An Alternative Approach to the Polishing Technique for Acrylic Resin Surfaces

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This study aimed to *(1)* devise a standardized method of polishing and finishing acrylic resins, *(2)* eliminate the variable linked to the single operator, and *(3)* guarantee the reproducibility of the conditions in which smoothness surface values are obtained for comparative purposes. Twenty acrylic resin samples were fabricated (Lucitone, Dentsply). Samples in group 1 were manually polished by a single experienced operator, while samples in group 2 were polished using an isoparallelometer. Surface roughness was measured for both groups with a ± 0.01-μm resolution profilometer (Mahr, GD25). Data analysis showed that mechanical polishing results in a more uniform surface quality. This preliminary investigation underscores the merits of a standardized method for polishing dental acrylic resins. This approach can eliminate the effect of human factors, thereby making it possible to assess and compare the inherent features of each polished dental material. *Int J Prosthodont 2008;21:409–412.*

Acrylic resins are used in dentistry to fabricate intraoral removable prostheses and orthodontic appliances.[1] Their polishing is of primary importance,[1] since in vitro studies demonstrate that microorganisms adhere better to rough surfaces.[2] Consequently, the accurate polishing of such materials' edges and surfaces may limit accumulation of bacterial plaque, thereby enhancing the material's biocompatibility.[3,4]

The roughness of dental acrylic resins is mainly affected by the inherent features of acrylic resins, the polishing technique and tools used, and the operator's manual skills. While the first 2 factors are regulated by precise standards, it is almost impossible to control the third. In fact, the International Organization for Standardization (ISO) standard 1567:1999/Amd 1:2003, "Denture Base Polymers," does not address the effect of the operator's manual skills.

This study aimed to verify the feasibility of establishing a standardized method of polishing acrylic resins regardless of an individual operator's skills. This would ensure repeatability and permit comparisons between different acrylic resins on a more homogeneous basis.

Materials and Methods

Twenty parallel pipe–shaped and thermopolymerized resin samples (Lucitone, Dentsply), each measuring $20 \times 20 \times 5$ mm, were divided into 2 groups of 10 samples each (Fig 1). Group 1 comprised the manually polished samples, while group 2 comprised the mechanically polished ones.

Figure 2 shows the mechanical polishing system used in this study. The mobile support has a metal base bearing the aluminium plate onto which the resin sample is fixed. The metal base and aluminium plate are joined by a perpendicular slot. The support is mounted on the carrying platform of a micrometric isoparallelometer. The speed of the motorized tool mandrel can be varied between 0 and 20,000 r/min (Precies Metaux,

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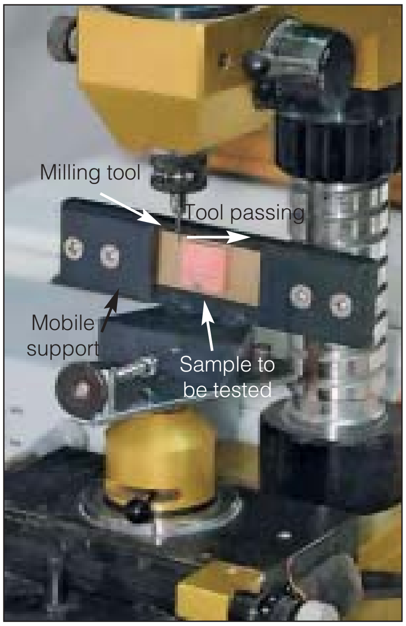


Fig 1 *(left)* Mechanically *(left)* and manually *(right)* polished acrylic resin samples tested in this study.

Fig 2 *(right)* The polishing device with a sample mounted.

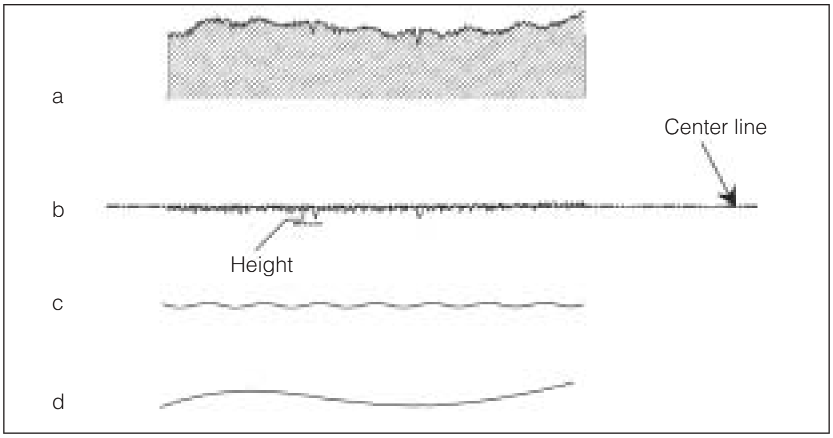


Fig 3 For a given surface *(a)*, the deviation from planarity can be considered as the sum over the roughness *(b)*, long wave-length irregularities *(c)*, and geometric shape errors *(d)*.

Neuchatel). The sample always remains parallel to the working axis of the tool. The working tool speed is 5,000 r/min as it progresses in the horizontal direction. Constant pressure is ensured by a micrometric movement system, which pushes toward the sample by 0.1 mm during each step. This value was maintained during finishing and polishing phases to eliminate the single operator's manual ability. All samples in both groups were polished following steps traditionally prescribed by ISO standard 1567/1999, using a tungsten carbide bur with a thin crosscut (ISO 500 104 302602 291) followed by a coarse grain cylindric rubber bur for acrylic resin (Super Acrylic Polish, Ravelli) and then a fine grain cylindric rubber bur. Next, a soft bristle brush with pumice dust was used, mixed with the same water volume, followed by a soft bristle brush with polishing dust.

The roughness of the samples was measured with a ± 0.01-μm resolution profilometer (Mahr, GD25).

The roughness parameters Ra, Rz, and Rmax were determined. As specified in the German Institute for Standardization no. 4768, Ra is the average of peak and valley distances, Rz is the average height of the 5 highest local maximums plus the average height of the 5 lowest local minimums, and Rmax is the maximum distance between the highest peak and the lowest valley. All roughness parameters are expressed in μm.

It is worth noting that Ra, Rz, and Rmax are computed by filtering surface height distributions as prescribed by DIN4768. Filtered height values are obviously different from height values measured directly by the profilometer. Filtering the output signal of the profilometer permitted removal of surface waviness introduced by low-frequency irregularities and shape errors. For a given surface, the deviation from planarity can be considered as the sum over the roughness (Fig 3), long wave–length irregularities, and geometric shape errors. The height of a generic irregularity with respect to the centerline is also represented in Fig 3.

In order to better describe the differences in roughness between a manually polished surface (group 1) and a mechanically polished surface (group 2), another parameter, Rtot, was introduced, which is defined in the same way as Ra but with unfiltered height values. In other words, Rtot describes the overall surface shape, including all irregularities that may be present.

A 1-way analysis of variance was carried out to determine the statistical significance of differences between roughness parameters measured for groups 1 and 2.

Results

Table 1 shows the roughness parameters measured as well as the corresponding average values and standard deviations for both groups. It can be seen that in each group, the mean value of Rtot is considerably larger than the mean value of Ra. The filtering operation removed most of the large-amplitude and low-frequency spikes of the surface profile, with Ra drastically reduced compared to Rtot.

Figure 4 compares the unfiltered surface profiles measured for the manually (group 1) and mechanically (group 2) polished specimens. The plotted curves are relative to the specimens that exhibited the maximum and minimum values of Rtot. The benefits of mechanical polishing are reflected by the increasing values of Rtot. Statistically significant differences were observed only for the Rtot values ($P = .048$).

Table 1 Roughness Data for the 2 Groups of Specimens Investigated

Specimen	Ra (µm)	Rz (µm)	Rmax (µm)	Rtot (µm)
Group 1				
1	0.175	2.681	9.920	0.916
2	0.170	1.534	3.120	0.594
3	0.163	1.923	2.880	3.138
4	0.101	0.922	2.240	1.515
5	0.141	1.446	2.540	0.665
6	0.140	0.633	1.200	4.646
7	0.176	1.031	1.490	0.801
8	0.139	0.920	1.430	2.788
9	0.170	1.166	1.580	1.788
10	0.200	1.317	1.850	3.156
Mean	0.158	1.357	2.825	2.007
SD	0.0277	0.593	2.576	1.370
Group 2				
1	0.118	0.615	1.260	0.347
2	0.115	0.737	1.260	0.960
3	0.113	0.973	1.920	1.760
4	0.176	1.576	2.860	0.869
5	0.192	1.029	1.230	1.750
6	0.151	1.016	1.660	0.879
7	0.079	0.623	0.810	0.435
8	0.182	1.174	1.800	0.870
9	0.101	0.733	1.730	1.409
10	0.173	0.960	1.280	0.990
Mean	0.140	0.944	1.581	1.027
SD	0.0395	0.292	0.562	0.483

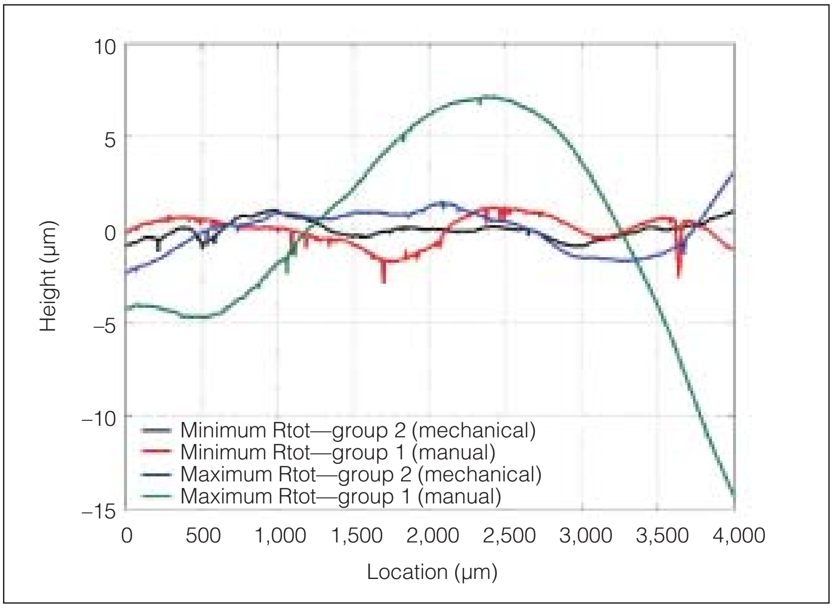
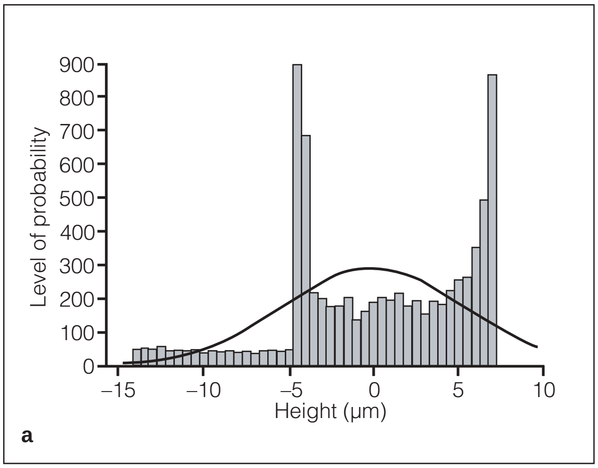
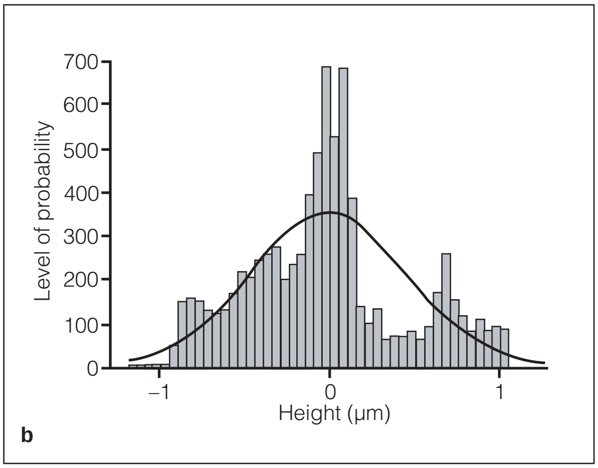


Fig 4 Unfiltered height distributions exhibiting the maximum and minimum Rtot values.





Figs 5a and 5b Probability of having a given surface height with respect to the centerline for **(a)** manually polished specimens and **(b)** mechanically polished specimens.

Discussion

From the analysis of roughness parameters, it appears that manual polishing results in larger average values of Ra, Rz, Rmax, and Rtot. While standard deviations found for Ra and Rz were rather close, those for Rmax and Rtot were between 3 and 5 times larger in the manually polished specimens (group 1). This may be explained by the fact that Ra and Rz provide "local" information, while Rmax and Rtot describe the whole shape of the surface.

The fact that statistically significant differences were observed only for Rtot confirms that this parameter is the most effective indicator of a surface's global level of precision. Figure 5 compares the probability of having a given surface height with respect to the centerline for each group. It can be seen that mechanically polished specimens exhibit a quasi-normal Gaussian distribution, while the distribution corresponding to manual polishing is clearly asymmetric. This seems to indicate that a procedure based on mechanical polishing can be standardized much more easily than a manual polishing process. The most important sources of geometric shape irregularities are human factors, which directly affect Rtot but cannot be standardized.

Conclusions

This preliminary investigation demonstrates the possibility of establishing a standardized method for polishing dental acrylic resins. This new approach could eliminate the effect of operator skill and make it possible to assess the inherent features of each acrylic resin. This could be useful when comparing different dental materials for which the polishing criterion is of primary importance.

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