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Cutting ability of an ultrasonic retrograde cavity preparation instrument

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Abstract – The aim of this study was to investigate the cutting ability of a working ultrasonic instrument designed for surgical endodontic use (Neosonic, Amadent Corp, Cherry Hill, NJ, USA). Three designs of tip, designated CT 1 to CT 3 were calibrated by measuring their displacement amplitudes in air using light microscopy over a range of power settings. Extracted teeth were sectioned longitudinally and polished to produce a smooth dentine surface onto which the tips were applied for 1 minute over the above range of power settings at a load of approximately 20 g. The depth of cut in the dentine surface was measured using a two dimensional surface profilometry technique. Results showed that a raising of the power setting produced an increase in displacement amplitude and cutting ability for all tip designs. This increase was linear, with minimal cutting occurring at lower power settings. In conclusion the ultrasonic tips could be successfully used to remove dentine, and medium to high power settings optimised their efficiency.

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Ultrasonic instruments are used in clinical dentistry for a variety of tasks ranging from the scaling of teeth to the cleaning of root canals. This latter technique is termed endosonics (1) and is a useful adjunct to conventional therapy as the ultrasonic file, together with the associated acoustic streaming in the irrigant solution, cleans and shapes the root canal.

The first application of ultrasound in apical surgery was described by Richman (2) where an ultrasonic chisel was used to cut bone and resect tooth tissue. This work followed previous studies investigating the use of ultrasonic instruments to prepare cavities in the crowns of teeth (3–6). Later an ultrasonic drill based on modified ultrasonic scaling tips was used to prepare retrograde cavities in teeth and condense amalgam root end fillings (7). It was claimed that such an instrument improved surgical access and allowed efficient root end debridement.

There are now specially designed ultrasonic instruments for carrying out retrograde preparations and the use of these is becoming more widespread. Preliminary studies on the use of such instruments have been performed (8–10). There is however a need for further evaluation, in particular instrument calibration and cutting ability.

The aims of this study were to (i) calibrate a commercially available ultrasonic retrograde cavity preparation instrument, (ii) determine its effectiveness in cutting dentine.

Material and methods

The instrument used in this study was of a piezoelectric type with an operating frequence of 29 kHz (Neosonic, Amadent, Cherry Hill, NJ, USA). This was supplied with interchangeable stainless steel tips designed for retrograde cavity preparation in the root ends of teeth during apicectomy. The tips were attached to the ultrasonic handpiece by a screw thread and wrench, and had different angulations in order to facilitate their use in all areas of the mouth. Three designs of tip designated CT 1 to CT 3 were used in this study (Fig. 1a). CT 1 was described as a universal/isthmus preparation tip, and CT 2 and CT 3 as right and left main preparation tips.

Calibration of surgical tips

The CT 1–3 inserts were clamped individually in a vice and their dimensions measured at 2 mm intervals along the shank length using a pair of digital callipers (Mitutoyo Digimatic Callipers, Mitutoyo Corporation, Tokyo, Japan). Additional measurements were made as to the angle of bend.

The displacement amplitude of the retrograde surgical tips was measured under a light stereomicroscope (Wild 3M Stereomicroscope, 3M, St. Paul, MN, USA), at magnification ×120 using a technique described previously (11). A strong directional light was shone onto the tip causing small irregularities on the surface to appear as points of light. When the unit was activated these became elongated producing lines which represented the total amplitude of oscillation of the tips. This was measured for all three tips over the full range of instrument power settings on a linear scale from zero (0) to maximum (10). Five measurements were taken at each setting and the mean displacement amplitude (that is half the peak to peak displacement) calculated.

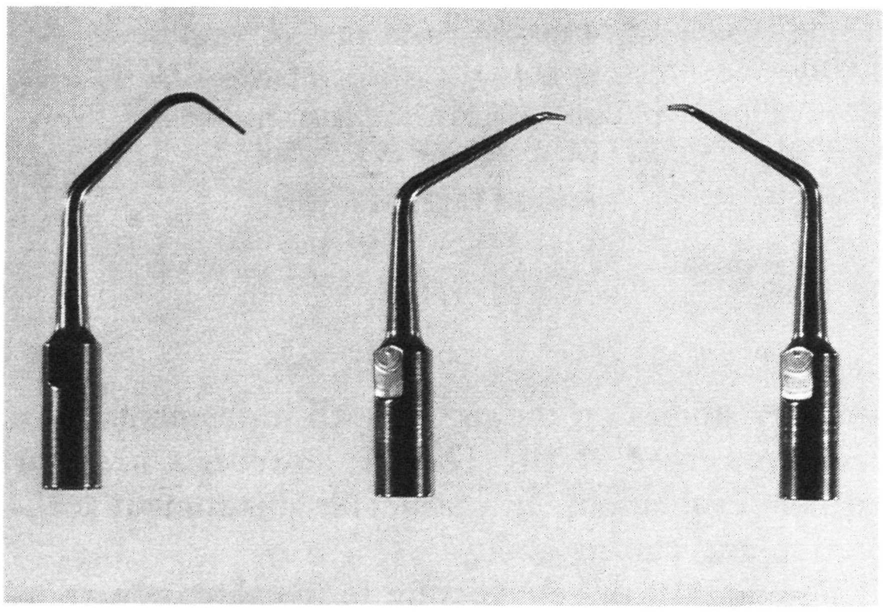

Fig. 1a. Photograph of surgical tips.

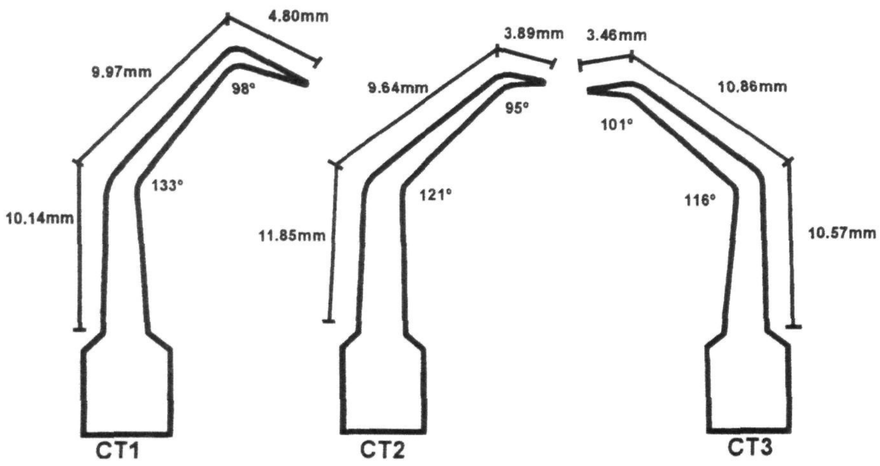

Fig 1b. Diagram showing dimensions of surgical micro tips. From l to r CT 1–3.

Preparation of specimens

Nine freshly extracted single rooted human teeth were selected, cleaned and stored in a 2% sodium hypochlorite solution. The teeth were polished to grade 220 grit along the longitudinal axis using a motor-driven rotating abrasive turntable (DAP7 Struers, København, Denmark) in order to produce a flat dentine surface onto which the oscillating surgical tip could be applied. The teeth were mounted in auto polymerising acrylic resin blocks with the prepared surface uppermost and attached to a pressure sensitive beam which had previously been calibrated with known weights. The activated ultrasonic tips were applied manually to the polished dentine surface for 1 min using a load of 20 g at 6 increasing power settings over the full range. Six runs were completed for each surgical tip.

Surface analysis and depth measurements

The prepared specimens were securely fixed in a small vice and the instrumented surfaces were measured using a Form Talysurf (Rank Taylor Hobson, Leicester, UK). This instrument consists primarily of a 2 μm tip diameter diamond stylus which can be traversed over a wide range of material surfaces within the confines of specific computer controlled reference points, in this case using a sampling length of 10 mm and a vertical range of 6 mm. Minute vertical and horizontal displacements in these surfaces are measured and analysed through software applications allowing accurate 2 dimensional traces to be produced. For the above measurements the Talysurf stylus was positioned to measure 1 mm in from the edge

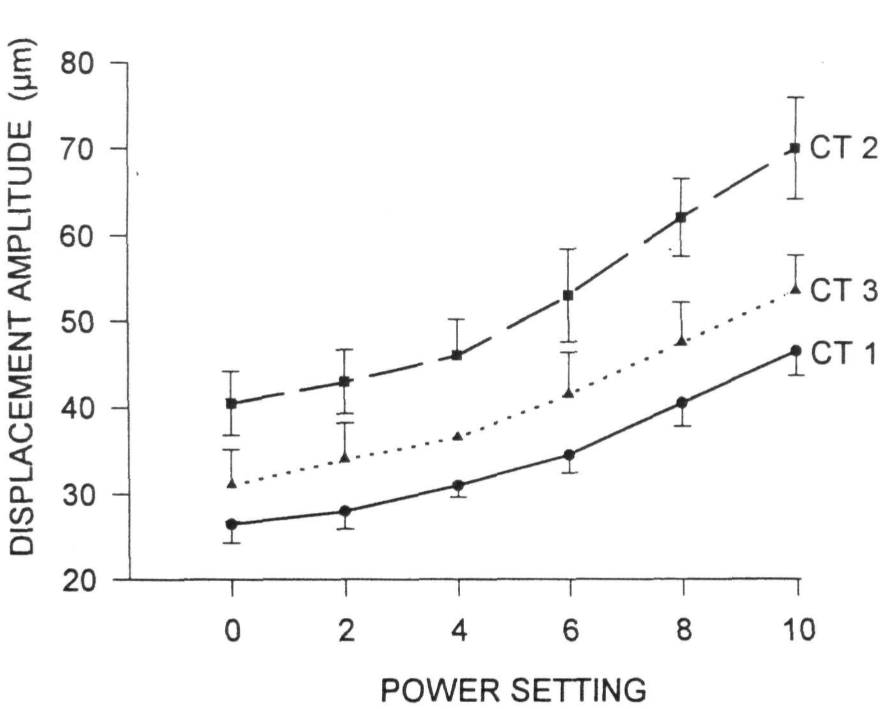

Fig. 2. Graphical representation of mean tip displacement amplitude as a function of power setting.

Table 1. The displacement amplitudes (n=5, 1 SD) of the CT 1–3 tips at each power setting

Power setting	0	2	4	6	8	10	ANOVA
CT 1	26.5±2.24	28.0±2.09	31.0±1.37	34.5±2.09	40.5±2.74	46.5±2.85	p<0.001
CT 2	40.5±3.71	43.0±3.71	46.0±4.18	53.0±5.42	62.0±4.47	70.0±5.86	p<0.001
CT 3	31.0±4.18	34.0±4.18	36.5±5.18	41.5±4.87	47.5±4.68	53.5±4.18	p<0.001

of the tooth surface to enable consistent measurement readings. Each experimental run of dentine grooves was measured twice. A polished tooth with no preparation was also measured to provide a negative control value for the surface roughness.

Results

The dimensions and degree of angulation of the surgical tips are shown (Fig. 1b). All the tips appeared to be made from the same stainless steel blanks with an average tip diameter of 0.35 mm±0.03 mm (n=3, 1 SD) and the same taper along their length. The CT 2 and CT 3 tips had similar angulations and positions of bend whereas the CT 1 tip exhibited a different geometry.

The displacement amplitude increased in a linear manner with increasing power setting for all three tips with the CT 2 tip exhibiting the greatest displacement (Fig. 2, Table 1). This was significant at all power settings (ANOVA, n=5, $p<0.001$).

A typical 2D Talysurf profile of the depth of dentine cut produced by a surgical tip is illustrated (Fig. 3). Six cuts are shown for the range of power settings which increased from left to right. A graphical representation of the mean depth of cut produced by the surgical tips is shown as a function of tip displacement amplitude in Fig. 4. It can be seen that the depth of cut increased in a linear manner along with displacement amplitude for all tips (Fig. 4). The control specimen of polished dentine showed surface roughness to be insignificant.

Discussion

The ultrasonic instrument used in this study is designed specifically to carry out retrograde cavity preparation as opposed to being a modification of an existing device. It is claimed to have several distinct advantages over conventional rotary preparation techniques, such as improved surgical access, an ability to prepare a cavity along the long axis of the root more easily, reduction of root face bevel, and speed of preparation. However, there is little information available regarding calibration of such equipment, and no quantifiable work has been carried out on its cutting ability.

The variation in oscillation of the retro-preparation tips can be attributed to the differences in tip design, in particular angulation and position of bend. The handpiece driver oscillates in a longitudinal manner, however, the transverse oscillations of the tips are dependant on their degree of offset from the long axis. The CT 1 tip exhibited the lowest oscillation and cutting ability. This tip is advocated for the preparation of fine isthmus are as between root canals and the safety aspects related to its lower displacement amplitude and cutting ability could be advantageous in the preparation of this difficult area. Both the CT 2 and CT 3 tips are described as main preparation tips, their angulations allowing them to be used on opposite sides of the mouth. These tips where shown to have higher displacement amplitudes and a greater cutting ability. An increase in displacement amplitude caused a linear increase in the tooth cutting ability of the tips and showed no signs of becoming exponential as maximum power was approached.

The optimal power setting to choose when using

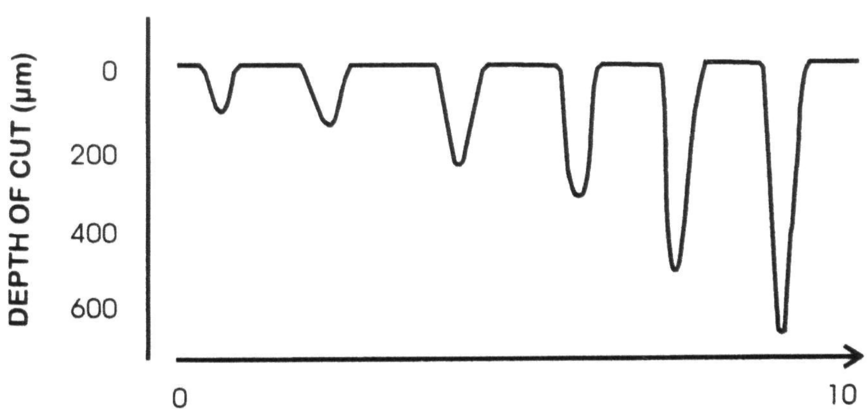

Fig. 3. 2D Form Talysurf profile of prepared dentine surface.

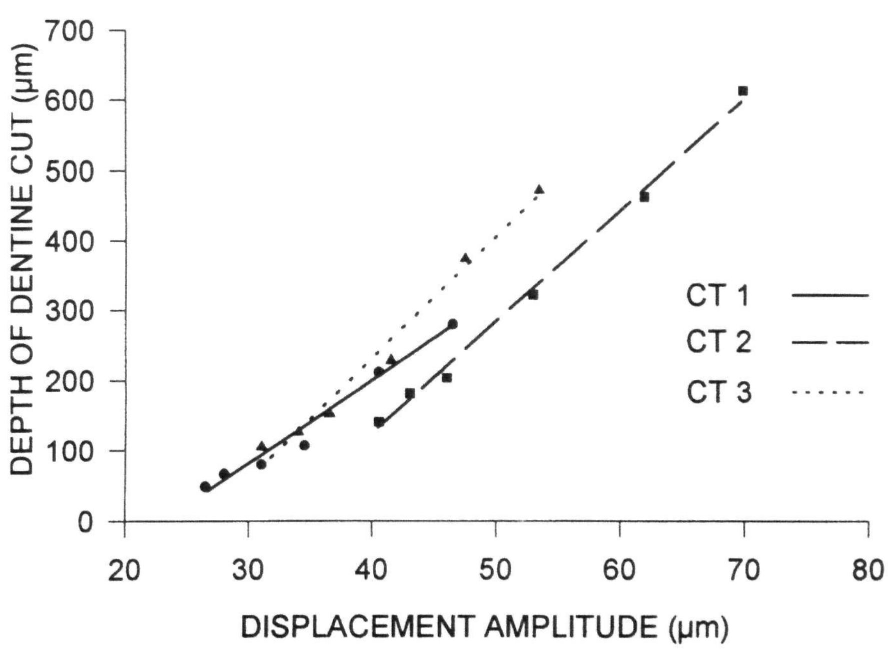

Fig. 4. Graphical representation of mean depth of dentine cut as a function of displacement amplitude for each tip.

an ultrasonic retrograde preparation instrument clinically is unclear as the tips are capable of removing tooth tissue across the full power range. However retrograde cavity preparation including both tooth and root filling material removal took longer at low power. It is therefore suggested as a result of this work that a medium to high power setting be adopted.

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