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Original Research Article

Alginate as a Natural and Gentle Abrasive Agent An In-Vitro Comparison with Pumice

Mohan Raj JP, Claudia Peter, Jonathan Enoch Zaccheus T, Jothiga M, Jothika V

Rajas Dental College and Hospital, Thirunelveli.

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Abstract - *Surface finishing and polishing of denture base acrylic resins are essential procedures to improve aesthetics, comfort, and longevity of dental prostheses. Traditionally, pumice has been widely used as a polishing agent in dental laboratories. However, interest in eco-friendly and sustainable alternatives has increased in recent years. Alginate impression material, which is commonly discarded after single use, contains diatomaceous earth that may possess abrasive properties. The present in-vitro study aimed to recycle alginate impression material and evaluate its potential as a polishing agent for denture base acrylic resin. Fifteen acrylic resin specimens were fabricated and divided into three groups: control (no polishing), pumice polishing, and alginate polishing powder. Surface roughness of the specimens was measured using a profilometer and statistical analysis was performed using two-way ANOVA. The results indicated that alginate polishing powder effectively reduced surface roughness and produced a smoother surface comparable to conventional pumice. The study suggests that recycled alginate powder may serve as a viable, eco-friendly alternative abrasive material for polishing dental prostheses.*

Keywords - *Alginate, Acrylic Resin, In-VITRO Study, Pumice, Surface Roughness.*

I. INTRODUCTION

Various materials have been employed for denture bases; however, poly(methyl methacrylate) (PMMA) remains the most widely used material [1]. This preference is due to its ease of manipulation, repair, and polishing, in addition to its favorable aesthetic properties and dimensional stability. Despite these advantages, PMMA exhibits certain limitations, including polymerization shrinkage, the potential for allergic reactions from residual monomer, and comparatively low wear resistance [2].

Furthermore, the quality of the final prosthesis is largely dependent on the surface finish achieved during polishing, which is significantly influenced by the operator's skill [3].In clinical dentistry, adjustments to denture base acrylic resin are frequently required. Such modifications disrupt the originally finished and polished surface, resulting in increased surface roughness [4].

This roughened surface can facilitate plaque accumulation and staining [5].The surface finish of acrylic resin prostheses is critical for achieving a smooth, glossy appearance that enhances their natural aesthetics [6]. A well-polished surface also minimizes irritation to oral tissues, thereby improving patient comfort. Additionally, it reduces plaque retention and bacterial colonization, which are essential for maintaining oral hygiene and preventing infections [7].

Traditionally, pumice has been the material of choice for polishing acrylic resins [8]. This fine abrasive powder, derived from volcanic ash, effectively smoothens acrylic surfaces to produce a polished finish. However, the use of pumice presents certain disadvantages. Its extraction and processing contribute to environmental concerns, including habitat disruption and carbon emissions associated with mining activities.

Moreover, as a finite natural resource, its continued use raises issues related to sustainability [9]. In light of these environmental concerns, there is increasing interest in identifying sustainable alternatives. This study introduces Alginate polishing powder, a novel polishing agent derived from recycled alginate impressions [10]. Alginate, a seaweed-derived material commonly used in dental practice for recording impressions of teeth and oral structures, is typically discarded after use. Alginate powder repurposes this waste into a functional polishing material, thereby promoting environmental sustainability and resource efficiency. The aim of this study was to evaluate the effectiveness of Alginate polishing powder in comparison with pumice in reducing the surface roughness (Ra) of acrylic resin. The null hypothesis stated that there would be no statistically significant difference in the polishing efficacy between Alginate polishing powder and pumice.

A. Aim and Objectives

The present study aims to assess the abrasive properties of alginate polishing powder and to evaluate its effectiveness in comparison with pumice. Specifically, the study focuses on analyzing the surface roughness of acrylic resin following polishing procedures carried out using alginate polishing powder and comparing the results with those obtained using conventional pumice. This evaluation helps in determining the suitability of alginate as an alternative polishing agent in dental practice.

II. MATERIALS AND METHODS

A. Sample Size Calculation

This study employed an in vitro experimental design. The sample size was determined using the means comparison formula with Statistical Software. Consequently, a sample size of 15 was obtained, then divided into three groups of 5 each. A total of 15 acrylic resin specimens were fabricated and randomly divided into three groups. Group A served as the control group and did not undergo any polishing procedure. Group B specimens were polished using pumice, which is a conventional polishing agent. Group C specimens were polished using alginate polishing powder. This grouping allowed for a comparative evaluation of the polishing effects of pumice and alginate on acrylic resin surfaces.

B. Fabrication of Alginate Powder

The fabrication of alginate polishing powder was carried out through a systematic process. Used alginate impressions were first collected, rinsed under running water to remove debris, and then disinfected by immersion in 2% glutaraldehyde for 10 minutes. Following disinfection, the impressions were thoroughly rinsed with distilled water to eliminate any chemical residues. The samples were then air dried using a chip blower and further dried in a hot air oven at 100°C for one hour until they became brittle. The dried alginate material was subsequently broken into smaller fragments and ground using a mechanical grinder to obtain a fine powder. This powder was then sieved through a 150-micron mesh to ensure uniform particle size, with any coarse particles being reground and sieved again to achieve a dehydrated, fine powder (figure 1). Finally, the prepared alginate powder was stored in an airtight container under dry conditions to maintain its quality.

Figure 1. Fabrication of Alginate Polishing Powder

C. Fabrication of the Acrylic Specimen

Rectangular acrylic specimens measuring 6 cm × 6 cm × 2 mm were fabricated using modelling wax patterns. The wax patterns generated were then flasked and processed using heat-cured acrylic material (Dental Products of India (DPI) heat-cure acrylic) (figure 2).

Figure 2. Fabrication of Acrylic Resin Specimens

D. Polishing Protocol

Samples were polished with sandpaper of various grits, 100→400→1,000. Shofu Acrylic Polishing bur kit was used with four burs, extra coarse (grey), coarse (blue), fine (dark green), and extra fine (light green) (figure 3). Group A were not polished and Group B with polished with pumice and Group C polished with Alginate polishing powder. The samples were then polished with a buff (wet buffing was followed by dry buffing) (figure 4). In Group A (unpolished), no Polishing was done. In Group B (Pumice), the 5 samples were finally polished with pumice using standard protocol. In Group C (Alginate), the 5 samples were finally polished with Alginate polishing powder using an identical protocol. Change in surface texture and translucency was noted for samples in all three groups.

Figure 3. Polishing of Acrylic Resin Specimens

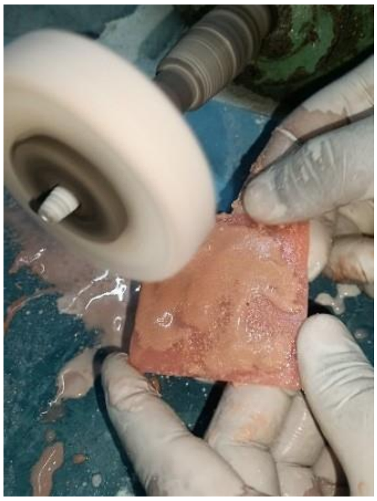

Figure 4. Buffing of Acrylic Resin Specimens

E. Analysis of Surface Roughness

A profilometer is used to measure the Ra of the polished samples, providing quantitative data on the efficacy of each polishing agent. The Ra (arithmetic average roughness) of each sample was measured using the profilometer at five different points per sample, averaging the readings for each group. The profilometer features a vertical measurement range of ±300 µm, a tip radius of 5 µm, and a cone angle of 90°.

Profilometric profiles were acquired over a traversing length of 10 mm. With a cut-off length of 0.8 mm, the arithmetic mean Ra values were determined. Each specimen underwent five measurements, with an incremental distance of 1 mm between each reading. The mean roughness value was calculated as the average of these five measurements. Measurements were taken in a direction perpendicular to the polishing direction (figure 5).

Figure 5. Surface Roughness Measurement Using Profilometer

F. Statistical Analysis

The Ra values obtained from the profilometer readings were analyzed using descriptive and inferential statistics with IBM® SPSS® version 25.0 (IBM, USA), considering a significance level of $p < 0.05$. The Ra of the resins was represented by the mean and standard deviation. The comparison of the average Ra values of the resin types subjected to a specific type of polishing with their respective controls was conducted using a non-parametric test. The Ra values were compared between different polishing methods using the Kruskal Wallis test for independent samples.

III. RESULTS

Surface roughness Profilometric profiles were measured across a 10 mm span. Using a cut-off length of 0.8 mm, the arithmetic mean Ra values were calculated. The following graph denotes the Ra values generated during the testing of the three groups (Graph 1). The Kruskal-Wallis test was performed to compare the means of the three groups, which showed p value < 0.05; indicating a significant difference.

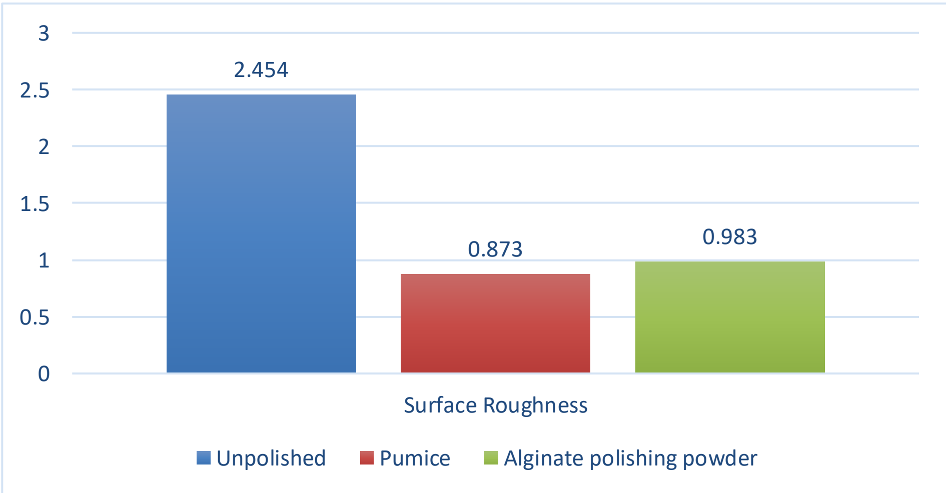

Figure 6. Comparison of Surface Roughness (Ra) Among Unpolished, Pumice-Polished, and Alginate-Polishing-Powder Groups

The table 1 provides Ra data for acrylic resin samples polished with different agents. Group A(Unpolished), has an average Ra value of 2.454 with a standard deviation of 0.5, indicating significant initial roughness and high variability, moderate surface smoothness and variability. Group B (Pumice), shows the best results with an average Ra value of 0.873 and a low standard deviation of 0.64, indicating the smoothest and most consistent surface finish. Group C (Alginate polishing powder) has the average Ra value of 0.983 and a standard deviation of 0.59, moderate surface smoothness and variability. Overall, Pumice outperforms Alginate in achieving a smoother and more consistent surface, while the Unpolished samples exhibit the roughest texture. The comparative data suggest that Pumice achieves a significantly smoother, surface finish compared to alginate. The

Kruskal-Wallis test was performed to compare the means of the three groups, which showed p value < 0.05; indicating a significant difference.

Table 1. Descriptive statistics and Intergroup comparison (Kruskal-Wallis Test)

S.No	Group	Mean	S.D	P value
1	Unpolished	2.454	0.5	<0.005*
2	Polished with pumice	0.873	0.64	
3	Polished with Alginate polishing powder	0.983	0.59	

*p-value <0.005 which is statistically significant

A. Discussion

The results of our study demonstrate that Alginate polishing powder, a novel polishing material derived from recycled alginate, effectively reduces the Ra of acrylic resin. This discovery is clinically and environmentally important. The major clinical advantage of a smoother acrylic resin surface is its improved esthetic result and patient comfort [11]. It is observed that the plaque formation is minimized on the polished surface which leads to decrease in the likelihood of oral infection and hence increase in the longevity of the dental prosthesis [12]. In order to seek natural alternatives to pumice as polishing material, other methods have also been tested. Polishing paste made from alginate powder has shown positive results when compared to traditional methods [13]. This topic has received limited attention in dentistry, and there is a lack of literature evaluating Ra with the experimental paste [14]. Based on the results presented, Alginate polishing powder can maintain or improve these clinical outcomes. With the confidence it provides, dental professionals can confidently use Alginate polishing powder, knowing that it meets the high standards required for patient care.

The most interesting feature of Alginate polishing powder is that it's recycled alginate impressions. Alginate, commonly used in dental impressions, typically ends up as waste after a single use. Alginate polishing powder helps reduce waste and fosters a circular economy in the dental industry by reusing the material for polishing. This is an increasingly significant sustainability element as dental practices work towards minimizing their environmental impact. Alginate polishing powder not only addresses the environmental impact associated with alginate disposal but also reduces the need for mining and processing pumice, further lessening ecological strain. The use of the alginate impressions in a polishing material may give dental practices a cost savings opportunity. Although traditional pumice is relatively cheap, it still comes with the costs of mining, processing and transportation.

By reusing alginate waste generated in-house, dental laboratories and practices can reduce material costs. Furthermore, if Alginate polishing powder is used, there may be a reduction in the costs of waste management, as there will be less waste to dispose of. Maintaining high-quality dental prosthetics is crucial for patient satisfaction and clinical success [15]. Using Alginate polishing powder results in the smooth surface, which makes acrylic resin prosthetics durable and wear resistant. A smoother surface will have reduced tendency to scratches and microbial colonization which ultimately can increase the useful life of the prosthesis [16]. This enhanced quality directly translates to fewer adjustments and repairs which equates to time and resource-saving for both dental professionals and patients [17].

The main limitation of this study is the lack of control over the force exerted during the acrylic polishing process, as well as the absence of a device to measure this force. To reduce the effect of this, the following criteria were used: All polishing was done by the same operator; The operator took short breaks after every 5 acrylic samples to avoid fatigue. One of the restrictions was the evaluation of only the microroughness of heat cured PMMA. Nonetheless, the use of Alginate polishing powder aligns with broader trends in healthcare towards sustainable practices and materials. As the dental industry becomes more conscious of its environmental impact, adopting eco-friendly materials like Alginate polishing powder can position dental practices as leaders in sustainability. This can enhance the practice's reputation among environmentally conscious patients and potentially attract a broader clientele. We need to ensure that the new material does not compromise the quality of the prosthetics ensuring continued patient satisfaction and clinical success.

B. Conclusion

The recycled alginate polishing powder exhibited good abrasiveness and was able to markedly reduce the surface roughness of acrylic resin specimens. The polishing results were comparable to those obtained with conventional pumice. Alginate polishing powder may therefore serve as a viable, eco-friendly, and cost-effective alternative polishing agent in dental procedures. Recycling alginate impressions into polishing powder also promotes sustainable waste management practices in dentistry while maintaining high standards of clinical outcomes.

In summary, Alginate polishing powder offers a promising sustainable alternative to traditional pumice for polishing acrylic resin in dental applications. It provides similar, if not better, surface quality, ensuring the aesthetic and functional excellence of dental prosthetics. Moreover, it is also a popular choice for dental practices that are dedicated to sustainability because of its environmental and economic advantages. Further research will help solidify Alginate polishing powder place in the dental industry, ensuring it meets the long-term needs of both patients and practitioners. While this study establishes the immediate effectiveness of Alginate in polishing acrylic resin, further research is necessary to understand its long-term implications fully. Key areas for future investigation include examining how the use of Alginate affects the long-term durability and wear resistance of acrylic resin prosthetics compared to those polished with pumice and conducting clinical trials to assess patient feedback on the comfort and appearance of prosthetics polished with Alginate polishing powder over extended periods.

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