R12

E. Kim, J.Y. Hyun*, S.W. Jee, S.I. Bark & H.J. Chang
Department of Conservative Dentistry, Dental College, Yonsei University, Seoul, Korea

The effect of canal filling with Gutta-percha or Resilon on *Enterococcus faecalis* in bovine dentinal tubules

Aim To observe the effect of canal filling on survival of *E faecalis* remaining in dentinal tubules and to compare the sealing ability of Gutta-percha and Resilon (SybronEndo, USA).
Methodology Bovine teeth were sectioned to produce specimens 4 mm thick with 6 mm external diameter and 2.3 mm of internal diameter. *E. faecalis* was inoculated into the specimens and incubated. The outer surface was coated with nail varnish and the internal diameter was increased to 2.5 mm by using an ISO 025 round bur. The dentine specimens were divided into 5 groups by canal filling method. Group 1 was the negative control. Group 2 was the positive control. In Group 1 and 2, the internal surface of the dentine blocks was coated with nail varnish. Group 3 was filled with ZOE based sealer and Gutta-percha, Group 4 with resin based sealer and Gutta-percha, and Group 5 with resin based sealer and Resilon. After 24 h at room temperature, the blocks were incubated at 37°C for 1, 2, 3 and 4 weeks on BHI agar plates. The internal layer of the dentine blocks was removed using ISO 027, 029, 031, 035 round burs and the resultant dentine chips were incubated on culture medium at 37°C; for 24 h. Following incubation, the optical density of the medium was measured using spectrophotometer.
Results There was a statistically significant reduction in the number of *E. faecalis* in the group where dentinal tubules were completely sealed with nail varnish in comparison with the groups obturated with gutta-percha or Resilon. In group 5, the number of *E. faecalis* in the dentinal tubules decreased significantly with time, whereas in group 3 and 4, there was no reduction.
Conclusions Canal sealing ability of both Gutta-percha and Resilon was not complete since *E. faecalis* in dentinal tubules survived after canal filling. Evidence emerged that the resin based sealer and Resilon would exhibit a better root canal sealing ability in the long-term.

Research Posters – Canal Preparation

R13

H. Hecker*[1], T. Bartha[2], C. Lost[2] & R. Weiger[1]
[1]*Department of Periodontology, Endodontology and Cariology, University of Basel Institute of Dentistry, Basel, Switzerland &* [2]*School of Dental Medicine, University of Tübingen, Tübingen, Germany*

Procedural errors during shaping root canals to increased apical preparation sizes using Lightspeed rotary instruments

Aim To evaluate the incidence of procedural errors following root canal treatment with Lightspeed (LS) rotary instruments with increased apical enlargement.
Methodology A total of 80 patients (117 teeth with 287 roots) underwent root canal treatment which was carried out under standardized conditions by a trained operator using Lightspeed rotary instruments (85 molars, 25 premolars, 7 incisors). The apical portion was enlarged to sizes varying on average between sizes 40 to 60. The mean apical preparation size was 52.5. Sixty-three teeth were recalled after a mean interval of 25 months. Initial and recall radiographs were assessed using the periapical index (PAI). Procedural errors such as instrument fractures, perforations and root canal transportation were noted.
Results Only three LS instrument fractures occurred (sizes 37.5, 40, 52.5), all in the apical portion of the canal. The presence of the fractured LS instruments had no impact on apical healing. One perforation was noted in the middle third of the canal. No root canal transportation was observed.
Conclusions In the hands of a trained operator, root canal treatment with Lightspeed rotary instruments was a safe technique, allowing apical enlargement to sizes larger than commonly recommended.

R14

F.L.G. Calberson*, G.M.G. Hommez & R.J.G. De Moor
Department of Operative Dentistry and Endodontology, Dental School, Ghent University Hospital, Gent, Belgium

Shaping ability of ProTaper in comparison to a ProTaper–Profile combined technique in simulated root canals

Aim To compare the shaping ability of ProTaper (Dentsply Maillefer, Switzerland) instruments and the combined use of ProTaper and ProFile (Dentsply Maillefer) instruments in severely curved simulated root canals.
Methodology Thirty simulated canals with curvature of 40° and different shapes in terms of position of curvature (straight section before curve: 8 and 12 mm) were prepared using two different preparation methods: group A with the ProTaper instrument set (apical preparation to F3) according to the recommendations of the manufacturer; group B with ProTaper preparation of the coronal two thirds (S1 to F1) and apical enlargement with ProFile .04 taper (sizes 20–35). Pre-operative, sequential and post-operative pictures, recorded using a digital camera, were superimposed. Measurements were carried out at 5 different points: canal orifice (O); half-way to the orifice in the straight section (HO); beginning of the curve (BC); apex of the curve (AC); endpoint (EP).
Results In both canal types the total canal width was significantly higher in group A compared to group B at points HO, BC and AC ($P < 0.05$); a similar result was found for the transportation of the central axis at the apex of the curve (AC, $P < 0.05$). Mean transportation was towards the inner aspect of the curve in all canal types at BC, towards the outer aspect in canals with 12 mm straight section at AC. In both canal types, the mean transportation was significantly higher in group A at point AC ($P < 0.05$).
Conclusions Under the conditions of this study, apical enlargement of curved canals with ProFile .04 taper instead of ProTaper instruments resulted in less apical transportation and a more centred preparation shape in and beyond the apex of the curve.

R15

O. Yoldas*, H. Oztunc, A.S. Isci & A. Topuz
Faculty of Dentistry, Cukurova University, Balcali Adana, Turkey

In vitro comparison of four different instruments for preparation of simulated curved root canals

Aim To compare the shaping ability of Hero 642, Hero Shaper (Micro-Mega, France), NiTi-TEE (Tapered file System, Sjöding Sendoline AB, Sweden) rotary nickel titanium instruments and stainless steel Hand K-Files (Dentsply Maillefer, Switzerland).
Methodology A total of 60 simulated canals with 42° curves (Endo training block; Dentsply Maillefer Instruments) were prepared with either Hero 642, Hero Shaper and NiTi-TEE rotary nickel titanium instruments using a crowndown preparation technique according to the manufacturers instructions or with K-files using a stepback technique ($n = 15$ for each group). All canals were prepared up to an apical size 30. Preparation time, changes of working length and instrument failures were recorded. In addition, post-instrument images were taken and assessment of the canal shapes was examined by a computer image analysis program (UTHSCSA Image Tool for Windows, University of Texas, USA).
Results Four NiTi-TEE instruments and one K-file separated; none of the Hero 642 and Hero Shaper instruments separated. All Ni-Ti instruments were significantly faster and maintained working distance better than K-files. In comparison with stainless steel K-files all Ni-Ti rotary instruments maintained the taper of root canals.
Conclusions Hero 642, Hero Shaper and NiTi-TEE instruments prepared curved root canals rapidly, without changing working length and maintained the taper of root canal. Some NiTi-TEE instruments fractured.

R16

P.R. Wesselink, L.W.M. van der Sluis* & M.K. Wu
ACTA, Amsterdam, The Netherlands

The efficacy of ultrasonic irrigation to remove artificially placed dentine debris from human root canals prepared using GT rotary instruments with different tapers

Aim To investigate the influence of diameter and taper of root canals on the effectiveness of ultrasonic irrigation to remove artificially placed dentine debris from different-sized root canals.
Methodology Forty-four maxillary and mandibular canines were selected after bucco-lingual and mesio-distal radiographs indicated that their internal diameters were smaller than the diameters of a size 20, .06 taper GT instrument. These canines were divided into three groups and prepared using either size 20, .06 taper GT rotary instruments, size 20, .08 or size 20, .10 GT instruments. Each root was then split longitudinally through the canal, forming two halves. In one canal wall, a standard groove was cut 2 to 6 mm from the apex, to simulate uninstrumented canal extensions. Each groove was filled with dentine debris mixed with 2% NaOCl to simulate a situation when dentine debris accumulates in the uninstrumented canal extensions. Each canal was reassembled by joining the two halves of the teeth by means of wires and sticky wax. In each canal ultrasonic irrigation was performed using 2% NaOCl as irrigant. Before and after irrigation, images of each half of the canal with a groove were taken using a microscope and a digital camera, after which they were scanned into a PC as TIFF images. The quantity of dentine debris in the groove was evaluated using a scoring system: the higher the score, the larger the amount of debris. The scores before and after irrigation were compared.
Results After ultrasonic irrigation, the debris score reduced by 73.9%, 80.9% and 92.7% respectively in the size 20, .06, 20, .08 and 20, .10 taper groups. However, the difference amongst groups was not statistically significant ($P = 0.078$).
Conclusions There was a tendency for ultrasonic irrigation to be more effective in removing artificial dentine debris from canals with greater taper.

R17

H.G. Kuah*[1], S.K. Tseng[2] & N.N. Chen[1]
[1]National Dental Centre & [2]National University of Singapore, Singapore

Effect of chelating agents on smear layer removal with and without ultrasonics

Aim To evaluate *in vitro* the effectiveness of chelating agents on smear layer removal with and without the use of ultrasonics.
Methodology One hundred and five extracted teeth were randomly divided into 7 groups. They were mechanically instrumented to apical file size 40 with a combination of rotary and hand instrumentation. RC-Prep and 1% sodium hypochlorite (NaOCl) were used during instrumentation in all groups except for Group 1, where only saline was used. All 7 groups had different final irrigating protocols, which were as follows: Group 1: Physiological solution (saline) for 3 min with ultrasonics followed by saline; Group 2: NaOCl for 3 min followed by NaOCl; Group 3: NaOCl for 3 min with ultrasonics followed by NaOCl; Group 4: EDTA for 3 min followed by NaOCl; Group 5: EDTA for 3 min with ultrasonics followed by NaOCl; Group 6: EDTA for 1 min followed by NaOCl; Group 7: EDTA for 1 min with ultrasonics followed by NaOCl. The specimens were then vertically grooved, split and prepared for SEM examination. Specimens were evaluated at the apical (2 mm) and mid-root (6 mm) levels at 1000× and 3000× magnification. Smear layer and debris removal were scored by 2 examiners based on the patency of dentinal tubules and amount of debris observed. Results were subjected to statistical analysis using Chi-square / Fischer's Exact Test.
Results At the 2 mm level, only specimens from groups with EDTA and ultrasonic irrigation (Group 5 and 7) had significantly more specimens with smear layer and complete debris removal compared to the other groups. At the 6 mm level, regardless of the use of ultrasonics, the groups with EDTA irrigation (Group 4, 5, 6 and 7) had more specimens with smear layer removed. However, only specimens with EDTA and ultrasonic irrigation (Groups 5 and 7) had a significantly higher number of specimens with complete debris removal at the 6 mm level.
Conclusions Within the limitations of the study, the combined use of EDTA and ultrasonics is more efficacious for smear layer and debris removal especially in the apical region. A one minute application of ultrasonics in the final irrigation sequence appeared to be sufficient for this purpose.
Acknowledgements A/P V Sac-Lim, Dr Chan YH, Prof. G Bergenholtz.

R18

J. Tanalp*[1], F. Kaptan[1], B. Kayahan[1], S. Sert[2], M. Karapinar Kazandag[1] & G. Bayirli[1]
[1]Department of Endodontics, Faculty of Dentistry, Yeditepe University, Goztepe & [2]Gulhane Military Academy, Dental Service, Uskudar, Istanbul, Turkey

Scanning Electron Microscope evaluation of the effectiveness of Glyde File Prep® on the removal of the smear layer

Aim To evaluate the effectiveness of 'Glyde File Prep®' in the removal of smear layer produced by rotary instruments.

Methodology Thirty extracted human mandibular canine teeth were used. The teeth were divided into three groups of 10 teeth. Instrumentation was performed with Protaper (Dentsply Maillefer, Switzerland) rotary instruments. The final instrument used at the working length was size 30. Irrigation was performed as follows: group 1: Routine irrigation with 2 mL of 2.5% NaOCl and 2 mL of 17% EDTA after each file + Final irrigation with 10 mL of 17% EDTA and 2.5% NaOCl + Distilled water. Group 2: Each file coated with 'Glyde – File Prep®' before instrumentation + Final irrigation with 10 mL of 17% EDTA and 2.5% NaOCl + Distilled water. Group 3 (Control): Routine irrigation with 2 mL of 2.5% NaOCl after each file + Final irrigation with 10 mL of 2.5% NaOCl + Distilled water. The teeth were split longitudinally into 2 halves. The coronal, middle and apical root surfaces were evaluated under scanning electron microscope at ×500 and ×1500 magnifications and scored for smear layer using a point scale. The efficacy of the irrigant regime in terms of smear layer removal was evaluated.
Results Statistical analysis revealed a significant difference between the coronal, middle and apical aspects within each group at both magnifications ($P < 0.05$). Less smear layer removal was observed in the apical level in both experimental groups. No statistically significant difference was observed in terms of smear layer removal between the experimental groups.
Conclusions No significant difference existed in terms of smear layer removal when Glyde was compared with the traditional NaOCl + EDTA regime.
Acknowledgements The authors would like to thank Tubitak Gebze Research Institute for their contribution in this study.

R19

A. Braun*, D. Kappes, F. Krause & S. Jepsen
Department of Operative Dentistry and Periodontology, University of Bonn, Bonn, Germany

Efficiency of a novel rinsing device for the removal of pulp tissue *in vitro*

Aim To assess the efficiency of a novel pneumatic device for root canal rinsing by evaluating the amount of remaining adherent pulpal tissue on the canal surfaces.
Methodology The roots of 90 extracted teeth were divided into two groups and prepared up to size 20 or 40 using hand instruments. Teeth were not rinsed during root canal preparation procedures. After completing the preparations, root canals were randomly assigned to 3 groups: pneumatic rinsing with NaOCl 2% for 1 min (Endorinse, Duerr, Germany), conventional rinsing by hand using a syringe with NaOCl 2% for 1 min, no rinsing (control). Teeth were fixed in formalin and embedded in a light-activated PMMA medium. Sections of 30 µm were cut at intervals of 2, 4 and 6 mm from the apex. After staining the sections with toluidine blue the specimens were examined by light microscopic analysis. For each root canal the amount of unprepared root surface with and without adherent pulpal tissue was evaluated. Additionally, the amount of prepared root surface with and without a smear layer was determined.
Results Regarding the non-prepared surfaces, the amounts of residual pulpal tissue in the control group (size 20: 93 ± 10%, size 40: 95 ± 10%) and after conventional rinsing (size 20: 91 ± 14%, size 40: 95 ± 10%) were not statistically different ($P > 0.05$). Employing the pneumatic device (size 20: 75 ± 26%, size 40: 76 ± 16%), statistically significantly less pulpal tissue was found in the size 40 group ($P < 0.05$). Evaluating the prepared surfaces, the smear layer was removed similarly in all groups rinsed with NaOCl.
Conclusions The present study indicates that the novel pneumatic device is capable of removing pulpal tissue more efficiently than conventional rinsing by hand by reducing the amount of adherent pulpal tissue. The system could improve disinfection procedures during root canal treatment.

R20

D. Abdullah*[1] & M. Abdullah[2]
[1]Faculty of Dentistry, UKM & [2]Faculty of Dentistry, UM, Kuala Lumpur, Malaysia

An *in vitro* investigation of the accuracy of two new apex locators

Aim To investigate the accuracy of two new electronic apex locators (EAL), Elements (SybronEndo, USA) and Propex (Dentsply Maillefer, Switzerland), and to compare these results with the radiographic technique and a well-known apex locator, Root ZX (J Morita, Japan) using an *in vitro* model.
Methodology Thirty anterior teeth with straight canals stored in a 10% formalin were used. The coronal part of each tooth was reduced to create a fixed reference point. Access cavities were prepared and the actual lengths (ALs) were measured. The teeth were then embedded in an alginate model. Electronic tooth length measurements (ELs) were carried out using the three EALs. The measurements were repeated 3 times and an average computed. Periapical radiographs of each tooth were taken using a digital sensor and the radiographic lengths (RLs) were measured 0.5 mm short of the radiographic terminus. The teeth were then divided into 3 groups of 10 teeth each. All canals were enlarged to a size 40 K-file for 2/3rd of the canal length. Saline was used as irrigant. In group 1, EL measurements were then taken three times by each EAL in dry condition, in group 2 and 3, with saline and sodium hypochlorite in the canals respectively.
Results The results showed that all the EALs were highly accurate to within +0.5 mm of the apical foramen, with mean differences between the AL and EL by Root ZX was 0.31 mm (SE = 0.05), Elements 0.23 mm (SE = 0.04) and Propex 0.36 mm (SE = 0.07). RLs were significantly less accurate compared to the readings from all the EALs. No significant difference was found in the reading between the three apex locators when measurements were taken in dry canals and the sodium hypochlorite solution did not affect the accuracy of the measurements.
Conclusions Both Elements and Propex proved to be as reliable as Root ZX and were user friendly.

R21

A. ElAyouti, I. Kimionis*, A. Chu & C. Löst
School of Dental Medicine, University of Tübingen, Tübingen, Germany

Accuracy of three apex locators in root-end resected teeth

Aim To assess the accuracy of apex locators in determining the working length in root-end resected teeth.
Methodology Ninety extracted human posterior teeth with 182 root canals were used. The root canal system was accessed, the canals prepared to a minimum of size 40 and then filled with gutta-percha and sealer. The apical 3 mm of root was then resected and the root fillings removed using Hero NiTi rotary instruments (MicroMega, France). The size of the apical terminus of the root canals following removal of the root fillings was between 50 and 90. The apical terminus of the root canal was then determined using 3 apex locators (Root ZX, J Morita; Raypex®4, VDW Germany; and Apex Pointer, Micro Mega, France). The media used for the measurements was isotonic salt solution (0.9% NaCl). A new mounting model that utilizes a micrometer was used to perform the measurements. The repeatability of each apex locator and the inter-operator agreement was determined.
Results All apex locators had a clinically acceptable repeatability; (0.03 mm coefficient of repeatability) and narrow limits of inter-operator agreement (+0.07 and –0.07 mm). The accuracy of determining the apical terminus within 1 mm in the root canal was as

follows: Root ZX 90% (164/182 root canals) [95% CI: 86%; 94%], Raypex®4 74% (135/182) [95% CI: 68%; 80%], and Apex Pointer 71% (129/182) [95% CI: 65%; 77%]. No overinstrumentation resulted when the Root ZX device was used. In contrast, using the Raypex®4 or the Apex Pointer device resulted in overinstrumentation in 8 out of 182 root canals (4%).
Conclusions All three apex locators were able to detect the apical terminus of root-end resected teeth within a clinically acceptable range, however; the Root ZX device had the greatest accuracy and resulted in no over-instrumentation of the root canal.

R22

J. Jan*[1] & D. Kri**ž**aj[2]
[1]*Department of Endodontics, Medical Faculty &* [2]*Faculty of Electrical Engineering, University of Ljubljana, Ljubljana, Slovenia*

Influence of canal wall thickness on electronic working length determination

Aim To investigate the influence of canal wall thickness on working length determination with the impedance method.
Methodology Electrical impedance was measured *in vitro* on three extracted single-canaled human teeth using an HP 4284 LCR meter (Hewlett Packard, USA). A file electrode was inserted into the root canal, the second electrode was placed in the saline solution surrounding the tooth. Measurements were performed at frequencies from 500 Hz to 20 kHz and repeated with different distances of the file from the apical foramen. From the data, electrical lumped element models were developed. Numerical simulation with Femlab (Comsol, Sweden) was performed to investigate the influence of the canal wall thickness on current conduction through the tooth.
Results With smaller thickness of the dentinal canal wall electrical conductance was increased and a reduction in impedance due to current flow directly through the dentine wall was observed. Changes in impedance caused by varying the distance of the file from the apical foramen were smaller and more difficult to interpret, which reduced the accuracy of the method. The use of impedance ratios measured at different frequencies improved the accuracy of apical foramen determination.
Conclusions Thickness of the canal wall is an important parameter influencing the accuracy of the impedance method for working length determination in root canal treatment.
Acknowledgements Supported by the Slovenian Ministry of Science, Education and Sport (No. J3-8713-0381-99).

R23

M. Kuzminski*
Department of Endodontology, Medical University of Lodz, Lodz, Poland

Apical extent of rotary canal instrumentation with an apex locating engine-driven canal preparation system

Aim To evaluate the apical extent of rotary canal instrumentation using the Dentaport (J Morita, Japan) at different automated settings.
Methodology Forty extracted human teeth with single roots with apparently mature apices were selected. Teeth were embedded into freshly mixed alginate mould. The canal lengths were measured initially using the Dentaport apex locator to the apical constriction and then instrumented with nickel titanium rotary files. For the instrumentation the automatic apical reverse mode was set to 0.5 (group A) and 1 (group B) that corresponded to different distances from the apical foramen (20 teeth in each group). Then a file was secured at the working length with a composite material. The tip of a size 10 K-file was introduced to the canal 2 mm deep from the apex side to mark the localization of the apical foramen. The apical 4 mm of the canal of each tooth was exposed by grinding with a water-cooled, high-speed diamond bur. Distances from the file tip to the apical foramen were measured with the use of an endodontic microscope (Karr, Switzerland) under 17-fold magnification. Paired *t*-tests were used to compare the results from both experimental groups.
Results When the automatic apical reverse mechanism's setting was 0.5, the instrumented length was 0.31 shorter then visually measured lengths and 0.2 shorter than electronically measured length. When the automatic apical reverse mechanism's setting was 1, the instrumented length was 0.43 mm shorter than visually measured lengths and 0.3 mm shorter then electronically measured length. There was a statistically significant difference between both groups ($P < 0.05$). Eight canals were instrumented up to apical foramen in group A and only in one in group B.
Conclusions The apical extent of rotary canal instrumentation was more consistent when the automatic reverse setting mechanism was set to 1.

R24

M. Leski* & H. Pawlicka
Department of Endodontics, Medical University of Lodz, Lodz, Poland

The effect of apical root-end preparation on crack formation

Aim To evaluate the effect of ultrasonic and bur apical root-end preparation on dentine crack formation.
Methodology Eighty single rooted teeth were prepared chemomechanically and filled with gutta-percha and AH Plus (Dentsply DeTrey, Germany) sealer using a lateral condensation technique. The root-ends were resected with a fissure bur. All teeth were randomly divided in two equal groups. In group 1 root-end cavities were prepared to a depth of 3.0 mm using a 010 inverted cone steel bur mounted on a slow speed micro-handpiece. In group 2 root-end cavities were prepared with S12/90.D tips (Satelec, France) at the intensity recommended by the manufacturer (*P*ower 7 at power mode S). All resected surfaces were analyzed and photographed using an endodontic microscope OPM 1F (Karr Dental, Switzerland) at ×34 and ×60 magnification before and after root-end preparation. Differences in the numbers of cracks following root-end preparation compared to those seen after root resection were recorded and analysed using the Fisher exact test ($P < 0.05$).
Results Dentine cracks before root-end preparation were noted in 14 roots of group 1 and in 11 roots of group 2. An increase in the number of cracks was present only in teeth prepared with ultrasonic tips (group 2) with new cracks developing in 13 teeth. Bur root-end preparation revealed no crack formation.
Conclusions Ultrasonic root-end preparation increased the incidence of dentine crack formation compared to bur root-end preparation.