Original Article

Reliability of The Pressure Indicating Film for Occlusal Force Analysis: A Pilot Study

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Abstract

Objective: : The aim of this study was to evaluate the reliability of the pressure indicating film in measuring pressure exerted on it with and without Polyethylene (PE) sleeve as infection control purposes, and to analyze the pressure produced with its software for occlusal force study.

Materials and Methods: The optimization of the pressure indicating film for occlusal force analysis commenced with the design and calibration of this sheet. The film was designed into horseshoe shape to suit the shape of maxillary and mandibular arches. The calibration was initiated with 5 different types of pressure which were 15 MPa, 25 MPa, 30 MPa, 35 MPa and 45 MPa exerted on two groups of the film: (i) with PE sleeve and (ii) without PE sleeve. Three readings were recorded for each group and mean value was documented. Then, the films were calibrated by its software for pressure analysis.

Results: There was no significance difference found between the film with and without PE sleeve during the calibration stage (P>0.05). In all groups of pressure, there was no significant difference documented between pressure exerted and read out value.

Conclusion: The results suggested that the film can be used for occlusal force analysis and improvement of the film with addition of PE sleeve for hygienic purpose is suitable to form the basis of clinical occlusal forces study.

Keywords: occlusal force, pressure indicating film, polyethylene sleeve

Introduction

Occlusal force is defined as the force responded by the group of masticatory muscles when upper and lower teeth are in contact, due to harmonization of masticatory structures, including muscles of mastication, bone and teeth (Bakke, 2006). Several researchers have investigated at the relationship between occlusal force and dental factors such as periodontitis (Miyaura et. al, 1999, Morita et. al, 2003, Takeuchi and Yamamoto, 2008 and Takeuchi, 2010), oral habits (Winocur et. al, 2006), wearing of a complete denture (Hayakawa et. al, 2000) and the presence of Temporomandibular disorders (Molin, 1972). Further

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investigation is recommended to see the clinical impact of occlusal forces such as its correlations if any with other clinical parameters such as the presence or absence of pain in the masticatory system and the presence of endodontic and periodontal disease (Awawdeh et. al, 2017).

There were several occlusal force diagnostic devices available in the market including the photocclusion and T-scan system. Photocclusion system manages to record the colour patterns of the occlusal contact, but quantitative measurement of this device was difficult and the sheet was rigid (Amsterdam et. al, 1987). On the other hand, the T-Scan system measured occlusal force based on changes in electrical resistance. This system offered only a narrow range of measurement for the occlusal force. However, it tended to record fewer occlusal contacts than actually present as checked by occlusal foils, due to its different sensitivity. (Hsu et. al, 1992). Also, the thick sensor may affect the function of the mandible.

Other than these devices, Dental Prescale/ Occluzer (GC Corp., Tokyo, Japan) has been studied in many aspects of dentistry (Alkan A, 2008; Moroi A, 2015; Idris RI, 2018). Dental Prescale/Occluzer contains a thin film which induces only a small change in the occlusal vertical dimension, making measurements at a position near the intercuspal position possible in the mouth (Watanabe et. al, 1995 and Suzuki et. al, 1997). However, the production of the Dental Prescale/Occluzer has been stopped in the market since 2012.

Another alternative is by using a pressure indicating film, which is a Mylar-based sensor film that reveals the distribution and magnitude of pressure between any two contacting, mating, or impacting surfaces. Fujifilm Prescale® (Fujifilm Corp. Kuala Lumpur, Malaysia) is the leading brand of pressure indicating film which is usually using with its software, the Pressure Distribution Mapping System FPD-8010E software (Fujifilm Corp., Kuala Lumpur, Malaysia). This system is available in the market and widely used in the industrial and medical fields. However, there are no studies reveal the usage of this film intraorally, therefore, small improvement of the design might be required as infection control purposes.

The aim of this study was to evaluate the reliability of the Fujifilm Prescale® film in measuring pressure exerted on it with and without PE sleeve, and to analyze the pressure produced with the Pressure Distribution Mapping System FPD-8010E software.

Materials and methods

Film and software

A film, type R270 Medium Pressure (MW) was used to measure pressure in a wide range between 10 and 50 MPa. The films were designed into horse-shoe shape using a template fit the maxillary and mandibular arches (Figure 1).

The film comprises of 2 sets of films, which are A and C films. A film is a set of film

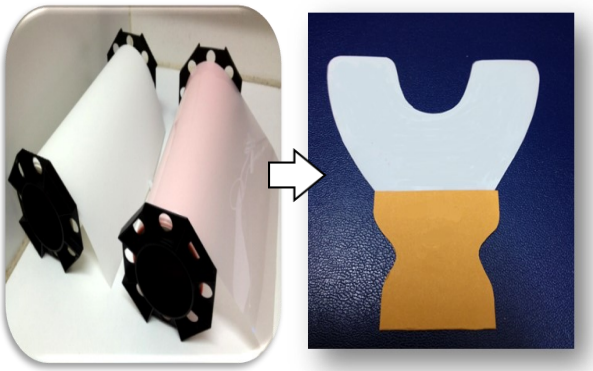

Figure 1. Fujifilm Prescale® film came in two roll formed of films. The film was cut into horse- shoe shape using a template.

covered with multiple sizes of micropules that contain colour forming material while C film is another set of film that comprise the base material coated with colour developing layer. Once pressure is exerted on both films, the micropules on A film will break and the colour former inside the capsules will leak out and act chemically with contacting C film. At initial pressure, the large and thin capsules will break first followed by small and thick capsules. As a result, colour gradient will be seen on the C film, which indicates different degree of force.

Further, the films will be analyzed by using an image scanner which connected to a computer installed with the dedicated software which is Pressure Distribution Mapping System FPD-8010E. Collected data then will be processed using this software according to the formula to measure the occlusal force;

Occlusal force (N) = Occlusal contact area (mm^2) × Mean occlusal pressure (Pa).

Methods for measuring the force

The film was divided into 2 groups; with and without Polyethylene (PE) sleeve. These 2 groups of film were tested by using Universal Testing Machine (Shimadzu Corp., Kyoto, Japan) at certain pressure, which were: 15MPa, 25MPa, 30MPa, 35MPa and 45MPa. They were scanned with dedicated software to get the force values. To improve the accuracy of the measurement of the pressure, each measurement was performed three times and a mean value calculated.

The values were analysed using IBM SPSS Statistics for Windows, Version 23.0. Levene's test was used for statistical analysis and significance was predetermined at $P<0.05$.

Result

Table 1 shows the data for the film that was given pressure at different values. Film was divided into 2 groups which are film with and without PE sleeve and were tested at 15.0 MPa, 25.0 MPa, 30.0 MPa, 35.0 MPa and 45.0 MPa. The results between applied and measured pressure between the film with and without PE sleeve was not significant difference ($P>0.05$,) as shown in table 2.

Figure 2 shows a direct relationship between measured and applied pressure on the film. When pressure was applied at certain value, the read out value was also directly proportion to applied pressure. The increasing values of applied pressure will produce the same read out values as applied pressure.

Discussion

A previous study of the Fujifilm Prescale® film reported that a linear relationship was observed between applied load and read-out load using the calibrating device consisted with the upper and lower dental casts (Watanabe et al, 1995). In the present study, a linear relationship was also observed between the applied pressure and read-out pressure, even with PE sleeve (Table 1 and 2). The software used was Pressure Distribution Mapping System FPD-8010E to measure pressure applied by Universal Testing Machine. This result indicated that the film and dedicated software were reliable to measure pressure and can be used for future development of occlusal force analysis in dentistry.

The purpose of application of PE sleeve is to improve the hygiene of the film. Polyethylene is considered as one of the most use plastics in the world that contribute to production around 80 million

Pressure exerted by Universal Testing Machine (MPa)	Test	15.0	25.0	30.0	35.0	45.0
Software reading on the film without PE sleeve (MPa)	1	14.8	25.7	30.6	34.8	44.5
	2	15.1	25.1	29.5	35.0	45.3
	3	14.6	25.3	31.0	35.6	45.1
Software reading on the film with PE sleeve (MPa)	1	14.7	25.1	29.8	35.6	44.9
	2	14.9	24.4	29.4	34.7	45.3
	3	15.4	25.3	29.8	35.2	44.7

Table 1. Read out results from film with and without PE sleeve at given pressure.

Applied pressure (MPa)	Film with sleeve		Film without sleeve		P-value
	Mean	Standard deviation	Mean	Standard deviation	
15.0	15.000	.3606	14.833	.2517	.481
25.0	24.933	.4726	24.933	.4726	.372
30.0	29.667	.2309	30.367	.7767	.103
35.0	35.167	.4509	35.133	.4163	1.000
45.0	44.967	.3055	44.967	.4163	.519

*Levene's test is not significant. Assumption of equal variances is met.

Table 2. Mean and standard deviation of film with and without sleeve at provided pressure.

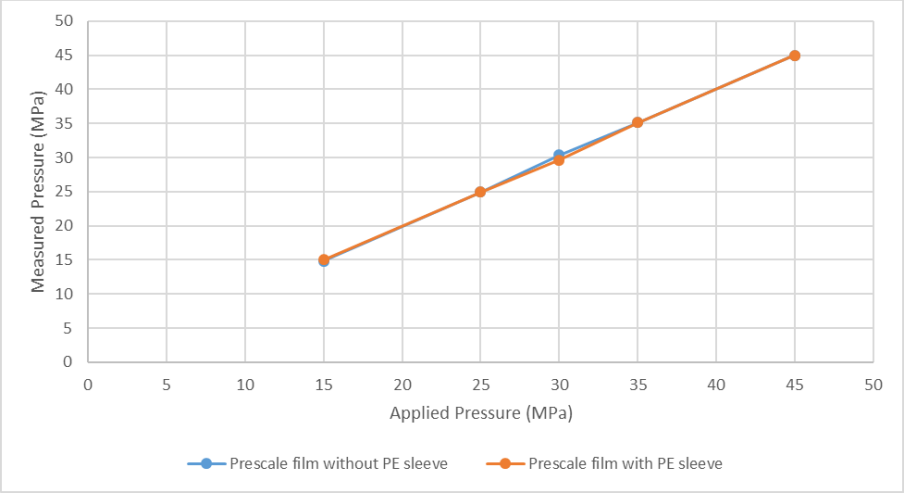

Figure 2. Mean measured pressure versus applied pressure of the film with and without PE sleeve.

tons yearly (Piringer and Baner, 2008). This preliminary study was to evaluate any differences in value of the film with and without PE sleeve and the result suggested PE sleeve can be used to measure pressure without altering the value.

The function of PE sleeve is to protect the material inside the A film from leaking out while in pressure since no literature revealed the materials contained in film. This is also to improve hygiene since this film is going to be used entirely in the mouth in the future. Besides, it is to prevent

the film being contaminated during transfer from patient to the scanner for data analysis. PE is safe to be used on human based on Final Report on the Safety Assessment of Polyethylene in 2007 and may not affect the measured value of the film (Figure 2). In the next development, this film will be used intraorally to measured occlusal force in patients. Pressure indicating film could be a single-use, affordable and easy to use tool that measures occlusal force.

However, due to limitation of this studies, it can be improved by providing multiple sizes of designated film for different patients with variable size of anatomical arches.

Conclusion

1. Pressure measurement using the pressure indicating film showed sufficient reliability.
2. No significant differences of force noted on the pressure indicating film with and without PE sleeve.
3. PE sleeve could be used as an infection control purposes without altering the value.

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