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The effects of lubrication on the temperature rise and surface finish of glass-ionomer cements

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ABSTRACT

Object: Previous work [Jones CS. Factors influencing the finishing of direct filling materials. PhD Thesis, University of London; 2002] has shown that there is an optimum load, speed and time that produced the smoothest surface when finishing glass-ionomer cement using each of four grades of a disc system. This study looks at the effects of lubrication on the temperature produced in samples of GIC when finished dry and with different lubricants using these optimal loads, speeds and times. It also compares the surface finish produced using different lubricants.

Materials and methods: A thermocouple connected so that it permitted the display and recording of temperature against time was inserted 1mm into the base of samples of a glass-ionomer cement. The samples were finished and polished using each of the grades of a disc system in a specially constructed jig that mimicked oral finishing. After roughening, the pre-determined optimum loads, speeds and times were used sequentially for each of the four grades of disc. Five samples were tested for each method of finishing. Firstly run dry, then in turn lubricated with water, walnut oil and petroleum jelly. After the use of each abrasive disc the surface roughness was measured using a profilometer. One of the five samples was selected at random and prepared for examination in the scanning electron microscope. All results were subjected to non-parametric statistically analyses.

Results: Walnut oil and petroleum jelly produced significant temperature increases compared to both dry and with water finishing. Lubricated with water significantly reduced the temperature rise compared to dry. The Ra values of 0.5 μm was obtained for the coarse and a value of 0.3 μm for the medium discs run without lubrication. With lubrication the Ra increased although there was little difference between the lubricants. However the photomicrographs showed that walnut oil and petroleum jelly caused gross morphological changes indicating major surface destruction.

Conclusions: The practice of finishing GICs using petroleum jelly or similar lubricant appears to be detrimental. Further experimental work needs to be done to advise practitioners on finishing GICs to produce the smoothest surface possible.

1. Introduction

Finishing dental fillings is necessary to produce the required anatomical form, tooth aesthetics and patient comfort. Finishing can also eliminate food traps and may enhance the materials properties.

It has been determined that patients are able to distinguish differences in roughness values of between 0.25 and 0.5 μm

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with their tongues therefore the finish of a restoration should be as smooth as enamel.[2] The final surface of a restoration is therefore important and may be influenced by factors such as lubrication.

The Oxford English Dictionary's[3] definition of lubrication is "That which is employed to reduce friction by interposing a film between rubbing parts". The lubrication system must continuously replace the film. Industrially the commonest lubricants are water and crude oils. Finishing and polishing are frictional processes and as such will produce heat. Excess heat will damage the pulp[4] and therefore the need for lubrication may be important. It could also enhance or prejudice the finishing process.

A search of the dental literature resulted in very little work having been done on the science of finishing of dental materials and very few references to temperature changes during polishing apart from Christensen and Dilts[5] looking at thermal changes during polishing, Alpen et al.[6] looking at the effect of overheating on amalgam hardness and Stewart et al.[7] looking at the temperature rise in direct filling materials. None examined the correlation of temperature rise surface finish and lubrication.

A previous studies by one of the authors[1] examining the range of loads, speeds and times used by practitioners' when finishing glass-ionomer cement (GIC) showed they used loads between 17 and 92 g, speeds between 8000 and 25,000 rpm and times between 5 and 50 s. It would seem that they need guidance as to the optimum loads, speeds and times to use to get the best surface finish for glass-ionomer cements.

The mean figures from this practitioner study were used to conduct a laboratory experiment[1] to determine the optimum load, speed and time to produce the best surface finish.

These results show there is no improvement in the surface finish following the use of the medium disc. Finer discs render the surface rougher than before using the disc. However, the load of 20 g at 15,000 rpm for 20 s was the optimum for the green, fine, disc and was used in subsequent experiments, as were these values for the red, super-fine disc.

In clinical dentistry the common lubricants are water and petroleum jelly and in this study it was decided to investigate these and also the engineering standard – oil. If this oil were to be used clinically it would have to be biologically safe. For this reason in this study a light vegetable oil was chosen for the investigation. Walnut oil was selected as walnut shells are used in the tumble polishing of gold jewellery.

This current work examined the temperature rise in samples of GIC when finished dry, and when finished with different lubricants. The surface achieved with the different finishing methods was also recorded. These experiments were all done using the optimum values obtained from the laboratory study and using the same GIC and disc system.

2. Materials

A conventional glass-ionomer cement (Fuji IX, GC Corp.) was finished using the four grades of a disc system (Super-Snap discs, Shofu Dental). Table 1 shows the colour coding of the discs their abrasive particle size and particle distribution. The lubricants were water, walnut oil and petroleum jelly.

Table 1 – Showing the colour coding, particle size and particle distribution of the disc system

Grade of disc	Coarse (black)	Medium (violet)	Fine (green)	Super-fine (red)
Particle size (μm)	>100	40	30	5–10
Particle distribution (No/200 μm^2)	6	16	72	750

3. Method

Samples of the material were mixed according to the manufacturers instructions and packed into a specially constructed brass mould. Producing samples 25 mm long by 6 mm wide by 2 mm deep. The samples were stored in deionised water in an oven at 37 °C for at least 24 h. They were pre-roughened to a Ra value of between 2.5 and 3.5 μm. This was determined using a two-dimensional profilometer (Mitutoya Surftest, Japan). Six runs were recorded; the readings were taken 0.5 mm apart in the axis of the sample. The traversing length was 4.8 mm with the cut off point of 0.8 mm. This roughness figure matched clinical conditions where some adjustment of the surface has been necessary after removal of the matrix. This surface roughness value is similar to that achieved after using a white stone.[8]

All the experiments were then conducted at the loads, speeds and times from the laboratory experiments and these values are shown in Table 2.

3.1. *Method for temperature rise*

The samples were constructed with a thermocouple that was inserted 1 mm into their base.

Fig. 1 shows the laboratory jig for finishing the samples. This comprised a flat bed that could be moved in the horizontal plane. A brass plate with the attached, pre-roughened sample was screwed to the flat bed. The sample with the wire from the thermocouple was connected via a pre-calibrated electronic thermometer to a computer that permitted the display and recording of temperature against time. This permitted temperature variations to be recorded at second intervals. The flat bed was capable of reciprocal movements of 20 mm 30 times a minute. A handpiece with the disc was attached to an articulated arm. This arm was capable of vertical movement in one plane. Attached to the arm was a platform to which weights could be added. The handpiece and disc were adjusted so that they were at the point of balance when the disc was just in contact with the surface of the

Table 2 – Optimum results from laboratory study for finishing glass-ionomer cement

Disc	Coarse (black)	Medium (violet)	Fine (green)	Super-fine (red)
Load (g)	40	30	20	20
Speed (rpm)	15000	15000	15000	15000
Time (s)	20	20	20	20