Measurement System of the Temporomandibulares Joint

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Abstract. Opening and closing the mouth is one of the most important biomechanical movements of the human being, being one of the first to be performed even before birth. This movement is accomplished by a set joint called the temporomandibular Joint (TMJ). Their dysfunction causes a number of problems always accompanied by pain, in which much of the world population have disorders in this system, requiring the search for treatment. Their dysfunction causes a number of problems always accompanied by pain, in which much of the world population have disorders in this system, requiring the search for treatment. In this way, this work contributes to varieties of knowledge, clarification and care of patients suffering from temporomandibular dysfunction (TMD), with its main objective, the construction of a device able to measure and diagnose abnormalities during biomechanical movement of the opening and closing the mouth, through a low cost imaging system and easy to handle.

Keywords: Temporomandibular joint (TMJ) · Image capture
Mandibular deviation · Biomechanics

1 Introduction

TMJ is an abbreviation used to refer to the temporomandibular joint. It is considered the most complex joint in the human body [1]. Its complexity is due to the fact that it is connected, that is, one is dependent on the other, both left and right moves at the same time to perform the opening and closing of the mouth [2], another factor that explains its complexity is that it performs two different types of movements, the rotation and the translation during this process [3].

She is involved in swallowing, chewing, breathing and speech. The opening movement and closing the mouth is accomplished by a set musculoskeletal joint-called stomatognathic system in which highlights the most complex joint in the human body, called a temporomandibular joint (TMJ) [4].

Although several previous studies, there is still in the middle scientific lack of globally accepted parameters for evaluation and treatment of pathologies of the TMJ, compromising the objectives of the treatment, which currently depends more on the

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therapist's experience than scientific evidence [4]. This work has as its main goal, building a capable equipment to measure and diagnose the temporo mandibular joint dysfunction (TMD) during the biomechanical movement of the opening and closing of the mouth, through an imaging system.

We used low-cost and easy handling equipment, compared to systems on the market today. The acquired images are processed by a specific software for this purpose, where the data are processed and modeled, providing motion in the frontal plane and the lateral jaw by analyzing its respective track the movement of laterality, protrusion and maximum amplitude of the opening and closing of mouth, providing millimeter measured data.

Developed a good precision equipment using a new noninvasive technique and rapid implementation that does not cause discomfort to the patient and provides the healthcare professional a tool to aid the diagnosis of structural dysfunction of the masticatory system and determine important data for guidance and treatment planning of possible pathologies of the temporomandibular joint.

2 Experimental Development

To obtain the ideal volunteer position, you must use an ergonomically adjustable device, and both opted for a dental chair that allows the following settings: Seat height; Back back; and headrest (Fig. 1). The adjustment of the headrest is formed by a vertical prey stainless steel rod on the back of the back and the apparatus fixation head, this shank has a double system hinges and a lock that moves to the head of the patient, for best fit your ergonomic position.

This system is arranged orthogonally in order to provide a fixed reference system for the guidance of a professional.

Fig. 1. Head restraint system.

Fig. 2. Support base.

2.1 Base of Support for Cameras

It is composed of metallic base supporting two aluminum bars allowing them to move in the vertical plane as required for the displacement of the shoot cameras (Fig. 2). This mechanical system allows manual positioning of the cameras in the three-dimensional shape space, allowing the professional to run the tests with ample opportunities in this position and individually for each patient.

2.2 Markers

To carry out the filming we used two types of markers, which after being idealized, were built to aid data collection.

2.3 Orthodontic Marker

The orthodontic marker (Fig. 3) was made of acrylic resin for a prosthetic dental arch where the volunteer was molded by a dentist. Through this mold was made a set of orthodontic appliance that is fixed in the anterior part of the lower dental arch and another in the upper. In this orthodontic appliance, a rigid steel wire 50 mm long and 1 mm in diameter and with a ball at its end red resin was stuck to facilitate their identification.

Fig. 3. Orthodontic marker (Color figure online)

Fig. 4. Adhesive marker

2.4 Adhesive Marker

The adhesive marker (Fig. 4) was made in a circular format with a diameter of 15 mm and an x mark to mark its center. These were used in order to facilitate data collection procedure. Five adhesives were used for each data collection, three used to collect the lateral plane, placed as follows:

The first was placed above the mandibular condyle, which serves as a fixed point of collection; the second was placed on the lower jaw angle serving as the first moving point of collection; and the third was placed in the anterior mandible angle serving as the second moving point of collection.

The latter two adhesives are used for shooting in the frontal plane, wherein: one was placed on the nasal base serving as a fixed point; and the other was placed in the mental protuberance of the jaw, serving as a moving point.

2.5 Filming System

The system for capturing images consists of two type webcam cameras, which are processed by two computers, one for the camera that captures the footage in the frontal plane and one for the camera that captures the images in the lateral plane, the signals obtained by cameras are sent as data processing system for display in the preview screen with the help of the TMJ program, specific to the data conversion, this program was developed in MATLAB.

The system allows an analysis of the dynamics of jaw movements.

2.6 System Calibration

When evaluating the results of measurements made by means of an image capture system, it is necessary to establish a calibration method that provides appropriate parameters for the recovery of the distances traveled by the point of interest in the movement of the investigation.

To perform an accurate measurement through the proposed system, it is necessary to have a standard so that the computer can turn an analogue measurement (mm), digital (pixel), where this transformation is called calibration.

The TMJ program has a tool that when you start the program, it opens a window that asks the first photo to be analyzed, this should have a scale that is possible to compare and convert this measure of scale in millimeters, with the measure of the computer screen in pixel. For this scale, a caliper was used with a stipulated measurement of 50 mm. By choosing the space between point A and B, we have the image size in pixels, which divided by the scale value know the value of pixel/mm, as this procedure all of the following steps are processed pixel to millimeters, this is only necessary to be done for the horizontal axis, since the program calculates the calibration of the vertical axis automatically. Calibration is done for each of the collections, and for all volunteers. Studies [5] claim that this type of calibration allows for a lower precision 1%. 140 data collection were obtained, being 40 for voluntário1 and 2, and 30 volunteers for 3 and 4. Among these samples, 20 samples were selected for voluntary 1 and 2, and 15 for collecting volunteer 3 and 4, amounting 60 collected analyzed.

2.7 Subjects Evaluated

This work does not aim at a statistical study, nor a case study refers only to the determination of the operation of the equipment. Therefore, we used four volunteers, three female and one male, aged 35–45 years with no history of previous pathology of any kind. All the volunteers agreed to the disclosure of your data and pictures.

3 Methodology Used

Description of the sequence of operations during the evaluation of the volunteer:

1. Adjust the chair as the volunteer biotype so that he continue with his usual posture, as if we change your posture, the chewing muscles will be influenced in the evaluation;
2. Adjust the locking device, the patient's head;
3. Place the markers at predetermined locations;
4. Move the camera to the most favorable position, front or sideways, the patient's face by adjusting the desired distance, and the focus of the image;
5. Coupled to the head unit fastener, the volunteer is instructed to make movements of openings and closures mouth 10 times, where these movements are filmed in the frontal plane, the webcam 1 (Fig. 6) and the lateral plane on webcam 2 through a Webcam own program, this data is sent to the computers. Figure 5 presents a volunteer able to conduct the evaluation after follow the sequence of operations described.

Fig. 5. Volunteer able to perform the evaluation.

Fig. 6. Determination of points above the frame.

6. Transformed the AVI footage, picture frame by frame, in jpeg format, for each opening movement and closing the mouth.
7. Using the TMJ program developed for this work, the following steps were taken: (a) System Calibration (b) determine the points of movement, frame by frame through the "mouse" computer (c) Create a numeric table of coordinates points marked transformed into "mm" through calibration (d) Generate graph of plotted points of trajectories.
8. Analyze the results and give expert advice.

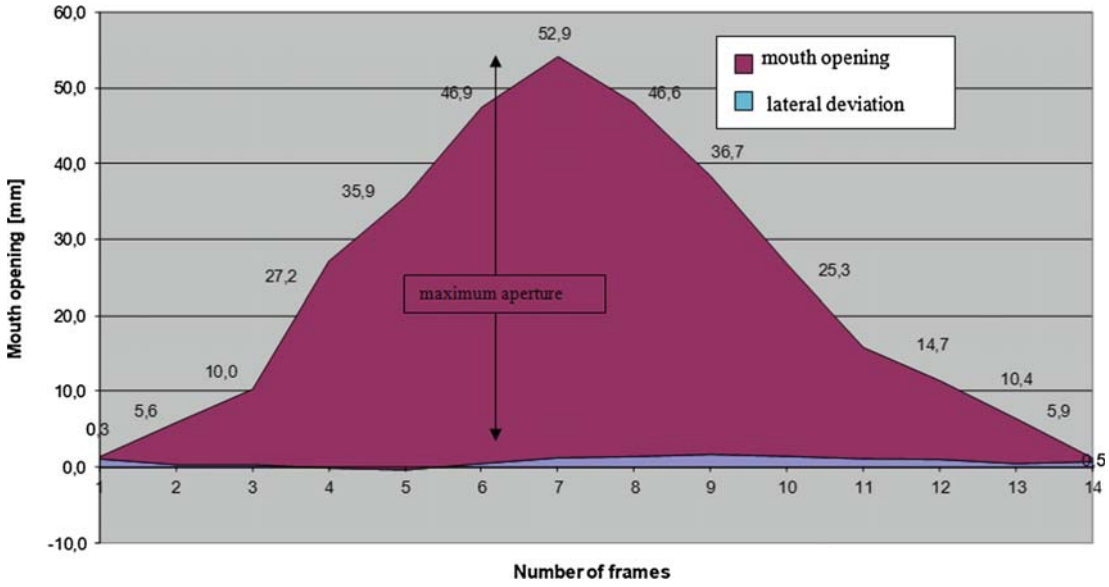

Fig. 7. Curve opening and closing movement of the mouth 4 of the volunteer.

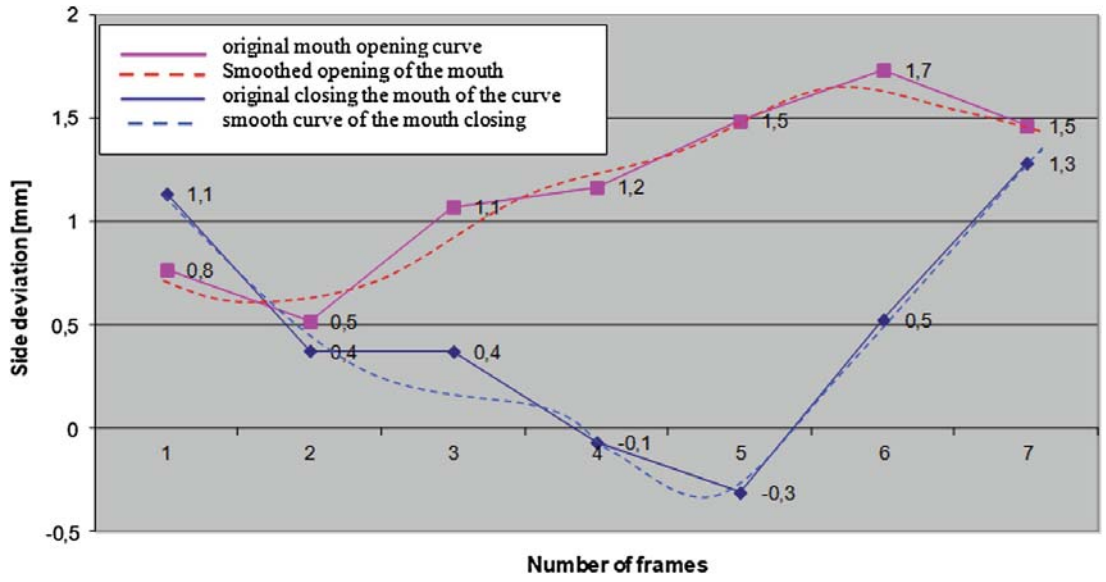

Fig. 8. Mandibular lateral deviation of the volunteer 4.

4 Results and Discussions

The results are shown in tables show the data collected and the mouth opening movement (AB) to the horizontal coordinate (x) and vertical (y) of four volunteers analyzed. For each volunteer were made five measured and calculated their average with the filming of the motion of: mouth opening in the frontal plane, opening and closing the frontal plane, opening and closing in a lateral plane, using this same sequence with the marker type apparatus orthodontic and then the adhesive for each volunteer was examined in which the efficiency of the orthodontic appliance type

marker and marker type adhesive for all volunteers, these values are shown in Table 1. These results can also be presented in graphic form, such as they can be seen in the example of Figs. 7 and 8.

Mandibular deviations were calculated for the maximum openings of the mouth and jaw protrusions.

Table 1. Results of volunteers.

Results of volunteers								
Marker Type	Abscissa (X) [mm] Lateral deviation				Ordinate (Y) [mm] Max opening			
Opening orthodontic marker	Vol1	Vol2	Vol3	Vol4	Vol 1	Vol 2	Vol 3	Vol 4
	3.0	5.1	2.3	0.8	34.3	46.3	49.3	50.1
Opening and closing orthodontic marker	2.6	5.1	2.3	0.8	35.0	46.5	49.5	50.0
Opening and closing adhesive marker	2.8	5.2	2.3	0.5	34.7	46.5	49.4	49.9
Opening and closing orthodontic marker protrusion	5.1	8.3	9.0	9.7	334.5	446.6	449.0	551.6

With respect to the mandibular lateral deviation to be have a normal joint is necessary for it to move on its axis perfectly without any lateral deviation, but is described as within normal deviations of less than 2 mm [6]. The results in Table 1 could interpreted observer for voluntary 1, the higher mandibular lateral deviation was 3.0 mm and less than 2.6 mm between evaluations, these values being outside the normal standards recommended, but the patient can be treated for the temporo-mandibular joint.

The difference, of all reviews for this volunteer was 0.4 mm, which is considered quite satisfactory for the error comparison between the marker and the orthodontic adhesive.

For voluntary 2, it is observed that the higher mandibular lateral deviation was 5.2 mm and less than 5.1 mm between the evaluations and these values outside the normal standards recommended, but the patient can be treated to temporomandibular joint. The difference, of all reviews for this volunteer was 0.1 mm, which is considered quite satisfactory.

For voluntary 3, it is observed that the higher mandibular lateral deviation was 2.3 mm and less than 2.3 mm between the evaluations and these values outside the normal standards recommended, but the patient also can be treated for ear-jaw articulation. There was no difference between the ratings for this voluntary and is considered ideal for both markers.

For volunteer 4, it is observed that the higher mandibular lateral deviation was 0.8 mm and the smallest of 0.5 mm between the evaluations and these values within the recommended levels normal. The difference, of all reviews for this volunteer was 0.3 mm, which is considered quite satisfactory.

In the evaluation of maximum opening mouth it is known that this limitation is also characterized as a basic criterion for diagnosing TMJ disorders. It is considered limiting mouth opening when in its final phase measuring less than 35 mm [7]. For normal limits the maximum opening range of 40 to 60 mm when measuring the incisal edges of the upper and lower teeth [8].

For voluntary 1, the minimum value was 34.3 mm, and a maximum of 35.0 mm, and the difference between them of 0.7 mm and this is quite satisfactory. For this patient the normal ranges corresponds to a decrease in mouth opening, thereby taking the treatment indication joint.

For voluntary 2, the minimum value was 46.3 mm, and a maximum of 46.6 mm, and the difference between them of 0.3 mm, which is quite satisfactory. For this patient the normal ranges corresponds to a reduction of mouth opening, thereby taking the treatment indication joint.

For voluntary 3, the minimum value was 49.0 mm, and a maximum of 49.5 mm, and the difference between them of 0.5 mm, which is quite satisfactory, These values are within normal standard.

To volunteer 4, the minimum value was 49.9 mm, and a maximum of 51.6 mm, and the difference between them of 1.7 mm, which is quite satisfactory. These values are within the normal pattern.

As regards the evaluation of the movement protrusion [9] found val-or maximum protrusive on average from 9 to 10 mm, [10] found higher values (10.7 mm) in children from 10 to 16 years old. Determining the maximum length of the protrusive movement in adults [11] found a value of 9.0 mm, considering the methodology with a millimeter ruler. There average of 9.28 mm, the protrusive movement and protrusive movement when considered restricted less than 5 mm [12].

In Table 1 the results are shown on the abscissa axis (X).

In one volunteer, the maximum protrusion of 5.1 mm was observed, that by the standards, this value is within the normal range.

For volunteer 2, the maximum protrusion observed was 8.3 mm, which by the standards is within normal limits.

For the volunteer 3, the maximum protrusion observed was 9.0 mm, which by normality values is within normal limits.

For volunteer 4, the observed maximum protrusion was 9.7 mm, that for the normal standards, this value is within the normal range.

5 Conclusions

The TMJ dysfunctions are generally used to refer to the pathophysiology of joint and between them stands out the deviations of the trajectory of the mandibular movement in the opening and closing of the mouth, as well as their joint locks and hypermobility of this joint, in which these movements characterize the principal object of study of this work.

The values obtained in the measurements carefully follow the same pattern, being the maximum difference between them is mostly smaller than 0.5 mm, which for this study, this figure shows a very satisfactory precision, demonstrating that the data were collected and processed correctly, but it must be borne in mind that these values are

identified as normal from studies of passive movements and compared with the data taken from active movements the value of normality can be considered even lower.

For the evaluation of mandibular movement, the data follow the same biomechanics of the standards described in the literature.

There were no significant differences between the use of markers like orthodontic appliance and the adhesive type, which proves that the use of adhesive on the skin does not suffer interference with the movement relative to the fixed marker in the bone of the dental arch.

Because of the facts presented it appears that the equipment developed using camcorders, is a very good method because it is simple and practical, non-invasive and very low cost, to show effective for what it is intended, which comes to meet your goal. Good results were obtained in a clear and with quite satisfactory precision, reinforcing its use in the day-to-day of the professional who does not have high quality measuring instruments.

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