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ORIGINAL ARTICLE / ARAŞTIRMA MAKALESİ

Assessment of Occlusal Force by Occlusal Contact Surface Area and Intensity from Cast Images: A Preliminary Study

Oklüzal Kuvvetin Oklüzal Temas Yüzey Alanı ve Yoğunluk ile Değerlendirilmesi: Ön Çalışma

Burcu BAL

ABSTRACT

Objectives: This study explores the use of occlusal contact surface area and intensity measures in assessing the occlusal force from articulating paper-induced dental images.

Materials and Methods: A pair of mandibular and maxillary dental casts obtained from a mandibular and maxillary complete denture fabricated in preclinical work was used. A 8-micron red articulating paper was inserted between the casts while they were mounted on an articulator. The occlusal force was implemented by applying 0.5 kg, and 5.0 kg weights to the articulator. The application was repeated ten times for each weight and the occlusal surface of the lower first molar tooth was imaged using a microscope from a fixed distance for each time. The images were analyzed first to identify the red-colored pixels and then to estimate the contact surface area and intensity from the pixels identified.

Results: The 0.5kg and 5kg forces lead to average contact surface areas of 1.6± 1.2 mm^2 and 13.4± 7.1 mm^2 while they deliver average contact intensity of 78.4 ± 2.8%, and 81.5 ± 1.9%, respectively. The average of contact area and contact intensity was statistically significantly higher in the 5 kg force group than in the 0.5 kg force group ($p< 0.05$).

Conclusion: Contact surface area and intensity measures offer potential estimates of the occlusal force. Fully automated methods for this purpose are needed to be developed.

Keywords: Occlusal force, Occlusal contact area, Articulating paper

ÖZ

Amaç: Bu çalışmanın amacı, artikülasyon kağıdı ile tespit edilen oklüzal temas yüzey alanı ve oklüzal temas yoğunluk ölçümlerinin oklüzal kuvvetin değerlendirilmesinde kullanılmasıdır.

Gereç ve Yöntemler: Preklinikte üretilmiş alt ve üst çene tam protezden elde edilen bir çift alt ve üst çene alçı modeli kullanıldı. Modeller artikülatöre bağlandı, modeller arasına 8 mikronluk kırmızı bir artikülasyon kağıdı yerleştirildi. Artikülatör üzerine 0,5 kg ve 5,0 kg ağırlıklar konarak oklüzal kuvvet uygulandı. Uygulama her ağırlık için on kez tekrarlandı ve alt birinci molar dişin oklüzal yüzeyi her seferinde sabit bir mesafeden mikroskop kullanılarak görüntülendi. Görüntüler önce kırmızı renkli pikselleri belirlemek için analiz edildi ve ardından tanımlanan piksellerden temas yüzey alanı ve yoğunluğu saptandı.

Bulgular: 0,5 kg ve 5 kg kuvvetler, sırasıyla 1,6 ± 1,2 mm^2 ve 13,4 ± 7,1 mm^2'lik ortalama temas yüzey alanlarına yol açarken, ortalama temas yoğunluğu %78,4 ± 2,8 ve %81,5 ± %1,9'dur. 5 kg kuvvet uygulanan grubun temas yüzey alanı ve yüzey yoğunluğu ortalaması, 0.5 kg kuvvet uygulanan gruptan istatistiksel olarak anlamlı düzeyde yüksektir ($p< 0.05$).

Sonuç: Temas yüzey alanı ve yoğunluk ölçümleri, oklüzal kuvvetin tahmininde kullanılabilir ancak bu konuda daha kapsamlı yöntemlerin geliştirilmesi gerekmektedir.

Anahtar Kelimeler: Oklüzal kuvvet, Oklüzal temas alanı, Artikülasyon kağıdı

INTRODUCTION

During functional (chewing) and parafunctional (e.g. bruxism) movements, mechanical load is applied onto the occlusal surfaces of teeth. Stress caused by mechanical loading on the dental and periodontal tissues modulates the masticatory function which is determined by the number of occlusal contact surfaces and the occlusal force (Flores-Orozco et al., 2016; Owens et al., 2002; Lujan-Climent et al., 2008; Lepley et al., 2011). The most common method for detecting the contact points between the maxillary and mandibular teeth and determining excessive forces at various occlusal contacts is to use an articulating paper (Dawson, 2007). Occlusal adjustments are achieved by grinding the paper marks selectively to have occlusal stability, make many simultaneous contacts in the arches, and relieve stress on the teeth and periodontium (Thanathornwong and Suebnukarn, 2017).

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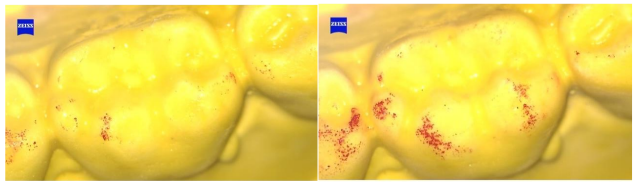
The mark area is claimed to be reflective of the load applied (Okeson, 2003). According to legends on images depicting the appearance of the paper mark, large and dark marks indicate heavy loading, whereas smaller and lighter marks indicate lighter loading (Kleinberg, 1991; Smukler, 1991). However, in a study varied loading was detected for the same, similarly sized marks (Kerstein et al., 2006). Given these data, it is probable that the relative sizes of various articulating paper markings don't effectively predict different occlusal loads (Carey et al., 2007). Although articulating paper is a widely applied method for occlusal adjustments in clinics, assessment of occlusal contact area with articulating paper in research is still a subject to debate. Thus this preliminary study aimed to explore the use of occlusal contact surface area and intensity measures in assessing the occlusal force from articulating paper-induced dental images. The null hypothesis was that larger markings do not reflect larger forces.

MATERIALS AND METHODS

In the present study, a mandibular and maxillary dental cast obtained from a mandibular and maxillary complete denture fabricated in preclinical work was used. The casts were mounted in maximum intercuspation on an average value articulator (Artex, Amann Girbach). Two different occlusal forces were implemented by respectively applying plates with two different weights (0.5 kg, and 5.0 kg) to the top of the upper member of the articulator. A 8-micron red articulating paper (Arti-Fol, Bausch, Germany) was inserted between right side of the upper and lower casts and loaded with the weights one by one and held there for 5 sec. After each loading the mandibular cast was removed from the articulator. The occlusal surface of the lower first molar tooth was photographed using a microscope (Opmi pico, Carl Zeiss Meditec AG, Germany) in a standard manner from a fixed distance (26 cm) for each time and orientation of the casts fixed relative to the microscope. This procedure was repeated 10 times for two weights (a total of 20 trials). For each trial, an unused articulating paper was placed. The images were transferred to a computer for analysis (Figure 1) and were analyzed to identify the red-colored pixels and then to estimate the contact surface area and intensity from the pixels identified. The data were statistically analysed with IBM SPSS Statistics 22 (IBM SPSS, Turkey). The Kolmogorov-Smirnov and Saphiro-Wilks tests were used to determine whether the parameters were suitable for a normal distribution. The Mann Whitney U test was used for comparisons of non-normally distributed quantitative variables between two groups. Data were expressed as number, percentage, mean ± standard deviation, median, minimum, and maximum. The significance level was set at $p < 0.05$.



a b

Figure 1. Images of the casts a) image with 0.5 kg force applied b) image with 5 kg force applied

RESULTS

The mean, median, minimum, and maximum values with standard deviation for both weights are shown in Table 1. The 0.5 kg and 5 kg forces resulted in mean contact area of 1.6 ± 1.2 mm^2 and 13.4 ± 7.1 mm^2, respectively (Figure 2). The mean contact area of the 5 kg force group was statistically significantly higher than that of the 0.5 kg force group (p:0.000; $p < 0.05$). The 0.5 kg group achieved a mean contact intensity of 78.4 ± 2.8 %, while the 5 kg force group achieved a mean contact intensity of 81.5 ± 1.9 % (Figure 3). The mean contact intensity of the 5 kg force group was statistically significantly higher than that of the 0.5 kg force group (p:0.031; $p<0.05$).

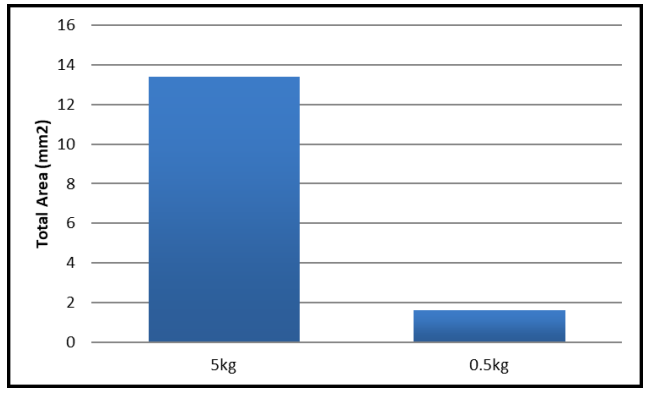


Figure 2. Mean contact area values of the groups

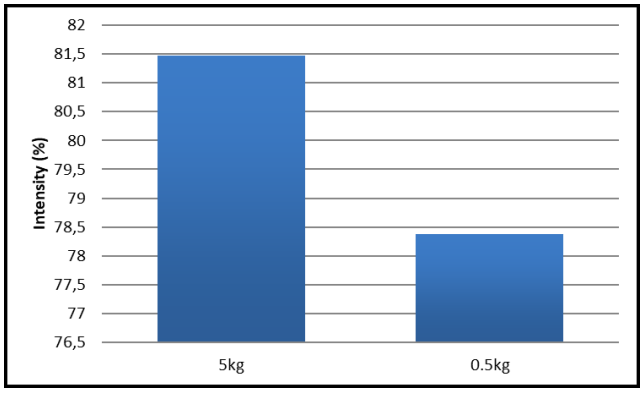


Figure 3. Mean contact intensity values of the groups

Table 1. Relationship of force with contact area and intenisty

	Total Area (mm^2)		Intensity (%)	
Force	Min-Max	Mean±SD (median)	Min-Max	Mean±SD (median)
5 kg	5.1-23.5	13.4±7.1 (13.25)	78.6-85.5	81.5±1.9 (80.95)
0.5 kg	0.6-4.6	1.6±1.2 (1.3)	74.9-83.3	78.4±2.8 (78.1)
p		0.000*		0.031*

Mann Whitney U Test *$p<0.05$

DISCUSSION

This study has shown that the occlusal contact area and the occlusal contact intensity are directly related to the applied occlusal force. The findings of the present study support the concept that mark area predicts the load. However, previous studies attempting to correlate occlusal force with the size of the paper mark differ from the results of the present study (Carey et al., 2007; Quadeer et al., 2007; Saad et al, 2008). It is claimed that the size of the mark is considered only as an indicator of the contact site and surface and does not quantify the occlusal force between the maxillary and mandibular teeth (Quadeer et al., 2007). Other studies either found a low positive relation or found no relation between these variables (Carey et al., 2007; Quadeer et al., 2007; Saad et al, 2008). The different findings may be due to the methodologies used in the studies.

During determining the occlusal contacts with articulating paper, factors such as tooth movements, intraoral moisture, and mandibular deformation under loading may alter the paper mark area (Carey et al., 2007). To eliminate these variables, the relationship between paper mark area and occlusal force was tested in vitro. Since the intraoral environment can not precisely be duplicated, no specific clinical implications can be taken from this investigation; however, the findings of this study may be useful in making adjustments in labratory procedures.

In a research where only one contact was recorded, a positive but non-linear correlation was observed between increasing force and mark area (Carey et al., 2007). The current study demonstrated a similar outcome since only one major contact point area on a single tooth (first lower molar tooth) was investigated. This was explained by the fact that if the force on a single occlusal surface was evenly distributed over the entire surface, the larger marks would represent areas of greater load. However, there is a lack of data regarding correlations among the force of the tooth-to tooth loads, and the size of the marks. There was no direct association between paper mark area (size) and applied occlusal load, according to studies conducted on mounted epoxy casts that were subjected to varied applied occlusal stresses (Carey et al., 2007; Saad et al., 2008). The published concepts that link the size of the markings to the load content of the paper are based on the assumption that the size of the markings indicates the range of the applied occlusal loads (Carey et al., 2007).

Although a positive relationship was detected, it may be more accurate to interpret the results of the current study, considering that the study was preliminary in which a single tooth was evaluated and the results of other studies should also be taken into consideration. Further studies are needed to document the relationship between the marking area and the applied occlusal load. Nevertheless, the method used in this study to determine occlusal contact area and intensity may lead to new studies to measure the contact areas of all teeth in an arch using different thicknesses of articulating paper and different occlusal forces. Although this study has some limitations, it is the first to show a very strong correlation between contact area and force and a moderate correlation between contact area intensity and force.

CONCLUSION

Within the limitations of this in vitro study, contact area and intensity measurements provide potential estimates of occlusal force. Measurement of these measures requires the utmost attention and experience when performed semi-automatically. Fully automated methods for this purpose have yet to be developed.

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Conflicts Of Interest Statement

There is no conflict of interest for this study.

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