vestibular face.

Following this procedure, a recording was performed in a parallel surface to the base of the bracket, so as to accurately replicate the brackets cementing surface, and take into account relief variations of the crowns vestibular side. This technique takes into consideration the surface of bracket placement, not just a tangential point *(Figure 8)*.

STATISTICAL ANALYSIS

Data have a hierarchical or nested structure, since teeth are grouped into quadrants; quadrants are grouped into regions, and regions into bases. This led to the use of a nested or hierarchical model to describe variability in crown rotation. Dependant variable is the natural logarithm variance of each tooth`s crown rotation. It is calculated from 110 bases of ideal occlusion patients. Independent or explicative variables are the tooth, the side and the region.

Seven types of teeth were studied: central, lateral, first premolar, second premolar, first molar and second molar, in both sides (right and left) of the two regions (upper and lower jaw) in which the mouth is divided. Statistical analysis was performed with R (http:www.r-project.org/).

RESULTS

Figure 9 diagrams show similar patterns between left and right side of one region. Most teeth presented rotation of about 0°. First and second upper molars

Figure 7. Laser beam guided over occlusal groove of posterior teeth and incisal borders.

were an exception. Almost 80% and 75 % of the second upper molar right and left respectively were over 5°.

In a similar fashion, almost 62% and 69% of first molar rotations (left and right respectively) exceeded 5°. It was equally observed that upper first and second molars were teeth which presented greater rotation variability. Some lower molars showed values which exceeded 5°.

Lower canines showed a 1° or 2° rotation (58% right side, 54% left side).

Table I shows some summarized statistical data for crown rotation of the 28 studied teeth. Teeth in the lower jaw presented an average rotation which was lesser or equal to the respective upper tooth. In the lower jaw, all average rotations were found to be in the range of -1° and 1° values. Conversely, average rotation of upper teeth fluctuated between -2° and 8.5 values.

In both regions, centrals, laterals, and canines presented negative average rotation. Premolars and molars, presented positive average rotation.

According to standard deviation, variability observed in rotation was approximately 2° for all teeth, excepting molars. Standard deviation in upper molars was almost twice the value of that observed in lower teeth.

We adjusted a hierarchical model[15] which ignored the side where the teeth were placed, and only considered teeth nested in regions (upper or lower jaw). According to the adjusted determination coefficient, this model ex-

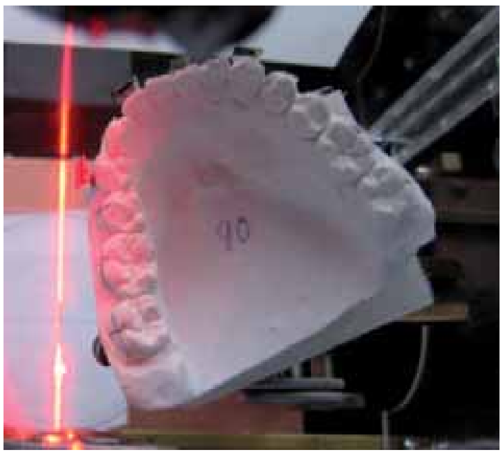

Figure 8. Rotation measurement: laser beam incidence over lamina adapted to bracket is observed. Projection over goniometers equally observed.

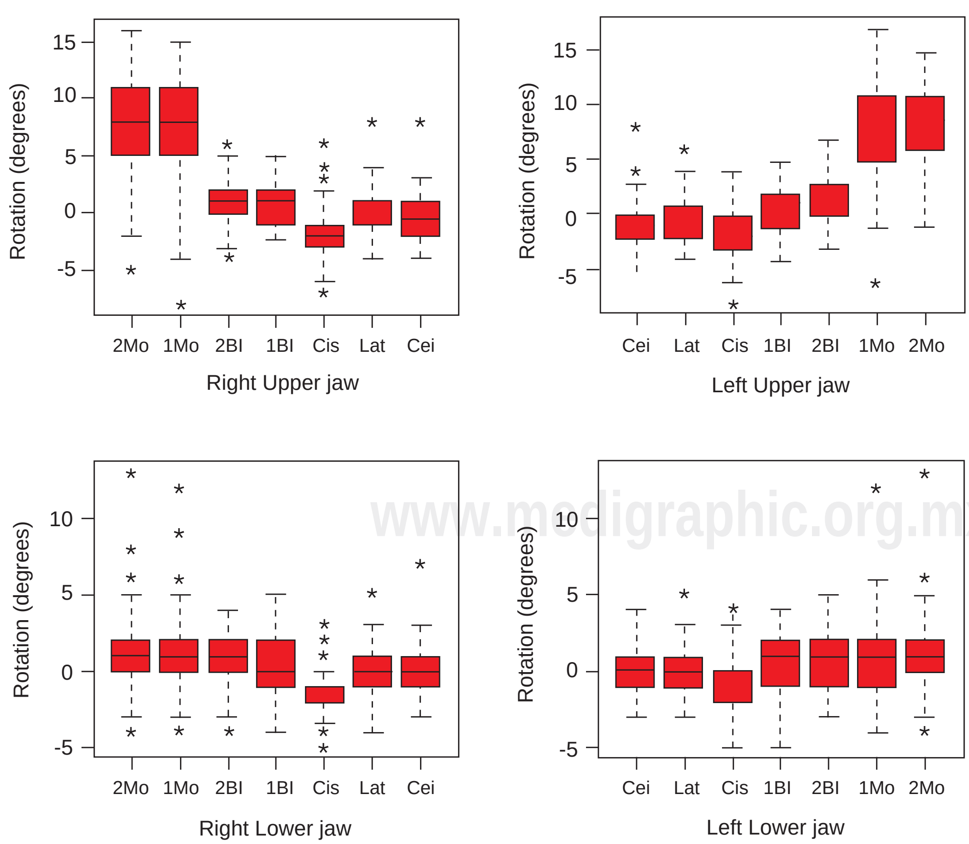

Figure 9. Boxed diagrams showing rotation pattern of right and left side of both arches.

plained 97.5% of total variation observed in the crown rotation variance natural logarithm. This model can be simplified when grouping teeth in the following fashion: group 1: lateral and central; group 2: canine; group 3 both premolars and group 4 both molars. When the hierarchical model is readjusted with these four groups of teeth, the result is an adjusted determination coefficient practically identical to that of the previous model: 97.6%. Estimated regression coefficients for this new model are shown in *table II*. The parameter reflecting the effect of the lower jaw is negative. This indicates that teeth in this region present a less variable rotation than teeth found in the upper jaw. Group 1, composed by central and lateral, was taken as the reference group. Parameters corresponding to the remaining three groups of teeth were positive. This indicated that group 1 was the one presenting more homogeneous (less variable) crown rotations among studied subjects.

The parameter corresponding to premolars in the upper jaw region was not significantly different from

Table I. Statistical summary (minimum, mean, standard deviation and maximum) of crown rotation measured in degrees in the 28 studied teeth. These statistics were calculated from 110 bases of a Mexican population with ideal occlusion (abbreviations: Cen = central, Lat = lateral, Cus = cuspid, 1Bi = first bicuspid, 2Bi = second biscuspid, 1Mo = first molar, 2Mo = second molar.

		Right							Left						
Region	Rotation	2Mo	1Mo	2Bi	1Bi	Cus	Lat	Cen	Cen	Lat	Cus	1Bi	2Bi	1Mo	2Mo
Upper	Minimum	-5	-8	-4	-2	-7	-4	-4	-5	-4	-8	-4	-3	-6	-1
	Mean	8.2	7.7	1.2	0.9	-1.6	-0.4	-0.4	-0.7	-0.4	-1.6	0.9	1.2	7.8	8.4
	Stand. Dev	4.2	4.3	1.8	1.7	2.4	1.8	1.7	1.9	1.9	2.2	1.9	2.1	4.2	4
	Maximum	16	15	6	5	6	8	8	8	6	4	5	7	17	15
Lower	Minimum	-4	-4	-4	-4	-5	-4	-3	-3	-3	-5	-5	-3	-4	-4
	Mean	1	0.9	0.7	0.5	-1.2	-0.3	-0.4	-0.1	-0.1	-1.1	0.5	0.7	0.8	1.0
	Stand. Dev.	2.4	2.3	1.7	1.9	1.7	1.4	1.4	1.4	1.5	1.9	1.7	1.7	2.2	2.3
	Maximum	13	12	4	5	3	5	3	4	5	4	4	5	12	13

Table II. Hierarchical estimated parameters describing variance logarithm of crown rotation variance based on region (upper or lower) and group to which teeth belong (group 1 lateral and canine, group 2 canine, group 3 both bicuspids group 4 both molars).

Parameter	Estimator	Std. Error	Std. W.	Sign. Level
Constant	1.21	0.05	24.09	< 0.0001
Region (Mandibular)	-0.47	0.07	-6.68	< 0.0001
Upper cuspid	0.45	0.09	5.21	< 0.0001
Lower cuspid	0.43	0.09	4.96	< 0.0001
Upper bicuspids	0.04	0.07	0.56	0.582
Lower Premolars	0.40	0.07	5.62	< 0.0001
Upper molars	1.65	0.07	23.39	< 0.0001
Lower molars	0.94	0.07	13.23	< 0.0001

Table III. Punctual estimator and interval at 95% confidence level for crown rotation standard deviation. Estimators were obtained from nested model which includes a independent variables the region (upper and lower) and the group to which the tooth belongs (group 1 lateral, group 2 cuspid, group 3 both bicuspids, group 4 both molars).[14]

Region	Group 1 Central & Lateral	Group 2 Cuspid	Group 3 Bicuspid	Group 4 Molar
Upper	1.8° (1.6, 2.0)	2.3° (2.0, 2.6)	1.9° (1.7, 2.1)	4.2° (3.7, 4.7)
Lower	1.4° (1.3, 1.6)	1.8° (1.6, 2.0)	1.8° (1.6, 2.0)	2.3° (2.0, 2.6)

cero ($p = 0.582$). As a consequence, this group of teeth presented rotations with similar variability to that observed in central and lateral teeth of the same region. The lower jaw canine had a 0.43 estimated regression coefficient. Premolars of this same region had a 0.40 estimated parameter. This then meant that premolars and canine of the lower jaw presented similar rotation variability.

These results can be clearly appreciated in *table III*, which contains punctual estimators and intervals at 95% confidence level, for standard deviation of crown rotation. Only upper molars presented rotation variability greater than ± 3°.

DISCUSSION

The fourth key to occlusion was considered to be the vestibular crown architecture determination performed by Andrews through measurements of crown contour and prominences as well as crown rotation. This showed the importance of vestibular crown architecture for location of teeth in the arches when performing orthodontic treatment, and therefore in the determination of bracket prescription. Andrews estimated crown rotation with 0° value for all teeth. He only measured crown contour and prominences with the aim of designing the shape and thickness of his brackets bases, establishing thus the arches` vestibular dental relief (architecture).[4-6] In the present study, dental crown rotation found in normal occlusion cases was measured. Results showed variability in values, that is to say, value was not always 0°.

We deem possible that results obtained in the present study were influenced by the measuring technique. In the present study, to perform crown rotation measurements, brackets bases were used, which represented the bracket`s placement surface. Therefore, one surface can take into consideration anatomical variations of the vestibular side architecture (relief). This differs from Andrews technique which uses as measurement reference a tangential point on the vestibular side . We therefore consider that standardizing crown rotation to 0° might not be the most appropriate procedure.[6]

On the other hand, crown rotation, in varied orthodontic techniques, has not been considered as important as crown angulation and inclination, with exception of Andrews and Roth which include crown rotation within their prescription values in a standardized manner for all populations.[11-13] Ricketts,[7] Alexander,[8] Bennet and McLaughlin,[9] Tip-Edge[10] (Kesling) do not mention crown rotation values in their prescriptions. In results obtained in the present study, there is variability in obtained values, therefore, the fact of taking into consideration the aforementioned variations could assume greater relevance in bracket prescription or programming.

Other studies[16,17] have also reported bone and dental anatomical variability in subjects of one predetermined population. This variability is responsible for the fact that functional occlusion of every individual is different from others, and consequently, the tendency of our results could be better explained. It is observed that there could be a possibility of an association between the anatomical architecture of a crown and its crown rotation value.[18,19]

CONCLUSIONS

Occlusal characteristics of one single ethnic group can present anatomical differences, which can in turn reflect into the architectural relief variations of dental crown vestibular side. Similarity in crown rotations of right and left side were found. Due to the variability in crown rotations, especially that observed in second molars, the use of standardized crown rotation values in orthodontic treatment is not recommended. Usage of appliances or individually prescribed orthodontic systems is deemed more convenient.

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