The validity of pressure indicating film for the measurement of occlusal forces transmitted to distal extension removable partial denture made by dual impression technique.

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Abstract: The study aimed to measure clinically the occlusal force, and the force transmitted underneath two different distal extension removable partial dentures fabricated according to different types of dual impression technique. Ten male patients with mandibular class I Kennedy classification recruited, two metal frameworks were made for each (fluid wax impression (Denture A) and selected pressure impression (Denture B). Both dentures were fabricated according to altered cast technique, and then pressure indicating film (PIF) was used to record the occlusal force as well as the force transmitted to supporting tissues beneath each denture at the molar region. The processed (PIF) and color calibration swatch were scanned. Photoshop program was used to get the color density and to determine the amount of pressure. The force beneath denture (A) was significantly lower than that measured in denture (B) at 5% level (P=0.008). High-localized pressure transmission was observed in the PIF opposite molar region in the distal extension RPD (B).The PIF enables to measure *in vivo* the pressure distribution under distal extension base of RPD**.** Furthermore, functional impression using fluid wax could be the impression of choice to minimize load induced by RPD, it provides more even force distribution and be more temperate to supporting oral tissues.

[Manal R Alammari, Lana A Shinawi and Seham B Tayel. **The validity of pressure indicating film for the measurement of occlusal forces transmitted to distal extension removable partial denture made by dual impression technique.** *J Am Sci* 2012;8(10):367-372]. (ISSN: 1545-1003). http://www.jofamericanscience.org. 54

Keywords: Dual impression technique, pressure-indicating film, bite force, RPD.

1. Introduction

Distal extension removable partial denture is a treatment modality used when many teeth are missing and the local, systemic factors as well as financial concerns may limit the application of implant. Removable partial denture, when correctly designed and cautiously made can be an exclusively satisfactory restoration. It serves as a means of preserving the remaining oral structures as well as restoring missing dentition. Stress in removable partial denture considered as a major clinical problem confronting the general dental prosthodontists when planning the design of the distal extension removable partial dentures. [1]

Distal extension base are liable to be displaced under occlusal pressure. This is a result of the displaceability of the mucosa [2]. The great difference between the higher resiliency of the residual ridge tissues and the lower resiliency of the teeth, permitted by their periodontal ligaments, presents a disparity of support that causes the denture to rotate about its distal abutment, inducing heavy torsional stresses on the teeth and possible traumatization of alveolar ridge. Several factors such as denture design, fit of the denture base and framework, occlusal consideration and morphology of residual ridges are known to be related to the movement of RPD .The occlusal forces primarily cause denture movement and result in harmful movement of the abutment teeth through occlusal rest of direct retainer.[3,4] Although many factors influence the support of distal extension base ,the accuracy and types of the impression registration and the total occlusal load are considered to be the most crucial .[5,6] Load distribution studies have shown that a well-fitting denture base distributes stresses favorably to the supporting bone and abutment teeth. Other studies showing that increased residual ridge coverage coupled with a well-fitting denture base reduces stress per unit area, potentially preserving the remaining supporting structures The altered cast technique is employed to prevent displacement of denture base under occlusal pressure by making an impression of the mucosa under controlled pressure. Cast partial denture made using the altered cast impression technique creates an environment in which the teeth and the edentulous tissues support the base as compatibly as possible. The result is a potentially more stable RPD that improves the support for the occlusal relationship of the opposing dentition and the RPD restoration.[7]However, this technique has the potential benefits of reducing the number of postoperative visits, preserving the residual ridges, improving stress distribution, decreasing food impaction and decreasing the torqueing of abutment teeth. This functional impression provides also denture stability and a reduction in occlusal load per

unit surface area of the residual ridge. All of which lead to increased patient satisfaction. [8]

Recently, some systems using thin, pressure indicating film (PIF), were developed to measure occlusal load on multiple points in the dentition [1,9.10] These new systems allowed the measurement of the occlusal load distributed over the dentition, which is an important variable, used to assess the functional state of masticatory system and for evaluating prosthetic treatment [11,12)]

Few researches measured the pressure under the denture bases of removable partial dentures *in vivo* ,therefore the purpose of the present study was conducted to evaluate and measure clinically the occlusal force as well as the force transmitted beneath two different distal extension removable partial denture fabricated according to different types of dual impression technique using pressure indicating film.

2. Materials and Methods:

This study was conducted in the prosthodontic clinics of King Abdulaziz University, Faculty of Dentistry (KAUFD) for rehabilitation of patients with removable partial denture. Ten male patients having Kennedy class I (bilateral missing posterior teeth) in the mandibular arch were selected. All patients had complete natural dentition in the opposing maxillary arch.Their ages ranged from 35-55 years old. Consent was taken from the patients and patients were briefly informed about the impression technique. Each subject receives two distal extension RPDs fabricated using cast metal frame-works, included rest, retainer, and rigid connectors. The two distal extension RPD's was identical except for the impression technique, one was constructed according to fluid wax method (Correct wax no.4 Sybron Kerr,U.S.A) (Denture A) and the other utilized selected pressure impression method (compound impression material Kemco Precision Compo ,The United Kingdom, and zinc-oxide eugenol paste Cavex Co.,Holland) (denture B),both dentures were fabricated according to altered cast technique[6] .The occlusal vertical dimension ,centric occlusion and type of teeth were standardize for both denture for each patient .The occlusal scheme was conforming to the patient's existing occlusion .The dentures were finished with heat cured acrylic resin. The finishing denture was inserted in the patient's mouth, necessary adjustments were carried out, and occlusal force was measured.

Occlusal force measurement:

The maximum occlusal force was measured using pressure indicating film . (Pressurex, Sensor Products INC, New Jersey, USA.).The sensor film (pressure indicating film) is a two-sheet type Mylar based film (Fig.1) that contains two polyester bases, one is coated with a layer of tiny microcapsules color forming material and the other is a layer of the color developing material (Fig.2). The application of force upon the film causes the microcapsules to rupture, producing an instant and permanent high-resolution "topographical" image of pressure variation across the contact area. It is used to measure pressure range from 28-1400 pound/ square inch (PSI).

Measuring Procedure of occlusal force:

The PIF was cut to the precise dimensions of the patient occlusal surface (horseshoe shaped) to measure the bite force which was carried out with the patient seated in the upright position. The film was placed between the maxillary and mandibular teeth. The patient was instructed to bite the sheet as hard as possible for ten seconds in the intercuspal position to record occlusal contact points on the molar teeth (Fig.3). Instantly the film turned to a magenta color, the color is permanently recorded and displays an intensity being directly proportional to the amount of force applied such that areas of high force turned to a dark magenta color, while areas of low force displayed lighter tones.

The bite force was measured after wearing the denture (time of insertion) with 30 minutes intervals between tests for each denture. The tested denture was removed from the patient's mouth and the other denture was inserted. The initial measurement for each subject was conducted to get the subject's accustomed to the process of occluding the film.

Measuring the force transmitted beneath the denture base:

Occlusal force beneath each type of the denture base was measured intra-orally to simulate the stress distribution in the underlying tissues. The sensitive pressure film was adapted in the fitting surface of the denture on the residual ridge opposite the molar region bilaterally. The film was bonded to the surface with denture adhesive (protefix adhesive powder, Queisser, pharma ,Flensburg, Germany). The denture was inserted in the patient mouth and securely seated .The patient was instructed to close the teeth tightly and perform a chewing movement. The test was repeated three times on each side and measurement of the areas turned a magenta color where the intensity was directly proportional to the amount of force being applied. The force was measured in both dentures at time of insertion with 1/2 hour elapse between the measurements.

Pressure indicating film interpretation:

The processed pressure indicating films were scanned (Fig. 4) and .Photoshop CS5 program (Adobe Photoshop® CS5, Version 12, USA) was used to get the color density on the film and correlate it

with the color swatch on the programe (Fig.5) to determine the amount of pressure applied over the film. The surface area of the exposed points was measured using the Photoshop CS5 program by matching the number of pixels to a known surface area. The force was determined as:

Force = Pressure × Surface area (m^2).

The occlusal force was calculated as the sum of forces on the molar teeth.

Statistical analysis

Data was collected and analyzed. Descriptive statistical as mean and standard deviation were used. Wilcoxon Signed Ranks Test was used to compare the right and left side within the same denture (A and B), and for comparison between the two studied denture at each side and for analysis of force beneath both dentures. Spearman's rank correlation coefficient was used to test the correlation between the occlusal force and the force beneath the denture base**.**

Fig 3: Pressure indicating film was placed

between the maxillary and mandibular teeth

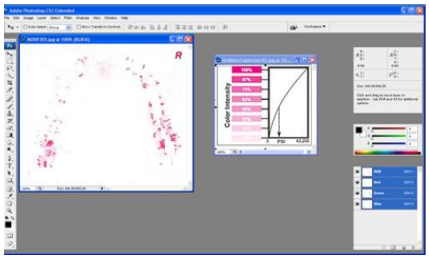


Fig4: After scanning of the PIF, the Photoshop CS5 was used to measure the color density with the use of color swatch

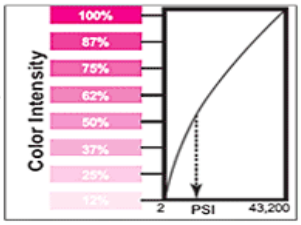


Fig.5: color swatch

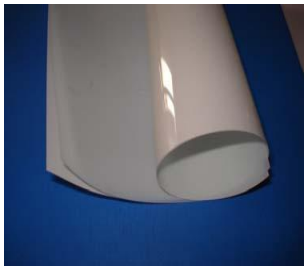


Fig1: Mylar based pressure indicating film which cut to the precise dimensions of patient occlusal surface

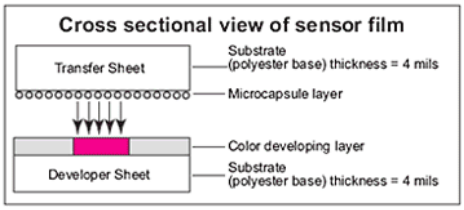


Fig2:Cross sectional view of the components of the pressure indicating Film.

3. Results:

The mean value of occlusal force at right and left side of molar region in denture (A) was 13.04± 2.19 and 12.54±1.75 N (Newton), while in denture (B) was 13.06±2.35 and 13.68± 1.95 N respectively.

No significant difference was found between right and left side of both denture (A & B), ($p1$ = 0.678, 0.507). Comparison between right and left side of denture (A) with right and left side of denture (B) showed no significant difference at 5% level (p_2=0.760 and 0.202). The percentage of change in denture (A) was 0.5 while in denture (B) was 0.62.(Table 1,Fig.6).

The mean value of the measured force beneath denture (A) was 26.95 ± 9.36 N, compared to denture (B) was 49.02 ± 22.29N which statistically significant at 5% level (P=0.008) as shown in table (2)

Fig.(7) Showed areas of color developed on the pressure indicating film obtained from two distal extension RPD with different dual impression technique which represent the pressure transmission beneath the denture base .The pressure indicating film demonstrated variation in the amount and pattern of pressure distribution. Distal extension RPD (A) showed a lower pressure transmission compared to distal extension RPD (B).The high and localized pressure transmission was observed in the pressure indicating film opposite the molar region in the distal extension RPD as supported with Table (2).

Upon comparison, no correlation was observed between occlusal force and the force transmitted beneath denture base in both dentures as shown in Table (3).

Table (1): Occlusal force measurement in denture A and B.

	Denture- A		Denture- B	
	Right Side	**Left Side**	**Right Side**	**Left Side**
Mean ± SD	**13.04±2.19**	**12.54 ± 1.75**	**13.06 ± 2.35**	**13.68 ± 1.95**
p_1	**0.678**		**0.507**	
Comparing denture A + B	**Right Side**		**Left Side**	
p_2	**0.760**		**0.202**	
% change	**0.50**		**0.62**	

p_1: value for Wilcoxon Signed Ranks Test between right and left side in each group

p_2: value for Wilcoxon Signed Ranks Test for comparison between the two dentures at each side.

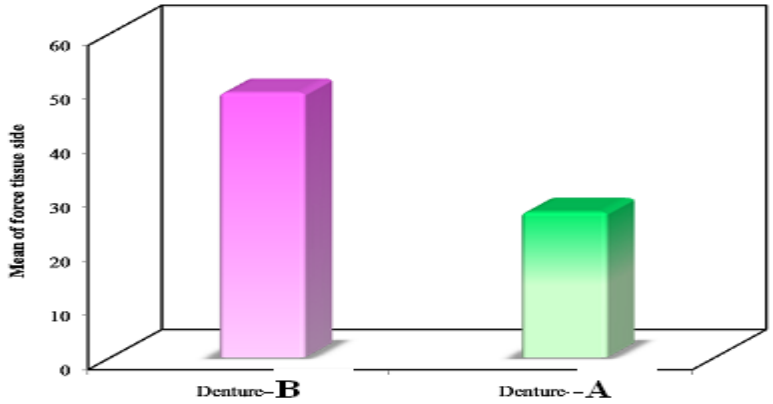


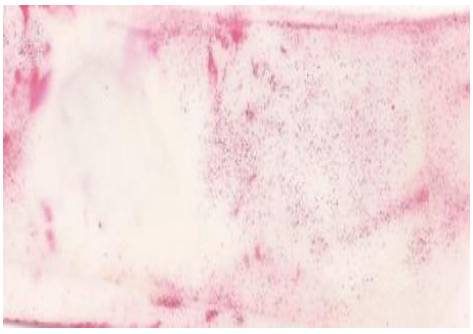
Fig6: Comparison of force beneath two types of denture

Table (2): Comparison of force transmitted beneath denture (A and B)

	Denture-A	Denture-B
Range	**12.40 – 44.60**	**19.30 – 81.20**
Mean ± SD	**26.95 ± 9.36**	**49.02 ± 22.29**
P	**0.008***	

P: *p* value for Wilcoxon Signed Ranks Test for comparison between denture A and B.

*: Statistically significant at $p \leq 0.05$



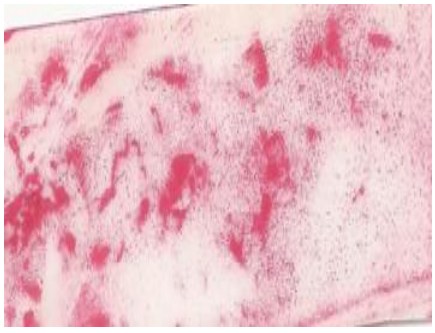


Fig 7: PIF. of t**he tissue side of denture A.** PIF .of t**he tissue side of denture B**.

Table (3): Correlation between force beneath denture (A and B) with occlusal force

Occlusal force		Force in tissue side of dentures	
		Denture-A	Denture-B
Right side	rs	0.195	0.261
	P	0.589	0.466
Left side	rs	0.225	0.200
	p	0.532	0.580

rs: Spearman's rank correlation coefficient

4. Discussion:

The pressure under denture base of removable partial denture during function should be distributed uniformly in order to avoid pressure concentration that may cause pain and inflammation in the tissues supporting the denture. This distribution is therefore taken into account in the modern principles of removable partial denture design. [13]

In this study two different types of dual cast impression technique were used and two distal extension removable partial denture were fabricated (Denture A and B) for each patient. The dual impression technique was selected because most of the authors in the dental literature advocate a technique that demonstrated the least amount of movement of the denture base at the time of placement and most favorable ridge to denture base relationship. [1, 14, 15]

Pressure indicating film was used in the present study to measure the occlusal force of the patient with each denture and at the same time to evaluate the load transmitted through both dentures to the supporting alveolar ridge. The pressure indicating film was bonded to the basal surface of the denture. The sheet was useful, easy to use for evaluation of large pressure ranges and regions. It has documentary value of occlusal contact pattern on the teeth and be considered as a useful method for occlusal analysis and patient's screening.[9] This method was used in our study because several investigators reported that it has been difficult to simulate the intraoral conditions accurately in vitro studies that may affect the results of pressure distribution under a denture base e.g. the direction of force exerted by jaw muscles in the viscoelasticity of the mucosa on the residual ridge. Therefore the data derived from in vivo measurement are needed in our study to know the realistic pressure distribution [16, 17].

The insignificant occlusal force in distal extension removable partial denture A and B at the right and left side of both denture might be due to the loss of molar teeth and loss of occlusal support that has a greater influence on the level of maximum bite force and removable prostheses do not compensate enough to maintain the previous level of maximum bite force. [18] The insignificant results of comparing denture A at right and left with denture B at right and left side was due to the fabrication of distal extension removable partial denture with altered cast impression technique to make accommodation between the difference of the soft tissue of the edentulous ridge and the hard tissue of remaining teeth .The fit of the denture base is the most important factor to minimize abutment teeth movement [7].

Our results was in accordance with Arksornnukit et al who concluded that maximum extension extension of denture base with anatomical and physiological limits is strongly recommended to increase the supporting areas and minimize the pressure to the underlying bone beneath denture base.[9]

The high force beneath the base of the distal extension denture (B) might be attributed to the pattern of pressure distribution that affected by the direction of the force exerted on the denture during chewing and by the shape of residual ridge ,the direction of occlusal force exerted on the denture would vary widely and the denture base would be slightly moved [13] and also the movable nature of distal extension base supported by soft tissues is displaced more than abutment tooth supported by periodontal ligament.10

The lower force in distal extension denture base of denture (A) could be due to the fluid wax impression technique that records the tissues more physiologically, captures the ridges in their functional form and cause less tissue displacement by the application of chewing movement [19,20] and the work load is spread uniformly as possible to avoid impinging on area with less displaceable mucosa.,this result was supported by figure (7).

5. Conclusion:

Based on the results obtained from this study, we conclude the follows:

1-The loss of tooth in the molar region has a greater influence on the level of occlusal force.

2-The pressure indicating film used in this study enable us to measure in vivo the pressure distribution under distal extension base of RPD.

3-High localized pressure transmission varied in vivo study was depending on the location of the film

under the denture base as the film was turned to magenta color where the intensity was directly proportional to the amount of force being applied .

Clinical significance:

Functional impression technique using fluid wax could be the impression of choice to minimize the load induced by RPD, distributes the forces evenly and more temperate to supporting oral tissues.

Acknowledgements

No fund from any source was used for this study. All work was done in the Oral and Maxillofacial Rehabilitation Department, Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia. Ethical approval: Number 011-12, approved by Research Ethical committee, Faculty of Dentistry, King Abdulaziz University.

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References:

1. Aras K, Hasanreisoğlu U, Shinogaya T. Masticatory performance, maximum occlusal force, and occlusal contact area in patients with bilaterally missing molars and distal extension removable partial dentures. Int J Prosthodont. 2009; 22(2):204-9.
2. Sajjan C. An altered cast procedure to improve tissue support for removable partial denture. Contemp Clin Dent. 2010;1(2):103-6.
3. Mizuuchi W, Yatabe M, Sato M, Nishiyama A, Ohyama T. The effects of loading locations and direct retainers on the movements of the abutment tooth and denture base of removable partial dentures. J Med Dent Sci. 2002;49(1):11-8.
4. Monteith BD. Management of loading forces on mandibular distal-extension prostheses. Part I: Evaluation of concepts for design. J Prosthet Dent. 1984; 52(5): 673-81.
5. Vahidi F. Vertical displacement of distal-extension ridges by different impression techniques. J Prosthet Dent. 1978;40(4):374-7.
6. Phonenix D,Cagna D, and Defreest F: Stewart's Clinical removable partial prosthodontics 2008, 4th edition.PP.351, MOSBY.
7. Feit DB. The altered cast impression technique revisited. J Am Dent Assoc. 1999; 130(10):1476-81.
8. Kato K. Impression procedures for removable partial dentures. Nihon Hotetsu Shika Gakkai zasshi, 2006;51:223-30.
9. Arksornnukit M, Phunthikaphadr T, Takahashi H. Pressure transmission and distribution under denture bases using denture teeth with different materials and cuspal angulations. J Prosthet Dent. 2011;105(2):127-36
10. Kondo T, Wakabayashi N.Influence of molar support loss on stress and strain in premolar periodontium: a patient-specific FEM study. J Dent. 2009;37(7):541-8.
11. Shinogaya T, Tanaka Y, Toda S, Hayakawa I. A new approach to evaluating occlusal support by analyzing the center of the bite force. Clin Oral Investig. 2002; 6(4):249-56.
12. Takishita M. A clinical and physiological evaluation of prosthodontic treatment by removable partial dentures with free-end saddles--a 3.5-year follow-up study. Kokubyo Gakkai Zasshi. 2001;68(3):254-61.
13. Kubo K, Kawata T, Suenaga H, Yoda N, Shigemitsu R, Ogawa T, Sasaki K. Development of in vivo measuring system of the pressure distribution under the denture base of removable partial denture. J Prosthodont Res. 2009; 53 (1): 15-21.
14. Leupold RJ, Flinton RJ, Pfeifer DL. Comparison of vertical movement occurring during loading of distal-extension removable partial denture bases made by three impression techniques. J Prosthet Dent. 1992;68(2):290-3.
15. Holmes JB. Influence of impression procedures and occlusal loading on partial denture movement. J Prosthet Dent. 1965;15:474-83.
16. Miyaura K, Morita M, Matsuka Y, Yamashita A, Watanabe T. Rehabilitation of biting abilities in patients with different types of dental prostheses. J Oral Rehabil. 2000;27(12):1073-6.
17. Miyaura K, Matsuka Y, Morita M, Yamashita A, Watanabe T. Comparison of biting forces in different age and sex groups: a study of biting efficiency with mobile and non-mobile teeth. J Oral Rehabil. 1999; 26(3):223-7.
18. Bakke M. Bite and occlusion. Semin Orthod., 2006;12 ;2:120-6.
19. Applegate OC. The cast saddle partial denture. J Am Dent Assoc 1973; 24:1280.
20. Applegate OC. The correctable Wax Impression. In: Essentials of Removable Partial Prosthesis. Ed. 3. Philadelphia: WB Saunders Co., 1966.

9/20/2012