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Fine-tuning of Bioactive Glass for Root Canal Disinfection

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INTRODUCTION: Bioactive glasses of the SiO_2-Na_2O-CaO-P_2O_5 type have recently been suggested as topical root canal disinfectants[1]. Similarly to calcium hydroxide, the gold standard material for that purpose, bioactive glasses disinfect their environment via continuous release of alkaline species in a wet environment[2]. Antibacterial effect of bioactive glasses could be greatly enhanced by lowering their particle size and thus their immediate release of alkaline species[3]. On the other hand, the antimicrobial effect is also related to the capacity of these materials to continuously maintain an alkaline environment over time[4]. In the restricted volume of a root canal system, this effect might be related to the mass of bioactive glass material per total volume of the applied suspension. The hypothesis of this study was that more material per volume of bioactive glass slurry is obtained with a superfine (<2 µm) micrometric material or a micrometric/nanometric hybrid rather than a solely nanometric counterpart. This should correlate with alkaline capacity and antimicrobial effectiveness.

METHODS: Conventional bioactive glass 45S5 (45 wt% SiO_2, 6 wt% P_2O_5, 24.5 wt% CaO, and 24.5 % Na_2O) with a mean particle size of < 5 µm (NovaminTM, US Biomaterials Corp., Alachua, FL) was obtained from a commercial source. Bioactive glass 45S5 of nanometric size was prepared from suitable anion precursors as described earlier[3]. A hybrid material with 50/50 wt% of nanometric and micrometric bioactive glass, respectively, was mixed. Calcium hydroxide (Stoke Canon, Devon, UK) served as control. Defined slurries with known specific surface areas and masses were prepared in physiological saline solution. Continuous titration of the slurries with hydrochloric acid was performed, and their antimicrobial effectiveness was tested in extracted human premolars mono-infected with *E. faecalis* ATTC 29212 (N = 12 per material). Dentin samplings from layers of different depths were conventionally cultivated. The number of specimens showing residual growth of *E. faecalis* per sampled dentin layer was compared between groups applying Fisher's exact test with Bonferroni's correction. The alpha-type error was set at 0.05.

RESULTS: While the nanometric slurry had a 12-fold higher specific surface than the micrometric counterpart, the latter had a considerably higher alkaline capacity and a significantly better disinfecting capacity (Fisher's exact test, Bonferroni, $P < 0.05$). The hybrid slurry behaved similar to the micrometric one (Table 1).

Table 1. Residual growth ratio (sample-positive specimens/total specimens) in sampled dentin layers of human premolars infected with E. faecalis ATTC 29212 after 10 days of test and control treatments. Identical superscript letters indicate that there was no significant difference between respective treatments within a sampling layer.

Material	Layer 1	Layer 2	Layer 3
Nano	$11/12^A$	$12/12^A$	$12/12^A$
Micro	$1/12^B$	$1/12^B$	$1/12^B$
Nano-Micro	$3/12^B$	$3/12^B$	$3/12^B$
$Ca(OH)_2$	$0/12^B$	$0/12^B$	$0/12^B$

DISCUSSION & CONCLUSIONS: Based on the current and previous results, it may be concluded that a combination of nano- and micrometric bioactive glass could be useful for root canal disinfection, as this system shows an early-onset effect and long-lasting antimicrobial effect.

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