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The influence of the retention feature in artificial teeth on its attachment to the thermoplastic resin denture base

Influência da forma de retenção em dentes artificiais de resina acrílica na fixação na base de prótese termoplástica

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ABSTRACT

Objective: Teeth play a crucial role in masticatory efficiency and esthetic harmony making rehabilitation of partially edentulous patients a challenge because of the limitations of conventional removable partial dentures. As a therapeutic alternative, thermoplastic polymers are used in current dental practice either for practical processing purposes or aesthetics. However, it is recognized that the bond between acrylic resin artificial teeth and thermoplastic polymers has no chemical interaction, and depends on retentive features added to the teeth. This study analyzed the efficacy of two retentive forms of features through compressive strength test and as a secondary outcome, fracture and displacement resistance test. **Material and Methods:** Three groups of samples each with 14 sets of acrylic teeth were compared when two retentive features, single hole and groove retention, and a control group with teeth without any specific form. The experimental unit consisted of six maxillary anterior teeth, positioned in a linear pattern into a polypropylene block, where each tooth was submitted to a static load until its removal, on a universal testing machine. **Results:** Those specimens with a groove retention presented larger resistance to displacement when compared to the other groups ($p < 0.05$). This was emphasized by the fracture of the tooth tested, with part of the cervical portion remaining embed in the base, and not its displacement as with (or without) the retentive feature. **Conclusion:** In this study, the type of retention influenced significantly to a better retention considering teeth and thermoplastic polymer base. The data in this study indicates that a groove placed on the artificial tooth offers significantly better retention efficacy to the point where the displacement was only possible after its fracture.

KEYWORDS

Artificial teeth; Acrylic resins; Denture base; Polypropylene; Retention.

RESUMO

Objetivo: Os dentes são um fator essencial na eficiência mastigatória. A harmonia estética e a reabilitação dos indivíduos parcialmente dentados tornam-se um desafio, frente às limitações das próteses parciais removíveis convencionais. Como uma alternativa terapêutica, os polímeros termoplásticos são utilizados na odontologia contemporânea, tanto para o seu processamento prático como seu apelo estético. Entretanto, pouco se sabe a respeito da união entre a resina acrílica de dentes artificiais e resinas termoplásticas, assim como a influência dos mecanismos de retenção, uma vez que não há interação química entre eles. O objetivo deste estudo foi analisar duas formas de retenção de dentes de resina acrílica a bases de prótese de material termoplástico, por força compressiva e como desfecho secundário, teste de resistência a fratura e deslocamento dos dentes artificiais. **Material e Métodos:** O presente estudo analisou dois tipos diferentes de retenções: uma cavidade com único

ponto e uma canaleta de mesial a distal; e como grupo controle, dentes colocados sem qualquer recurso específico. A unidade experimental consistiu de seis dentes superiores anteriores, posicionados em linha em um bloco de polipropileno. Em cada dente artificial foi aplicada força até a sua remoção, em uma máquina universal de ensaios. **Resultados:** Os resultados mostraram que a retenção com canaleta apresentou maior força de deslocamento, quando comparado com os outros grupos ($p < 0,05$). Tal fato foi evidenciado pelo teste de fratura e deslocamento, no qual parte da porção cervical do dente artificial permaneceu unida à base, não ocorrendo o deslocamento com (ou sem) a retenção. **Conclusão:** Neste estudo, o tipo de retenção influenciou de forma significante a retenção de dentes artificiais de resina acrílica a bases de prótese termoplásticas. Os dados deste estudo indicam que a confecção da retenção em canaleta nos dentes artificiais oferece significante aumento na eficiência da retenção, ao ponto em que o deslocamento do dente ocorreu somente após sua fratura.

PALAVRAS-CHAVE

Base de dentadura; Dente artificial; Polipropilenos; Retenção; Resinas acrílicas.

INTRODUCTION

The main goal of oral rehabilitation of edentulous subjects is to achieve masticatory function. However, aesthetics is also a matter to be valued, especially now when patients expect to have bright, white teeth in their mouths [1]. The sight of metal clasps of the removable partial dentures (RPDs) in the patient's smile will be disappointing to him both cosmetically and psychologically [2]. An alternative removable partial denture has been developed that avoid the use of conspicuous clasps [3] by employing thermoplastic polymers (TR) and injection molding which eliminate the need for metal retainers [2]. Polyamide, polyester, polycarbonate and polypropylene are examples of polymers which offer a more pleasing result. Added advantages include easier handling during insertion and removal of the dentures and high fracture resistance of its base. However, it has been alleged that these thermoplastic partial dentures may adversely affect the periodontal tissues of the abutment teeth and the residual ridge [2]. But perhaps the most troublesome problem with these materials is the frequently observed detachment of the artificial denture teeth from the base [4-7]. While acrylic resin teeth (ARAT) are chemically bonded to conventional polymethyl methacrylate (PMMA) resins, artificial teeth have no chemical interaction with the thermoplastic polymer denture and, as such, are susceptible to dislodgement [3].

Surface treatments and mechanical retention features have been applied to artificial teeth in order to overcome the detachment issue, though little has been presented on the influence of the retention mechanism characteristics on its efficacy. The aim of this study was to analyze two forms of retention of ARAT to TR denture bases through a compressive strength test.

MATERIALS AND METHOD

A total of 42 sets of the six anterior maxillary artificial teeth (Natusdent, VIPI Indústria Comércio, Exportação e Importação de Produtos Odontológicos Ltda, Brazil) were divided into 3 groups (Figure 1):

Group I (n=14) (GI): no retentive feature applied.

Group II (n=14) (GII): a retention hole was made with a 3.5 mm diameter round bur (Spherical Carbide JET-PM # 8, Labordental, Brazil).

Group III (n=14) (GIII): a groove retention was made with a 3.5 mm-diameter round bur (JET-PM # 8, Labordental, Brazil).

The experimental unit consisted of artificial teeth set up at a 45° angle to the tip of the universal testing machine (VersaTest Mecmesin Ltd, UK) on wax blocks formed with a RTV silicone mold. This angle simulated the natural relation of the load applied by the inferior incisors [8-10].

This unit was transformed into the experimental specimen of polypropylene (Rocalflex, Brazil) processed by injection molding, under controlled temperature and pressure. The resulting samples were polished with wet-and-dry sandpaper (T223-37/A type 320 Norton, Brazil) and the supporting surface rectified to a plane in order to stabilize it on the VersaTest platform without the need of a fastening device [10]. The load force was applied to the incisal surface of each tooth at

Table I - Two -factor ANOVA and Tukey test. Comparison between types of treatment and groups of teeth (Canine, Lateral Incisors, Central Incisors) (p<0.05)

Group	Treatment	Difference	Q	p-value (p)
	GI- GII	416,667	52,399	< 0.01 *
Canine	GI-GIII	128,375	161,442	< 0.01 *
	GII-GIII	867,083	109,043	< 0.01 *
	GI-GII	8,875	11,161	ns
Lateral	GI-GIII	437,917	55,072	< 0.01 *
	GII-GIII	349,167	43,911	< 0.05 *
	GI-GII	134,583	16,925	ns
Central	GI-GIII	874,583	109,986	< 0.01 *
	GII-GIII	74,000	93,061	< 0.01 *

(Group I: none; Group II: retention hole; Group III: groove retention). * indicates results with significant statistic differences.

Figure 1 - Artificial teeth with the respective retentive feature: (a) Group I – none; (b) Group II – retention hole; (c) Group III – groove retention.

0.05 mm/min and the necessary load to dislodge the tooth (Figure 2) verified. A spot observation was made to identify if the separation occurred at the interface of the tooth and its socket or thru the tooth itself, leaving part of its structure embedded (Figure 3) [10].

Compressive strength tests were run at random to avoid any sort of bias because of the application order. Therefore, both retention type and the test sequence were performed with the blinding to the operator. Data was collected and analyzed with BioEstat software (version 5.3, Instituto Mamirauá; Tefé, Brazil).

Figure 2 - Artificial teeth angled 45° in relation to the tip.

RESULTS

The data was grouped by teeth instead of being analyzed between left and right specimens because no statistical difference could be established among homologous. Lilliefors and ANOVA tests were used in the statistical analysis for the resulting displacement force, complemented by the Tukey test (Table I).

When comparing all three types of artificial teeth, it was observed that the groove retention (GIII) presented statistically significantly greater values than groups with no retentive feature (GI) or a retention hole (GII) (p<0,05) (Figure 4). For the incisors, however, while GIII consistently showed a significantly better performance, no statistical difference was observed between GI and GII (Figure 4).

When analyzing the types of treatment (no retention, hole and groove retention), Tukey test showed statistically significant difference (p<0,05) (Table II) for the analyzed groups.

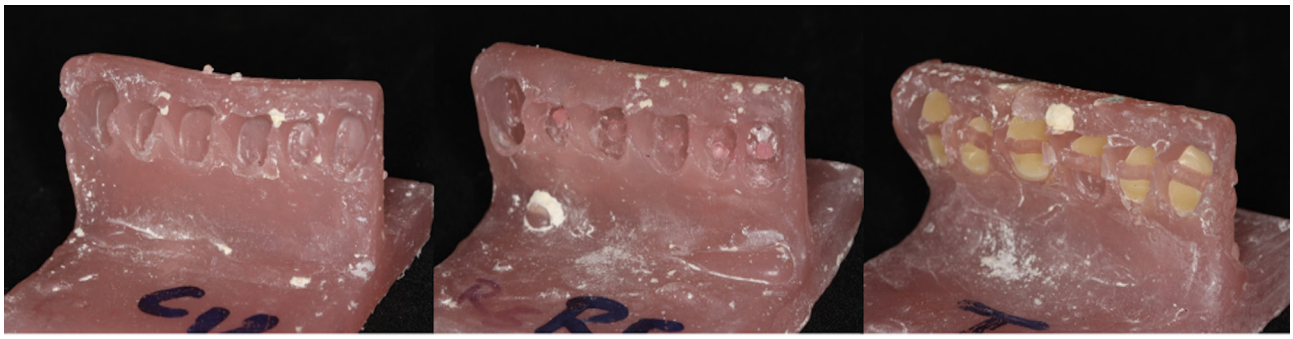

Figure 3 - Different types of fracture caused by the load force.

Table II - Two -factor ANOVA and Tukeys' test. Comparison between types of treatment (Canine, Lateral Incisors, Central Incisors) (p<0.05)

Treatment	Difference	Q	(p)
GI-GII	205,915	41,093	< 0.05 *
GI-GIII	866,338	172,89	< 0.01 *
GII-GII	660,423	131,797	< 0.01 *

(Group I: none; Group II: retention hole; Group III: groove retention).
* indicates results with significant statistic differences.

Higher retention was observed in GIII (Figure 5). It was also significant to note that a tooth where the retentive grove was placed practically could not be removed from its socket and the experimental cycle ended with its fracture at the cervical level, leaving part of its structure embedded in the base polymer (Figure 6).

DISCUSSION

One of the most common causes for partial denture wearers to return to the dental office is the tooth dislodgment of the artificial tooth from the denture base. There is little discussion available regarding the thermoplastic polymer vulnerability [3,11] when compared to studies for acrylic resin teeth adhesion to its denture base [6,9,10]. This has been theorized as a consequence of the lack of residual monomer in TR, differently from the acrylic resin base. Thus, there is no chemical adhesion between TR and ARAT a condition which might lead to dislodgment.

In studies with acrylic resin denture bases and ARAT, applied retentive features determined statistically significantly better results [9]. The values indicate that providing retention to the artificial teeth might improve resistance to their displacement in most specimens placed in thermoplastic polymer base. Both vertical and horizontal retention values presented better results.

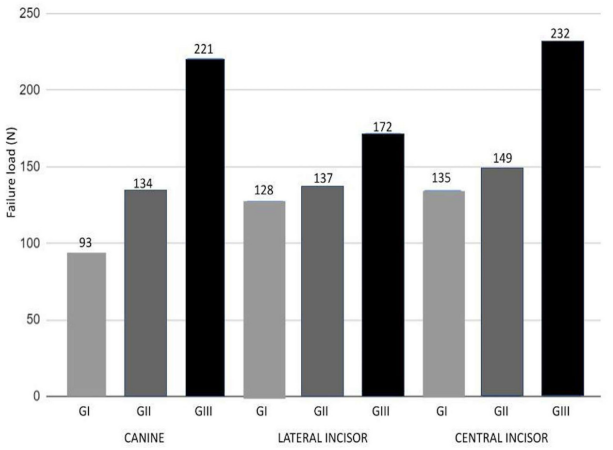

Figure 4 - Mean value from each group of teeth in its different groups (GI- no retention; GII – hole retention and GIII – groove retention).

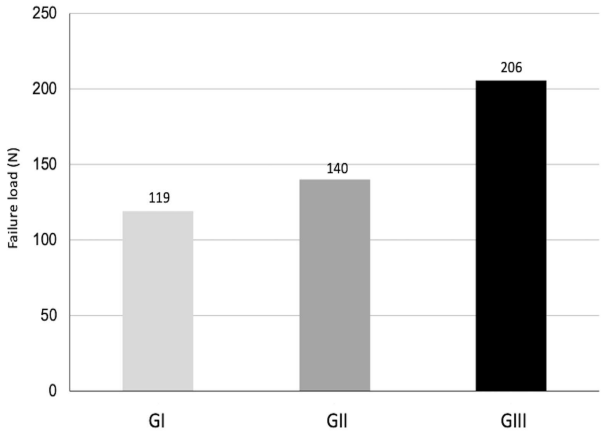

Figure 5 - Mean value for different group treatments (GI- no retention; GII – retention hole and GIII – groove retention).

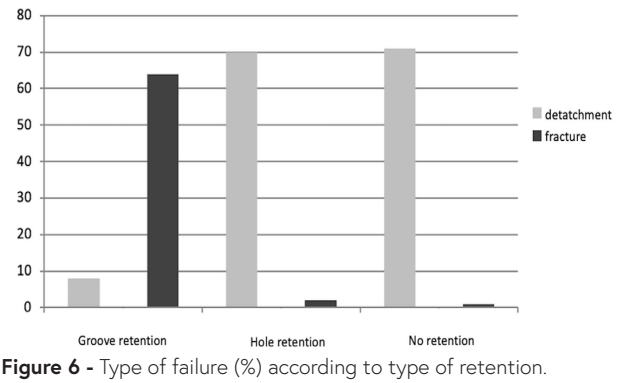

Figure 6 - Type of failure (%) according to type of retention.

By procedural determinant of the study, all experimental teeth were dislodged completely or suffered catastrophic fracture (Figure 6). Despite the deformation of the polymer socket when the the artificial teeth were displaced, there was no apparent fracture of the material in the contour of the tooth or in the place where the retention was made. Mechanical retentions improved ARAT fixation to acrylic resin denture bases, although it should be noted that the latter feature has a vertical orientation and no horizontal component [9]. However, Takakusaki et al. (2022) did report good results for composite artificial teeth retention in TR denture bases with a similar retentive form [11]. Our results indicate that the groove (horizontal) retention demonstrated consistently higher means for resistance (GIII - $p<0,05$). It is also interesting that all of the specimens in the control group (GI) were dislodged cleanly while the teeth with groove retention were fractured in their respective sockets. In those specimens with the hole type feature (GII), teeth did not fracture suggesting even though exhibiting better resistance than the control group, the retentive feature could not prevent the dislodgment.

The mean failure loads of GII and GIII were 140 N and 206 N, respectively. These values were significantly higher than those of the control group (119 N). All the experimental groups showed a mean value higher than 110N, which is the minimum bonding strength expected for a maxillary central incisor artificial tooth and an acrylic denture base resin, according to ISO 3336:1993 [12]. According to some authors [13,14], the maximum occlusal force at the anterior teeth is approximately 100–200 N. Therefore, the failure loads observed in this study are clinically acceptable and would be able to support the masticatory function.

Lateral and Central incisors presented no statistically significant results when comparing GI and GII. It has been reported that the hole diameter of the retentions might influence bond strength of the artificial [3], therefore an analysis with different sizes of burs might be necessary.

In order to improve retention of artificial teeth to TR, more studies on the subject are required. Studies with different materials for both tooth and denture base, as well as different retention formats and sizes.

CONCLUSION

Since there is no chemical interaction between TR and ARAT, the material requires additional forms of retention. The data in this study indicates that a groove placed on the artificial tooth offers significantly better retention efficacy to the point where the displacement was only possible after its fracture.

Author's Contributions

PRVM: Methodology, Validation, Investigation. MKM: Conceptualization, Methodology, Design of the study, Data Curation, Writing – Review & Editing. BC: Data interpretation, Formal analysis, Writing – Review & Editing. CMI: Writing – Original Draft Preparation, Writing – Review & Editing. RCS: Conceptualization, Methodology, Design of the study, Data Curation, Writing – Review & Editing.

Conflict of Interest

No conflicts of interest declared concerning the publication of this article.

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Regulatory Statement

Not applicable.

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