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Orohanditest: A new method for orofacial damage assessment

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ABSTRACT

Background: Currently, orofacial sequelae are recognized as very influential on the quality-of-life for a victim of orofacial damage. Therefore, correct forensic assessment for indenisation purposes is mandatory. However, orofacial damage is frequently reduced to organic components, which results in a forensic assessment process, which are inadequate. This study aims to improve the orofacial damage assessment through the development of an auxiliary tool, the orohanditest.
Materials and Methods: A preliminary inventory was constructed, using relevant bibliographic elements and retrospective study of forensic examinations reports concerning orofacial trauma. This inventory was then utilized in the assessment of 265 orofacial trauma victims for validation. Validity was studied by analyzing the internal construct validity (exploring factorial validity and assessing internal consistency) and the external construct validity (assessing convergent validity and discriminant validity). The level of significance was defined as $P < 0.05$.
Results: The final inventory (orohanditest) was comprised of the three components of body (8 items), functions (10 items) and situations (24 items), which were found to be statistically reliable and valid for assessment. The final score (orofacial damage coefficient) reflects the orofacial damage severity.
Conclusion: Orohanditest provides a reliable, precise, and complete orofacial damage description and quantification. Therefore, this method can be useful as an auxiliary tool in the orofacial damage assessment process.

Key Words: Forensic dentistry, maxillofacial injuries, maxillofacial sequelae

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INTRODUCTION

Orofacial injuries are common[1-5] and several studies have reported that prevalence has increased in the past few years.[2,6-8] Regarding the aetiology of orofacial injuries, road accidents[9-13] and interpersonal violence[14-19] are the most common mechanisms of trauma, but these injuries can also occur as a result of seizures,[20] domestic accidents,[8,21,22] sports injuries,[2,5,23-25] work-related accidents,[2,26,27] and animal injuries,[9,28] as well as iatrogenic[29-31] or self-produced injuries,[32,33] which are rare. In Portugal, there is a similar prevalence of orofacial injuries in road accidents and inter-personal violence,[15,34] with the former producing more severe injuries. However, as road accident injuries are often life-threatening, even severe orofacial injuries may be regarded as minor and may rarely be correctly described in initial medical certificates. When physical damage is assessed for indenization purposes in these situations, orofacial sequelae are sometimes difficult to prove and the description and evaluation of these injuries is often neglected. Nevertheless, orofacial sequelae can be serious and disrupt some orofacial functions, impair social life, result in troubling relationships, or even adversely affect professional

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Figure 1: The body sequel in the temporomandibular joint (limited mouth opening) causes a functional impairment (pain and difficulties in opening the mouth) and both results in situational sequelae (cannot eat)

activity[34] [Figure 1]. Therefore, orofacial sequelae must be properly assessed from a three-dimensional perspective, considering the components of body, functions and life situations, in order to correctly assess road accident victims.

The aim of this study was to present a three-dimensional, validated methodology to assist in orofacial damage forensic assessment.

MATERIALS AND METHODS

For selection of items to include in the comprehensive inventory, PubMed was used to perform a computerized literature search for publications on orofacial injuries and their consequences published in the last 10 years in English. The medical subject headings of "orofacial injuries," "maxillofacial injuries," "oral injuries," "orofacial sequelae," "maxillofacial sequelae," "oral sequelae," "orofacial functions," "maxillofacial functions" and "oral functions" were used in this search. The inclusion criteria included availability of the full-text article, format as a review article, written in the English language, publication in the last 10 years and limited to humans.

With the same purpose, a retrospective analysis of the final reports of forensic examinations was performed in the North Branch of the National Institute of Legal Medicine. The inclusion criteria included that the document be a road accident final report with a conclusion date between January 1998 and December 2002 and that the document refer to orofacial trauma and be written with expertise in common law.

Finally, an analysis of reports from the Faculty of Dental Medicine of University of Porto on orofacial trauma victims that were written between November 2002 and July 2003 was also performed.

This study was conducted according with the ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration of 1975 as revised in 1983; it was also approved by the Faculty of Dental Medicine of University of Porto ethics committee and the subjects who participated in this study had signed the informed consent form.

Selected publications and reports were reviewed and analyzed according to the nature of consequences associated with the orofacial injuries. These consequences or sequelae, were assessed for body, functional and situational impact as previously described in the "Bodily Damage Assessment Inventory".[35]

A first inventory was constructed with the selected items and utilized in the orofacial damage assessment of 265 patients, which were sent from the North Branch of the National Institute of Legal Medicine to the Faculty of Dental Medicine of University of Porto between July 2003 and January 2007. Items were assessed using ordinal injury scales [Table 1].

Prior to the validation studies, a final item selection step was undertaken for functional and situational items only as all body items, except those that scored 0, were considered to be of the utmost importance, due to the descriptive nature of forensic assessment. The following rules were followed for functional and situational item selection:

a. Items that scored 0 (not present in any participant) were excluded.
b. Items of low relationship ($r < 0.2$) with the final grade, as analyzed using the Spearman's rank correlation coefficient (rho), were excluded.
c. Factor analysis with varimax factor rotation was applied and loadings inferior to 0.5 were excluded.
d. The reliability of both scales was verified using Cronbach's alpha coefficient; items that scored

Table 1: Sequelae scales

Body level	Capacities and situational level
0 — Without sequelae	0 — Without difficulties
1 — Minimal sequelae	1 — Minimal difficulties (pain, discomfort)
2 — Medium sequelae	2 — Medium difficulties (technical or pharmacologic aid needed)
3 — Important sequelae	3 — Serious difficulties (some human aided needed)
4 — Very important sequelae	4 — Impossible or total human aid (replacement)

less than 0.7 or caused a higher final alpha were removed.

The assessment of intra- and inter-observer reliability was checked using the kappa test. Validity was studied by analyzing the following:[36]

1. The internal construct validity
   a. Exploring factorial validity: The suitability of the data for factor analysis was verified using the Bartlett's test of sphericity (which should be significant — $P > 0.5$) and the Keiser-Meyer-Olkin measure of sampling adequacy (which should score 0.6 as a minimum value for a good factor analysis). Factor extraction was then performed. Factors were retained following Kaiser's criteria (eigenvalue of 1.0 or more) and a scree plot analysis. Factor interpretation was performed after varimax rotation.
   b. Assessing internal consistency: Items that scored less than 0.7 or caused a higher final alpha were removed, as indicated by the Cronbach's alpha test. Mean inter-item correlation within each factor was calculated using Spearman's rho and analyzed considering Briggs and Cheek's recommendations[37] (optimal range of inter-item correlation of 0.2-0.4).
2. The external construct validity
   a. Convergent validity: The relationship between the final score for each level and orofacial disability was assessed using Spearman's rho (calculated using Le Concours medical)[38]
   b. Discriminant validity: Investigated by verifying if factors scored different grades under varying global scores; each sample was divided into extreme groups and the U or Mann-Whitney test was used to assess the difference.

Final results were analyzed and the functional and situational final grades were converted into a grade ranging from 0 to 4. These grades were added to the highest score obtained at the body level and divided by three to yield the orofacial damage coefficient.

RESULTS

The computerized literature search using the PubMed yielded 207 publications. The retrospective analysis of forensic examination final reports (n = 693) for road accidents resulted in 108 usable reports. In total, 70 reports from the faculty of Dental Medicine of University of Porto were analyzed. As such, preliminary items related to the three components could be defined as followed:

a. The body level was comprised of 9 items that were defined according to the quoted anatomic location in the selected publications and forensic reports: Teeth and periodontal tissue, oral mucosa, upper and lower lip, tongue, soft oral tissues (including blood vessels and nerves), facial bones, mandibles, temporomandibular joint as well as salivary glands and ducts.
b. The functions level was comprised of 16 items that were selected from quotation in the studied publications and forensic reports: Chewing, swallowing, vomiting, digestion, perception of stimuli, word articulation, facial mimic capabilities, sense of taste, analysis of mouth content, maintaining content inside the mouth, spiting, gripping teeth, gripping with lips, breathing, velopharyngeal competence and blowing.
c. The life situation level was comprised of 28 items that were chosen as described previously: Eating, drinking, performing oral hygiene, retaining a prosthetic device, undergoing implant placement, having dental treatment, biting (self-defence), biting nails, chewing gum, licking ice cream, smoking, speaking, smiling and laughing, using a telephone, making a speech, diving, playing an instrument, singing, whistling, using a computer (instead of hands), eating in workplace/school, relating in workplace/school, having a meal in public, relating with husband/wife/companion, relating with family, relating socially, kissing, as well as having sexual and love life.

After final selection of these items, salivary glands and ducts was excluded from the body sequelae, since this item was not a site of sequelae in any of the studied victims. All other body items were considered essential to a correct medico-legal assessment. For the 16 initial items at the functional sequelae level, the following 6 items were excluded:

a. Spitting, vomiting, digestion and breathing were excluded, since these did not apply to any victims.
b. Velopharyngeal competence and blowing were excluded, since Spearman's rho demonstrated a weak correlation of these items with the global score ($r < 0.2$, $P = 0.023$ and $P = 0.007$, respectively).
c. Factorial analysis did not result in the exclusion of any item, since all analysed items presented significant loadings (>0.5).
d. Reliability was verified using Cronbach's alpha coefficient and no item was removed, since every item scored over 0.7.

In the situational sequelae level of 28 initial items, the following 4 items were excluded:

a. Using a computer, using a phone and diving, since these items did not apply to any victim.
b. Having dental treatment was excluded, since Spearman's rho demonstrated a weak correlation of this item with the global score ($r < 0.2$, $P = 0.0001$).
c. Factorial analysis after varimax rotation demonstrated that 3 items (retaining a prosthetic device, chewing gum and relating with co-workers, colleagues) had no significant loadings (0.463, 0.416 and 0.469, respectively); however, these items were kept in the analysis, since all were well-defined in a component factor.
d. Reliability was checked using Cronbach's alpha coefficient and no item was removed, since every item scored over 0.7.

Reliability of intra- and inter-observer was confirmed for the three scales (Kappa > 0.81).

Owing to the special characteristics of the medico-legal examination process at the body sequelae level, validation of each item at this level was described in a single dimension (the orofacial area that the sequelae occurs). Therefore, only the Spearman's rho of the body sequelae level score with the orofacial disability was studied. These results indicated a strong correlation ($r = 0.558$, $P < 0.001$).

For the functional and situational sequelae levels, the overall validity was confirmed by analysis of the factorial validity. Internal consistency was verified using Cronbach's alpha, resulting in a good correlation of scale items ($\alpha = 0.611$ for the functional scale and $\alpha = 0.567$, for the situational scale). The correlations of item at each level for each factor and between factors were also studied, since the Cronbach's alpha coefficient was determined to be good rather than great. The results obtained did correspond to the Briggs and Cheek recommendations,[37] which indicate that the optimal correlation value should be between 0.2 and 0.4.

Convergent validity was confirmed with a high Spearman's rho between the scores at the functional and situational levels and orofacial disability ($r = 0.660$, $P < 0.001$ and $r = 0.534$, $P < 0.001$).

Discriminant validity was also confirmed with the U or Mann-Whitney test, which demonstrated a good differentiation in extreme groups ($P < 0.009$).

The final orohanditest consisted of 42 items [Table 2], with each graded from 0 to 4, resulting in an orohanditest final score that varied from 0 to 168. Since the scores of the Tables of Permanent Disability used to assess physical damage in Europe vary between 0 and 100, an orohandistest final grade can be transformed using this formula:

$$\frac{\text{Orohanditest final grade} \times 100}{168}$$

Finally, orofacial damage severity can be easily comprehended using the orofacial damage coefficient. As in the procedure adopted by Magalhães,[35] a 0-5 final grade was created to represent the severity of the orofacial damage suffered. Therefore, the body sequelae scale score is represented by the highest item score obtained. Functional and situational sequelae scores were calculated by adding the scores of each item and dividing by the total scale item number (10 for the functional scale and 24 for the situational scale). Then, all final scores were added and divided by three, resulting in a number that represents the orofacial damage coefficient.

DISCUSSION

Orofacial damage can be defined as the consequence of orofacial injuries. Traditionally, these consequences have been strictly evaluated based on organic components. In fact, though many classifications have been proposed for assess dental traumatic injuries,[1,39-41] most of them focus on classifying traumatic dental injuries on the basis of etiology, anatomy, pathology, therapeutic considerations and degree of severity. For instances, the first classification, we have found dates from 1936 and was proposed by Brauer (Loomba *et al.*[1]) and classified only anterior tooth fractures. Ellis, in 1961,[40] proposed a classification

Table 2: Final orohanditest

Body sequelae level	Prior					After				
	0	1	2	3	4	0	1	2	3	4
Teeth and periodontal tissues		1					2			
Oral mucosa		3					4			
Lips		5					6			
Tongue		7					8			
Soft orofacial tissues		9					10			
Facial bones		11					12			
Mandible		13					14			
Temporomandibular joint		15					16			
Functional sequelae level										
Chewing		19					20			
Swallowing		21					22			
Analyzing mouth content		27					28			
Sense of taste		29					30			
Perception of stimuli		31					32			
Maintaining oral content inside mouth		33					34			
Articulating words		35					36			
Performing facial mimic		37					38			
Gripping with teeth		39					40			
Gripping with lips		41					42			
Situational sequelae level										
Eating		47					48			
Drinking		49					50			
Retaining a prosthetic device		51					52			
Performing oral hygiene		53					54			
Undergoing implant placement		57					58			
Biting (self-defense)		59					60			
Biting nails		61					62			
Chewing gum		63					64			
Licking ice cream		65					66			
Speaking		67					68			
Whistling		69					70			
Smoking		71					72			
Having a meal in public		81					82			
Making a speech		83					84			
Smiling and laughing		85					86			
Singing		89					90			
Playing a musical instrument		91					92			
Relating socially		93					94			
Relating with family		95					96			
Relating with husband/ wife/companion		97					98			
Kissing		99					100			
Having sexual and love life		101					102			
Eating in workplace/school		103					104			
Relating in workplace/school		105					106			

in six groups: Enamel fracture, dentin fracture, crown fracture with pulp exposure, root fracture, tooth luxation and tooth intrusion. This classification, still used nowadays,[42] only addresses the body injury. The García-Godoy classification[43] dates from 1981, but it still is widely used[44,45] and is a classification that again, is based in the organic component of the injury. The same happens with the Berman *et al*.[39] classification, that divides tooth injuries in three groups: Crown fractures, root fractures and luxation injuries. Another classification is proposed by Loomba *et al*.,[1] and they also underline the organic component, proposing a tooth fracture classification based on the treatment needed. Heithersay and Moule[41] gave a classification of subgingival fractures in relation with various horizontal planes of the periodontum and thus, referring mainly to the body injury. The most known and probably most used classification is the one proposed by Andreasen,[46] who modified the previous world health organization classification.[47] A study on dental trauma classifications showed that among the 54 distinct classification systems identified Andreasen classification was selected in 32% of the papers studied.[42] Guyonnet and Soulet[48] underlined the necessity of orofacial damage assessment, but only indicated that a detailed organic sequelae examination was required. Muller *et al*.,[49] Christophersen *et al*.,[50] and Parguel *et al*.[51] have all have studied body orofacial sequelae in children, but none of the resulting studies refer to potential non-physical outcomes, specifically the effects on social consequences or ability to learn. Garbin *et al*.[14] studied the types of traumatic dental injuries in situations of domestic violence, not referring the potential functional and social impairment that these injuries can cause. Similarly, many epidemiological studies[2,20,23-25,52-59] reduce orofacial sequelae to the associated organic component. Other authors present classifications that focus on the injury treatment[46,60,61] or in the association between dental injuries and global injury severity.[61]

However, orofacial damage has several dimensions in regards to the body, functional and situational impact, which has been acknowledged by several authors. For instance, Porrit *et al*.[62] investigated a variety of clinical and demographic factors that may influence the quality of life impacts experienced by children after a dental injury and stated that functional limitations and school-related activities impairment could happen following dental injury. Fanghänel and Gedrange[63] addressed some orofacial functions, describing a dimension beyond organic characterization. Eriksen and Dimitrov[64] described orofacial functions, such as chewing and breathing and have also approached the social dimension of orofacial damage dimension. For instance, the consequences of orofacial damage could result

in a person that does not eat in restaurants due to teeth-related problems. Chan *et al*.[65] recognized that orofacial trauma can have social and economic impacts with regard to the treatment required.

However, none of these previously published studies are clinical or epidemiological investigations, which refer to orofacial damage in a non-forensic perspective. In fact, only a few references could be obtained that include a forensic context for the three orofacial damage dimensions in Système d'Identification et de mesure des handicaps,[66] which further justifies the need for further investigations in this area. With orohanditest, orofacial sequelae are assessed in a three-dimension way, reflecting the true impact they have in the victim's life.

In this study, orofacial injuries due to road accidents were chosen for analysis due to the importance of this etiologic factor in orofacial trauma. In fact, several other studies report that road accidents,[9,58,59,67] together with the interpersonal violence[16,17] are the main etiologic factors for orofacial trauma. Both causes were previously studied by our group in Portugal,[34,68] and we found that these etiologic factors have a similar rate of incidence (15.8% and 11.6%, respectively). However, road accident injuries produced more severe orofacial sequelae.

Regarding the population studied, victims that were less than 14-year-old were excluded due to the specificity of orofacial sequelae at younger ages. Specifically, the coexistence of two dentitions and the natural growth process occurs at these ages.

Furthermore, some items were excluded regarding more severe sequelae, such as breathing or vomiting. The presence of such rare sequelae justifies another medical-legal approach, one that is outside the scope of orohanditest. In fact, this assessment should be made through a more detailed and meticulous description as for severe handicaps.

The orohanditest can be safely used, since this method has already been validated. In fact, Brace *et al*.[69] stated that the most important considerations in such assessments are external and internal construct validity, even without definitive markers of validation. The orohanditest obtained appropriate results in both cases, which accounts for the safe utilization of this metric in orofacial damage assessment.

The orohanditest has been compiled to respond to the increasing demand for forensic evaluation and to meet the primary goal of physical damage assessment to provide the victim with the means to obtain a situation that is similar to conditions prior to injuries. The orohanditest is comprised of several items that are divided into three scales, which prevents the reduction of orofacial damage to the body component alone, allowing for a global and personalized evaluation of all damages suffered. However, the orohanditest was not developed to be utilized as a single methodology, but as an additional tool in the whole physical damage assessment process that is based on detailed descriptions of all sequelae. The orohanditest can be utilized during an examination to enhance damage description and promote a more reliable, precise and complete orofacial damage assessment process.

In addition, the orohanditest can also be useful in orofacial damage quantification. Most Tables of Permanent Disability currently in use focus on the orofacial damage body component; however, the orohanditest considers all three levels and the final score can be converted to a value in the range of 0-100, which contributes to methodology harmonization and enables easy interpretation of data.

Our goal is to better assess orofacial trauma victims. The orohanditest is a useful tool for this purpose that provides:

a. A personalized, uniform, sequential and detailed description of orofacial sequelae.
b. A three-dimensional orofacial damage assessment, resulting in a global and personalized orofacial damage description.
c. Utilization of simple and ordinal five-point severity scales with few categories, which allows for easier usage with clear distinctions for objective quantification.

The current methodology was also validated due to the inclusion of the following:

a. Intra- and inter-examination reliability.
b. Construct validity (factorial validity and internal consistency).
c. External validity (convergent validity and discriminant validity).

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