Proposal of a formula mouth opening reduction assessment, for forensic purposes

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ABSTRACT

Objectives: To propose a formula for determining reduced mouth opening due to oral and maxillofacial trauma, based on the normal standard of the Brazilian population. Materials and Methods: First, the maximum mouth opening was established, in millimeters, using a digital pachymeter, in patients between 22 and 60 years of age. The opening was measured from the upper to the lower incisor, at maximum amplitude, without pain and overbite. Second, the facial profile type and height were determined. A formula was developed to calculate the percentage of reduced mouth opening based on the normal average. Results: The average mouth opening was found to be 51.71 mm in men and 47.94 mm in women, thus establishing a statistically significant difference in mouth opening between sexes. However, there was no statistically significant difference between age and profile type with mouth opening. The following formulas were developed to calculate the reduced mouth opening, based on the averages found, by using RA= [100-(A.1.93)].0.3 for males and RA= [100-(A.2,08)] .0.3 for female patients. Conclusion: Considering that mouth opening tends to be larger in men than in women, valid formulas can be used to determine the correct percentage of reduced mouth opening.

INTRODUCTION

The maximum mouth opening is formally considered as the interincisal distance without pain, plus an overbite [1]. Its amplitude can be modified by several factors, such as gender, height, age, and facial profile. [2-5]

Mandibular movements are complex and depend on the harmonious functioning of the structures that make up the stomatognathic system, namely the mandible, maxilla, temporomandibular joint, skull bones, hyoid bone, and musculature[6]. The face is the most commonly affected part of the body in cases of trauma because it is not protected. Lesions in this region can be highly devastating because of their physical and psychological consequences.[7,8]

The main causes of trauma in the oral and maxillofacial regions are traffic accidents, falls, and aggression. The most prevalent consequence is fractures of the mandibular region[9]. As a result, major detriments may include pain and clicks in the temporomandibular joint, facial asymmetry, change in occlusion, and limitation of mouth opening.[10]

The Brazilian civil code states that any injury caused by an unlawful act should be repaired, whether the damage is to

material or non-material property.[11] Damage to the bodily integrity must be reimbursed proportional to the injury caused to the victim, whether psychological or physical.[12]

Since the expert examination is subjective, the auto insurance for personal injury caused by motorized land vehicles (DPVAT), Brazil's federal regulatory body on private insurance issues, and the Portuguese table of disabilities for quantifying bodily harm are important elements for unifying language and criteria. The upshot is that the same situation can be assessed and understood in the same way by more than one expert.[13] In legal terms, a table of disabilities serves as a tool, listing diseases or sequelae that can be correlated to a value, normally expressed as a percentage.[14] For this reason, it is of utmost importance to know the standard of normality of the mouth opening of a population. This is so that any permanent consequences caused to the victim can be established.[2-5]

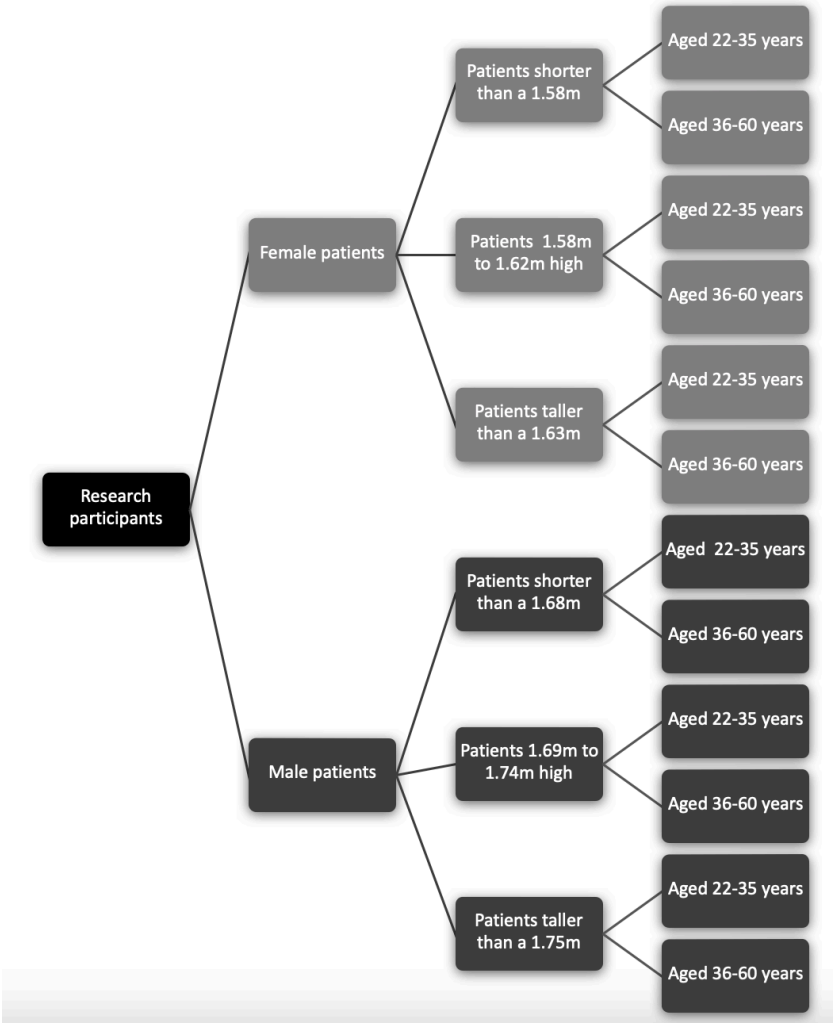
This study aimed to propose a formula for determining reduced mouth opening due to oral and maxillofacial trauma, based on the normal standard of the Brazilian population.

MATERIAL AND METHODS

This project was approved by the ethics committee of the School of Dentistry of the University of São Paulo (FOUSP), Protocol no. 59004816.7.0000.0075. Informed consent was obtained from all participants included in the study.

The participants selected included those in the range of 22 to 60 years of age, who had never suffered from trauma to the face, who were not in pain at the time of the research, and who had at least one upper and lower central tooth. All participants were selected from the waiting room of the emergency clinic run by FOUSP, whether patients or visitors, and were stratified according to sex, height, and age. The facial profile of all the participants was assessed but not paired (Fig. 1).

Figure 1. Sample distribution according to the variables analyzed



A questionnaire was administered for possible traumas involving the face and pain sensations at the time of the examination. The mouth opening was measured in millimeters using a digital pachymeter. The opening was measured from the upper to the lower incisor, at maximum amplitude without pain, plus overbite, as recommended by Machado et al.[15] The same instrument was used to measure the middle third and the lower third profile, to determine the facial profile at a later date, according to the study by Reis et al.[16] The patient's facial height was measured with a portable stadiometer, with him standing barefoot, with his head positioned so that the Frankfort plane was parallel to the ground, based on methodology by the Brazilian Institute of Geography and Statistics (IBGE). [17] A formula was developed based on the mean of normality to calculate the percentage of reduction in mouth opening.

This study was conducted by one examiner, and intra-examiner calibration was performed. The measurements were obtained at two different moments, and the kappa was calculated.

The results are tabulated in Excel®. An analysis was conducted to determine the statistical difference in mouth opening between sex, height, age, and facial profile. The student's *t*-test was used to perform the statistical analysis of sex and age. Whereas, the one-way ANOVA test was used to analyze the stature and facial profile. A significance level of 5% was considered.

RESULTS

The kappa agreement test result was adequate ($p > 0.9$).

A total of 486 participants enrolled in this study (286 women and 200 men). Table 1 shows the mean mouth opening, standard deviation, and confidence interval for the females and males studied, as well as the statistically significant difference in mouth opening between the sexes. The table shows that the range of mouth opening tended to be larger in men than in women.

Tables 2 and 3 show statistically significant differences in mouth opening between stature, age, and facial profile of the female and male participants, respectively. No significant relationship was found between mouth opening and the variables for both sexes.

Table 1. Mean difference mouth opening between women and men

Gender	N	Mean of the mouth opening (mm)	Standard deviation	P-value
Female	286	47.94	6.17	<0.001[*a]
Male	200	51.71	7.07	

*Statistically significant p≤0,05. [a] Student's t-test

Table 2. Mean difference of mouth opening with stature, age, and facial profile of female patients

Variable		N	Mean mouth opening (mm)	Standard deviation	P-Value
Stature	< 1.58	115	47.89	6.14	0.9152[b]
	1.59 – 1.62	81	48.17	6.08	
	> 1.63	90	47.79	6.34	
Age	18-35	128	47.98	6.17	0.9113[a]
	36-60	158	47.90	6.18	
Facial profile	Short Face	22	50.4	4.07	0.1332[b]
	Mean Face	145	47.89	6.27	
	Long Face	119	47.53	6.29	

*Statistically significant p≤0,05. [a] Student's t-test. [b] One-way ANOVA test

Table 3. Mean difference of mouth opening with stature, age, and facial profile of male patients

Variable		N	Mean mouth opening (mm)	Standard deviation	P-Value
Stature	< 1.68	53	50.45	7.57	0.638[b]
	1.69 – 1.74	66	51.52	7.01	
	> 1.75	81	52.69	6.72	
Age	18-35	82	52.07	7.17	0.547[a]
	36-60	118	51.45	7.01	
Facial profile	Short Face	4	47.97	12.15	0.4797[b]
	Mean Face	68	51.38	7.03	
	Long Face	128	52.00	6.93	

*Statistically significant p≤0,05. [a] Student's t-test. [b] One-way ANOVA test

The means found in the present study refer to the 100% normal mouth opening of the studied population. In cases of trauma, three calculations are required to determine the percentage reduction in the mouth opening of the victim. First, it is necessary to establish when the mouth opening remains normal. Subsequently, this value must be reduced by 100% to establish a reduction value. Lastly, this value must be multiplied by 0.3, because the European table determines that the total limitation of mouth opening corresponds to 30% of the corporal damage.

where "x" represents the mean mouth opening of the population to be assessed, "RA" means the reduction in mouth opening, and "A" refers to the mouth opening of the patient at the time of the expert examination, measured in mm.

For men:

$$RA = \frac{\left[100 - \left(\frac{A \,.\, 100}{x}\right)\right] \,.\, 30}{100}$$

$$RA = \frac{\left[100 - \left(\frac{A \,.\, 100}{51.71}\right)\right] \,.\, 30}{100}$$

$$RA = \left[100 - (A \,.\, 1.93)\right] \,.\, 0.3$$

For women:

$$RA = \frac{\left[100 - \left(\frac{A \,.\, 100}{x}\right)\right] \,.\, 30}{100}$$

$$RA = \frac{\left[100 - \left(\frac{A \,.\, 100}{47.94}\right)\right] \,.\, 30}{100}$$

$$RA = \left[100 - (A \,.\, 2.08)\right] \,.\, 0.3$$

DISCUSSION

Any change in the component structures of the temporomandibular joint may cause facial pain, articular noises, headaches in the cervical region, and limitation of mandibular movements.[18] However, the foremost step in determining mouth opening reduction involves defining what is normal and studying how some variables may interfere.[2]

The present study found a statistically significant difference in mouth opening between sexes. Thus, substantiating a major part of the research that assessed the normality of mouth opening, in which the correlation of this variable with gender became clearer.[2,3,5,19] In general, men tend to have a larger mouth opening than women. This is attributed to the difference in mandibular size and strength of the depressant jaw muscles, which are factors that favor a greater and maximal mouth opening in male patients. This is mostly owing to their larger structure and greater strength than women.[3,4] Accordingly, stature is usually studied less than gender. In a study by Sawair et al.[20], the authors found a positive correlation between height and mouth opening in adults. Rakaraddi et al.[5] related height with maximal mouth opening only in patients aged 11 to 25 years; at other ages, height was not found to be significant. This corroborates the findings of the present study, in which no statistical difference was observed in females or males aged 18 to 60 years.

The majority of authors who included age as a variable found a positive, inversely proportional correlation. In other words, as age increased, the range of mouth opening decreased.[1-3,20-23] This can be explained by the dehydration of joints and the reduction in muscle elasticity over the years.[2]

This decrease in mouth opening was observed in the present study, where an opening of 47.98 mm was observed for women aged 18 to 35 years, and a slightly smaller opening (47.90 mm) for women aged 36 to 60 years. Likewise, the opening for men was 52.07 mm and 51.45 mm, respectively. However, this reduction was not statistically significant, as corroborated by the studies by Casanova-Rosado et al.[4], Rakaraddi et al.[5], and Al-Dlaigan et al.[24].

No statistically significant difference was found with regards to facial profile, although the female patients with a short face in this study had a larger mouth opening. Whereas, short-faced male patients had a larger mouth opening in the facial profile. Likely, the variation is more closely related to mandibular growth than the facial profile.[25]

The importance of establishing maximum mouth opening in different populations should also be emphasized, as it differs from one population to another. This can be observed when comparing studies that analyzed mouth opening within the standards of normality.

Four of the six continents have studied mouth opening in relation to the standard of normality of their populations. In the African continent, Chima[1] examined individuals in Nigeria and found a mean mouth opening of 56.1 mm for men and 52.3 mm for women. In the European continent, the research developed in Ireland obtained a mean of 43 mm for men and 41 mm for women[22]. In contrast, the mean in Germany was 52.15 mm and 54.91 mm for male and female participants, respectively.[26]

Four countries were studied on the Asian continent, namely, India,[2] Saudi Arabia,[21] Jordan,[20] and Japan.[25] The results obtained for men and women were a mean mouth opening of 50.3 mm and 49.9 mm, 43.5 mm and 35.5 mm, 45.3 mm and 41.6 mm, 54.46 mm, and 46.9 mm, respectively.

On the American continent, Mexico[4] had a mean of 48.17 mm for men and 44.90 mm for women. Whereas the United States[27] had a mean of 47.4 mm and 50.7 mm, for male and female participants, respectively. In the present study reporting on the Brazilian population, the mean mouth opening was 51.71 mm for men and 47.94 mm for women. Given the disparity in the results, among not only continents but countries, it should be stressed that individualized studies are needed for each population, to determine the real maximum mouth opening.

Regarding personal injury, Ferrara et al. (2016)[28] elaborated the first "International Guidelines on Medico-Legal Methods of Ascertainment and Criteria of Evaluation of Personal Injury and Damage under Civil-Tort Law" which includes a detailed step-by-step personal injury ascertainment. Permanent damage is a frequent finding in cases of facial trauma, and legal claims for damage have increased over the years[29]. Personal injury ascertainment must be performed in the chronic phase once the injured area is healed or stabilised.[30]

Tables of disabilities were created to facilitate the valuation of bodily injury and to unify the language used by examination experts and magistrates to improve mutual understanding.[2,15]
Conceptually, when a table of disabilities is deemed appropriate, similar results should be produced when assessed by different experts. However, when analyzing the main tables used in Brazilian forensics, this has not been case.[2] The tables of disabilities should not be a compendium of all the pathologies or methods for assessing the damage. Instead, they should be minimally provisioned to assist the examination expert in quantifying an injury.[2,15,31] Because of the lack of detail regarding lesions in the stomatognathic system, the DPVAT[32] and SUSEP[33] tables of disabilities are insufficient to assess dental injuries.
The Portuguese table of permanent disabilities has a section just for lesions of the stomatognathic system, which correlates to a greater number of dental sequels.[12] Although this table is more convenient to use, it should be emphasized that it was created in Europe, making its application in Japan incompatible. When analyzing the sequel of the European mouth opening limitation, we noticed that it was assessed with a reduction of only 40 mm.
Real bodily injury is ideally determined by the current state minus the previous state.[14] The problem is evident when we realize that the dental care routine does not normally record a patient's mouth opening. Thus, making it difficult to identify the previous state.
When the previous state is not known by the expert, the definition of the mouth opening due to injury becomes subjective. However, it is extremely important to define the functional defect in an expert examination. Because of this, an attempt is made to turn what is subjective into something objective. To assess the compatibility of a mouth opening limitation due to injury, the previous state must be known; otherwise, the result will be questionable. Thus, the importance of knowing the standard of normality of a population remains unquestionable. Only in this way can a limitation be correctly determined.[2] Since the present study was conducted on the Brazilian population, the values of limited maximal mouth opening should be quantified from the resulting values.
It was suggested that the European table of disabilities be adapted to receive proper valuation by using a method of proportionality. In other words, by drawing up a formula. Although the means of normality of the mouth opening used in constructing the formulas were determined in this study, conducted in Brazil, it should be elucidated that the formulas ($RA = [100 - (A \,.\, 1.93)] \,.\, 0.3$ for males and $RA = [100 - (A \,.\, 2.08)] \,.\, 0.3$ for females) have limitations because they were developed from the means found in this study, corresponding to the population analyzed. However, by using the base formula $RA = \frac{\left[100 - \left(\frac{A \,.\, 100}{x}\right)\right] \,.\, 30}{100}$, a specific equation can be determined for each country by merely replacing the letter "x" with the mean of the mouth opening of the desired population.

CONCLUSIONS

The present study concluded that there is a significant difference in mouth opening associated with gender. Namely, the male participants tended to have a larger mouth opening than the female participants.
The table of disabilities of Portuguese legislation must be adapted to the Brazilian reality in order to enable the correct valuation of the mouth opening limitation, and indicates that the formula $RA = [100 - (A \,.\, 1.93)] \,.\, 0.3$ for male patients, and the formula $RA = [100 - (A \,.\, 2{,}08)] \,.\, 0.3$ for female patients was applied in Brazil. The formula used to determine the reduction in mouth opening in other populations was as follows:

$$RA = \frac{\left[100 - \left(\frac{A \,.\, 100}{x}\right)\right] \,.\, 30}{100}$$

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