Retention of Approximal Guiding Plane Surfaces in Removable Partial Skeletal Prosthesis

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Abstract

BACKGROUND: The morphology of the retention tooth often does not correspond with the required design; hence there is often an indication for enamel recontouring or other restorative procedures.

AIM: The study aimed to determine the impact of changing the path of insertion of the prosthesis by reshaping the anatomical and morphological structures of the natural teeth predetermined for the retention of the prosthesis.

MATERIAL AND METHODS: The group of 40 patients with Class II, Subclass 1 according to Kennedy was formed, and 120 approximal surfaces of retention teeth were obtained. Two different types of prostheses were made on the models: one group in the zero point position of the model, and another group in the zero position of the model, with changing of the direction of input at an angle of 2°.

RESULTS: The difference between the established and theoretical normal distribution of frequencies was tested with the Kolmogorov-Smirnov and Lilliefors tests (r < 0.10; r < 0.01). The first group showed a retention force of 0.08 N. In the second group the retention force was 0.94 N.

CONCLUSION: It could be concluded that the change in the path of insertion of the dental prosthesis with conservative restorations as composite inlays, as well as the accurate extension of the prosthesis onto guiding plane surfaces, will undoubtedly increase the retention force of the prosthesis.

Introduction

Creating a successful partial skeletal prosthesis (PSP) by a general practitioner or a specialist prosthodontist is always a tough requirement. The prosthesis should fulfil the basic prosthetic principles of patient aesthetics, speech or phonation, function and even distribution of pressure, stability and retention [1].

To achieve these characteristics, the prosthesis must be carefully planned, designed and constructed. The basis of these processes is the parallelometry surveying that allows a dimensional analysis of the ratio between oral soft tissue and oral hard tissue. Parallelometry is accomplished by the collaboration of a therapist and a technician depending on the choice of retention teeth and the location of the occlusal rests. An analysis of the dimensional ratio between the anatomical characteristics must be completed before a final decision on the design of the PSP is made by a therapist. Parallelometry and dental surveying is an essential component of PSP therapy [2] [3].

However, in spite of the advantages of a well-made prosthesis, some studies have pointed out to the problems that arise when wearing the prosthesis, such as caries, gingival inflammation, increased sulcus depth and loss of retention [4]. The deviation from fabrication standards that later leads to unwanted consequences regarding pressure distribution, are one of the main reasons why patients are not satisfied with their prostheses [5].

The basic idea of this study was to examine the effects of modifying the guiding plane surfaces on the retention of PSP. Guiding plane surfaces are

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vertical parallel surfaces of retention teeth and abutments of dental implants, so oriented that they contribute to the determination of the path of placement and the path of removing the PSP [6]. The guiding surfaces are usually formed on the approximal surfaces of the retention teeth that look toward the edentulous ridge. It is generally accepted that the guiding surfaces cover about two-thirds of the width between the buccal and the lingual tubers [7].

The functions of guiding surfaces on a single desired path of insertion of the prosthesis are equal retention of all abutment teeth, protecting from horizontal masticatory forces, minimising forces that may destabilise the partial prosthesis and allow the prosthesis to be removed without premature contact and damaging effect on retention teeth. They also direct the forces to act on the longitudinal axis of the teeth and provide frictional retention of the parallel guiding plane surfaces [8].

Changing the path of placement for equalisation of the undercut spaces on the teeth often occurs as a need for planning and surveying of the diagnostic cast of the prosthesis. In a very small number of cases, the zero point position will allow preparation of the prosthesis without additional alterations of the retention teeth [9].

One of the factors influencing the proper planning of the guiding surfaces and their modification is the correct transmission of the analysis of the path of placement of the prosthesis by a dentist on a model in the dental laboratory. This problem was solved using a surgical operating microscope combined with coaxial illumination [10]. A special technique for fixing pins and the cylinder device, described by NaBadalung _et al._, [11] ensured proper positioning and easy handling in the design planning process. Advantages and increased function of guiding surfaces can be achieved by reshaping the approximate guiding surfaces of retention teeth. Alfonso C. _et al._, [12] in their clinical trials showed a simple method that made contact between the skeleton and retention teeth closer, which increased the retention of the prosthesis.

When testing the value of the guiding surfaces of the PSP, Ahmad and Waters used the ratio between the direction of the guiding surfaces and their inclination angle. They have found that the increase in retention occurs when the incline of the surveyor table grows to 22º with an inclination of guiding surfaces up to 12º [13]. Multiple methods and devices for parallelising retention teeth were created to determine the guiding surfaces of the definitive model and precisely transpose them into the patient's mouth. However, these techniques are quite expensive and complicated for practical application [14].

The preparation of the guiding surfaces mostly depends on the experience and ability of the dentist [15]. Friction retention or retention created from contact on guiding surfaces is an excellent source of retention force in the prosthesis, but often cannot be accomplished, because the leading surfaces must always be parallel. Since the creation of a guiding plane surfaces is difficult and often impossible, the friction force is not always a reliable source of retention. One of the circumstances in which the friction force is used is when the crowns on retention teeth are used, and the approximal and lingual surfaces are parallelised in a laboratory. In his research, Uemura _et al._ compared the techniques of equalising leading surfaces, showing that the intra-oral method was superior to other techniques [16].

Today, modern technology provides unlimited possibilities for performing morphological interventions on teeth, with non-invasive or less invasive techniques. This can be used in optimal interventions on the teeth, depending on the needs indicated, which will replace the preparation of the crowns. All of these, as well as other problems, should be properly observed with a thoughtful solution from the first contact with the patient to the finally provided function of the prosthesis in the patient's mouth due to its long-term use.

The paper aimed to determine the force of retention on the approximate guiding surfaces at the zero point position of the model and to determine the force of retention by remodelling the approximate guiding surfaces that occupy an angle of 2º concerning the model base.

Material and Methods

The investigation was performed at the University Clinic for Dental Prosthetics at PHI Dental Clinical Center "St. Panteleimon " - Skopje, during a specified period. The patients were with the partially edentulous ridge, an endless one-sided terminal and one inserted saddle or class II, sub-class 1 according to Kennedy. A group of 40 examinees was created, which resulted in 120 approximal surfaces of retention teeth for further analysis. The parallel-meter, model AF 30 (NOUVAG, Switzerland) was used in the test. This parallel-meter possesses the possibility for adjustment of the head when milling the inclination angle of 2º, 4º and 6º, about the vertical axis. The formation of the guiding surfaces according to the principles of the purpose-built inlays in the test was made with the material Grandio (VOCO). For fabrication of the removable partial denture framework, a Co-Cr-Mo alloy metal (Dentaurum, Remanium GM 380+), with the following chemical composition: Co 64.6%, Cr 29%, and Mo 4.5% was used.

The dynamometer that measures the strength of the denture retention consists of a power sensor, a

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DO663i model, a CoachLab II interface, a table kit for fixing models and a computer. The first three sections are produced by CMA (Center for Microcomputer Applications) Amsterdam, Netherlands. The sensor was connected to a computer through the CoachLab II interface. It was a multifunctional interface that offered many possibilities for computerised measurement and control of devices. It was supplied with its microchip and its embedded system.

Anatomic impressions with a two-phase method were taken from the selected patients. The first impression was made with the heavy body silicone impression material (Optosil, Heraeus Kulzer) and the second with the light body material (Xantopren L, Heraeus Kulzer). The impressions were cast with super hard stone (Polident, Polish one type IV). Two types of dentures were made on the master cast, and the strength of retention force was measured. In the first case, the model was set to zero points, and the planning of the framework of the prosthesis was made in that position. In the second case, the model was also set to zero point position.

Inlays were made in the cavities on the approximal surfaces of retention teeth, oriented towards the free space, and the nanocomposite material was applied. The guiding surfaces of the three retention teeth were modelled by a cylindrical milling cutter placed in the parallel-meter head. The milling cutter was placed in an anteroposterior position, at an angle of 2º, whereby, with the help of milling, a remodelled, the artificial guiding surface was obtained (Figure 1).

Figure 1: Formation of guiding surfaces

We made a framework for removable partial prosthesis on the master casts prepared according to the standard procedure. Thus, as a result of the test, a modification was made in the fabrication of the framework, and the retention clasps, the occlusal rests and the stabilisation elements were omitted. To enable the measurement of the total retention force, three rings were placed on the same level, at the area of the guiding surfaces. This allowed attaining tension evenly and deployed the tensile force on all parts of the prosthesis (Figure 2).

Figure 2: The framework with three rings

The process of measuring the retention power was made as follows: the model with the framework of the prosthesis was fixed on the table that was able to move in a vertical direction, and then it was put under the clasp that was connected to a power sensor (Figure 3).

Figure 3: Measurement of retention force

The retention force or the tension between the clasp and the model was accomplished through the rings on the framework and the strings that connected them to the clasp. The power of tension was caused by lowering the carrier table vertically downwards (Figure 4). Its intensity was automatically read and registered on the computer screen. Each model was measured in five series, and the obtained data were statistically processed with descriptive statistical analysis.

Figure 4: Moving the carrying table downwards for tension force

Results

Descriptive statistical indicators of measured data for the group of unprepared retention teeth or zero position of the model are given in Table 1. Distribution of the data for the variable "unprepared retention teeth-zero angle" is shown by using a histogram, as well as by expected distribution of frequencies.

Table 1: Mean size of retention force in prostheses without preparation of retention teeth

N	$\overline{X}_{(N)}$	$SD(N)$	$SE_{x\,(N)}$	$SE_{\overline{x}\,(N)}$	V_x	$P(N)$	$I_{v\,(N)}$
40	0.08	±0.037	±0.038	±0.008	0.46	-0.07-0.081	0.0-0.13

The difference between the established and theoretical normal distribution of frequencies was tested with the Kolmogorov-Smirnov and Lilliefors tests (r<0.20; r<0.01). The established distribution was significantly different from the theoretical one (Figure 5).
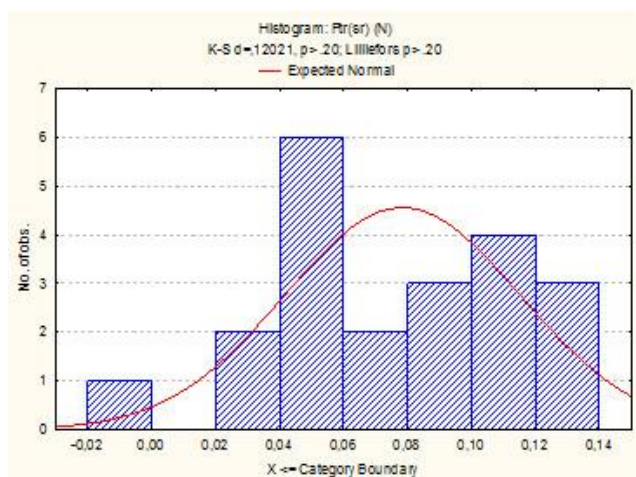

Figure 5: Histogram of the distribution of the variable retention force in unprepared retention teeth

Distribution of data on the variable "prepared guiding surfaces of retention teeth, at an angle of 2°" is shown by using a histogram. At the same time, the theoretical (expected) distribution of frequencies is also shown. The difference between the established and theoretical normal distribution of frequencies was tested with the Kolmogorov-Smirnov and Lilliefors tests (r<0.10; r<0.01). Determined distribution was significantly different from the theoretical normal, but after several measurements, it came close to the normal one (Figure 6).

Table 2: Mean size of the retention force in prostheses with prepared retention teeth

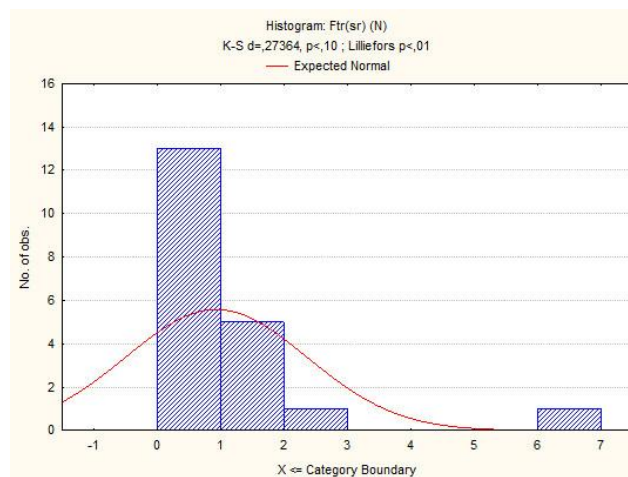| N	$\overline{X}_{(N)}$	$SD(N)$	$SE_{x\,(N)}$	$SE_{\overline{x}\,(N)}$	V_x	$P(N)$	$I_{v\,(N)}$
40	0.94	±1.43	±1.467	±0.328	±1.52	0.297-1.583	0.075-6.51

Figure 6: Histogram of the distribution normality of the retention variable strength in prostheses with prepared guiding surfaces

Discussion

The value of the retention force is a determining factor and a measure of the success of planning and implementation, as well as of the functional capabilities of the PSP. The term "retention force" of the prosthesis presents the size of the resistance of the retention elements to the forces that tend to remove the prosthesis from the basis. In the particular case, the resistance/retention arises from the friction between the parts of the prosthesis and the remaining teeth, which is achieved on the contact surface on which they accurately lie down. It is a result of a frictional force between retention teeth and prosthesis, as well as the mechanical resistance from the restrained retention tooth.

In this study, to make a comparison, two groups of subjects were treated: the first group of models - without preparation of the retention teeth, and the second set of models with planned and prepared to guide surfaces at an angle of 2°. The following condition was determined: in the first group, the retention was very small and varied from 0.0 to 0.13 N, with the medium value of 0.08 N. This value does not satisfy the stability requirements and functionality of the PSP. In fact, the measured values were close to zero, as a constant size, with a narrow confidence interval P = -0.07-0.081 N, and with an interval of variation Iv = 0.0-0.13 N.

In the second group with planning and preparation of the guiding surfaces and by providing the angle of retention of 2°, the size of the retention force significantly increased. It varied from 0.075 N to 6.51 N, with the medium value of 0.94 N. These results showed that with the increase in the angle of undercut, the strength of retention increases.

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These results are consistent with those obtained by Walter [17], who, as a disadvantage of the vertical path of placement and removal of the prosthesis, assumes that it coincides with the path of denture displacement when sticky foods are chewed. The same author in his analysis of retention has suggested that when the guiding surfaces are chosen or formed so that the path of placement is different from the path of maximum displacement, other parts of the prosthesis, such as the base, acrylate wings or minor connectors can be modelled as guiding surfaces.

In a very small number of cases, the current position of retention teeth will satisfy the necessary undercutting. Although in some cases the approximal surfaces of retention teeth are assessed as favourable and able to serve as guiding surfaces, however, due to the filling of the undercut spaces, the possibility of retention is lost. In this study, we decided to increase the influence of the guiding surfaces on the retention force of the prosthesis by modifying the guiding approximal surfaces on retention teeth. This decision is based on the fact that higher inclination changes the position of the prosthetic equator, and the possibility of applying stabilisation elements and retention clamps in precisely determined areas of a tooth is disabled.

Wulfes [18] came to a similar conclusion, which confirms the fact that, very often with minor corrections through reshaping, ideal conditions are created in cases where there are no natural guiding surfaces. With this inclination, although minimal, we are changing the path of placement and removal of the prosthesis, which has also been supported by Bates [19], Borges [20], Krikos [21] and other authors. The inclination of the model in the parallelogram and the change in the direction of the prosthesis with the formation of guiding surfaces has also been accepted by Garcia, Bohnenkamp [22].

In conclusion, by implementing the procedure with the reshaping of guiding surfaces and creating the undercut areas, the prosthesis lied better on the retention teeth.

1. It can be concluded that due to the wide variability of the angle of the undercutting, it is difficult to ensure a unique path of the PSP and its proper function without reshaping of the potential retention teeth.

2. With the formation of artificial approximate guiding surfaces of retention teeth from nanocomposite inlays, conditions have been created for placement and removal of the PSP into a single direction, which is not perpendicular to the occlusal plane resulting in the appropriate size of the retention force and satisfying other expected functions.

3. Further research is necessary to achieve a significant frequency of occurrence of each potential retention tooth and studying the dependence, defining a diagram of the change in the size of the force of retention, depending on the increase in the angle of guiding artificial surfaces.

References

1. Rodney PD, Cagna DR, DeFreest CF. Stewart's Clinical Removable Partial Prosthodontics. Quintessence Publishing Co., Inc. Chicago, 2008. http://www.thewitheringapple.com/stewart_39_s_clinical_removable_partial_prosthodontics

2. Stratton J. Russel. /Frank J. Wiebelt. An Atlas of Removable Partial Denture Design. Quintessence Publishing Co., Inc. Chicago, 1988. https://www.abebooks.co.uk/book-search/author/stratton-russell-j-und-frank-j-wiebelt/

3. Witter D, Barèl JC, Keltjens HM, Creugers NH. Designing metal frame removable partial dentures. Ned Tijdschr Tandheelkd. 2011; 118(2):79-87. https://doi.org/10.5177/ntvt.2011.02.10270 PMid:21438358

4. Frank RP, Brudvik JS, Leroux B, Milgrom P, Hawakins N. Relationship between standards of removable partial denture construction, clinical acceptability, and patient satisfaction. J Prosthet Dent. 2000; 83:521- 527. https://doi.org/10.1016/S0022-3913(00)70008-4

5. Loney W R. Removable Partial Denture Manual, Dalhousie University, 2011. removpros.dentistry.dal.ca/ewExternalFiles/RPD%20Manual%2011.pdf

6. The Glossary of Prosthodontic Terms. JPD. 2005; 94(1):10–92.

7. Henderson D, McGivney GP, Castleberry DJ. McCracken`s Removable Partial Prosthodontics. 7th ed. St.Louis: The C.V. Mosby Co., 1985.

8. Akaltan F, Kaynak D. An evaluation of the effects of two distal extension removable partial denture designs on tooth stabilization and periodontal health. J Oral Rehabil. 2005; 32:823-829. https://doi.org/10.1111/j.1365-2842.2005.01511.x PMid:16202046

9. Vaibhav D Kamble, Rambhau D Parkhedkar. A device for recording and reproducing the path of insertion for removable partial dentures. Indian Journal of Dental Research. 2015; (25)2:260-262.

10. Mamoun JS. The path of placement of a removable partial denture: a microscope based approach to survey and design. J Adv Prosthodont. 2015; 7(1):76-84. https://doi.org/10.4047/jap.2015.7.1.76 PMid:25722842 PMCid:PMC4341191

11. NaBadalung PD, Nicholls IJ, Brudvik SJ. Frictional Resistance of Removable Partial Dentures With Retrofitted Resin Composite Guide Planes. Int J Prosthodont. 1997; 10(2):116—122. PMid:9206450

12. Alfonso C, Toothaker RW. Wright RF., White GS. A technique to create appropriate abutment tooth contours for removable partial dentures. J Prosthodont. 1999; 8(4):273—275. https://doi.org/10.1111/j.1532-849X.1999.tb00051.x PMid:10895681

13. Ahmad I. Waters NE. Value of guide planes in partial denture retention. J Dent. 1992; 20(1): 59—64. https://doi.org/10.1016/0300-5712(92)90017-7

14. Han J, Wang Y. A preliminary report on designing Removable Partial Denture framework using a specifically developed software package. Int J Prosthodont. 2010; 23:370- 375. PMid:20617229

15. Niu E, Tarrazzi D. Use of a silicone transfer index to prepare parallel guide planes. J Prosthet Dent. 2010; 104:347-348. https://doi.org/10.1016/S0022-3913(10)60155-2

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16. Uemura E SH, JM da Silva, ALS Borges, ETC Yamamoto. Techniques for preparing of guide planes: in vitro comparative study. Braz Dent Sci. 2014: 17(2): 60-71. https://doi.org/10.14295/bds.2014.v17i2.936

17. Walter JD. Partial Denture Technique, Part 4: Guide Planes. Brit Dent J. 1980; 148: 70-72. https://doi.org/10.1038/sj.bdj.4804382 PMid:6986155

18. Canning T, O'Sullivan M. Acrylic resin jigs as an aid to parallel guiding plane preparation. J Prosthet Dent. 2008; 99(2):162-4. https://doi.org/10.1016/S0022-3913(08)60034-7

19. Waghorn S, Kuzmanovic DV. Technique for preparation of parallel guiding planes for removable partial dentures. J Prosthet Dent. 2004; 92(2):200-1. https://doi.org/10.1016/j.prosdent.2004.05.011 PMid:15295332

20. ALS Borges et al. Evaluation of a New Intraoral Paralleling Device for Creating Guiding Planes: A Pilot Study. The Journal of Contemporary Dental Practice. 2010; 11 (1): 1-7.

21. Krikos AA. Preparing guide planes for removable partial dentures. J Prosthet Dent. 1975; 34(2):152-5. https://doi.org/10.1016/0022-3913(75)90007-4

22. Garcia LT, Bohnenkamp DM. The use of composite resin in removable prosthodontics. Compend Contin Educ Dent. 2003; 24(9): 688—690. PMid:14596209