Research Posters – Filling

R25

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The influence of irrigant solution volume used during passive ultrasonic irrigation on the quality of root fillings

Aim To investigate the quality of root fillings following passive ultrasonic irrigation using three different volumes of irrigant solution.
Methodology Three groups of 20 oval shaped distal root canals of mandibular molars were cleaned and shaped and passive ultrasonic irrigation performed using three different volumes of sodium hypochlorite (NaOCl) namely 50, 120 and 200 mL. The root canals were dried with paper points and filled with AH26 and gutta-percha using a warm vertical compaction technique. The roots were sectioned horizontally 2, 4 and 6 mm from the apex of the tooth using a low-speed saw. The sections were photographed using a digital camera and pictures of the sections were taken under a Photomacroscoop M400 microscope at ×40 magnification. These photographs were then scanned as Tagged Image File Format (TIFF) images. Using a KS 100 Imaging system 3.0 the area of the canal and gutta-percha were outlined by hand and then measured. The percentage of gutta-percha filled area (PGP) was calculated. The data was analysed using multiple linear regression models; the PGP was the dependent factor; the volume of irrigant and the level of section were covariates.
Results The volume of irrigant did not influence the values of PGP ($P = 0.978$), whereas the sectioning level did ($P = 0.000$). The average PGP was 87.4%, 95.6% and 95.1% at 2, 4, and 6 mm respectively.
Conclusions There is no significant difference in the quality of the root filling after using volumes of 50, 120 or 200 mL of NaOCl solution during passive ultrasonic irrigation.

R26

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A 1-year follow-up study on leakage of single-cone fillings with RSA RoekoSeal

Aim To measure long-term leakage along single cone fillings.
Methodology Two groups of canines ($n = 30$) were prepared to a size 55 master apical file. Stepback was performed using files of sizes 60, 70 and 80. The canals were filled using a single cone technique using RoekoRSA (Coltene Whaledent Roeko, Germany) as sealer. A bi-directional spiral was used in one group to place sealer into each canal whereas a gutta-percha cone was used in the other group. Immediately after root filling, the coronal portion of root filling was removed during post-space preparation. After one week and one year, leakage along 4 mm of the remaining apical root filling was measured using a fluid transport model. Ten additional canine roots were prepared and filled with gutta-percha cones without sealer, serving as positive controls. Occurrence of apical extrusion of materials was recorded.
Results The apical root filling in all 60 canine roots did not show leakage either at one week or at one year. All ten positive controls showed gross leakage (>20 μL/h). In no cases was gutta-percha extruded through the apical foramen. Sealer extruded apically in 88% of the roots where a gutta-percha cone was used to introduce sealer and in 28% of the roots where a bi-directional spiral was used to introduce sealer (chi-square test, $P < 0.01$).
Conclusions In wide and straight canals single cone fillings with RoekoRSA sealer prevented fluid transport for one year. Using a bi-directional spiral to place sealer reduced sealer extrusion.

R27

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A meta-analysis of the sealing ability of various root canal sealers

Aim To compare the sealing ability of various root canal sealers based on reliable *in vitro* research papers and to reveal possible parameters that may influence their results.
Methodology The search of the articles was performed via MEDLINE for the years 1980–2003. Key words were 'root canal sealers', 'endodontic microleakage', 'endodontic leakage', 'root canal sealers and microleakage', 'root canal sealers and leakage', 'obturation and microleakage', 'obturation and leakage'. All full articles were then thoroughly evaluated, in order to assess whether they fulfilled the pre-requisites of the study. Statistical analysis determined the quantitative differences of leakage among various sealers in the basis of fixed effects or random effects, depending on the homogeneity of each individual study. When possible, meta-regression models were applied. Data analyzed included mean value and standard deviation of leakage of each specimen tested, number of specimens, sealer used, removal of smear layer or not, obturation technique and method of leakage measurement, including details on the dye and direction of measurement.
Results Of the initial 93 articles, 46 fulfilled all the inclusion criteria. Statistical analysis showed that zinc oxide-eugenol sealers possess inferior sealing ability compared to epoxy resin-based and calcium hydroxide-based sealers, whereas no significant differences were revealed between zinc oxide-eugenol and glass ionomer based sealers. A common finding in the paired comparison was that the results were not influenced either by the filling technique or from the direction of leakage. It also showed that dye leakage techniques were not reproducible, while type of the dye and removal of smear layer influenced the values of leakage.
Conclusions The findings imply that the critical role of sealers in the achievement of a seal is fully justified.

R28

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Sealing ability of different gutta-percha techniques: Thermafil, Quick-Fill, Soft-Core, Microseal, SystemB and lateral condensation technique

Aim To compare apical microleakage of roots filled with 6 different gutta-percha techniques; Thermafil (Dentsply Maillefer, Switzerland), Quick-Fill (JS Dental Manufacturing Inc, USA), Soft-Core (Soft Core

System, Denmark), Microseal (Tycom, USA), SystemB (Sybron Endo, USA) and lateral condensation, using a fluid filtration system.
Methodology Sixty single rooted teeth were used for this purpose. Six groups of 10 teeth were randomly filled by either Thermafil, Quick-Fill, Soft-Core, Microseal, System B or lateral condensation techniques. After 2 years of storage in 100% humidity, a fluid filtration system was used to evaluate apical leakage. Filtration rate was measured by the movement of an air bubble in a micropipette for 5-min. intervals under a pressure of 120 kPa (1.2 atm). Measuring was performed four times for each specimen. The mean values were determined and expressed as $\mu l\,cm\,H_2O^{-1}\,min^{-1}$. All data were fed into PC-compatible software and analyzed statistically using ANOVA followed by Duncan tests ($P < 0.05$). The negative control group was tested with a root of which the apex was covered to ensure that there was no leak in the device.
Results Thermafil, Soft-Core, Quick-fill, SystemB techniques were superior to Microseal and lateral condensation techniques ($P < 0.05$). Although Microseal had the most microleakage, no statistically difference was found between Microseal and lateral condensation ($P > 0.05$). Thermafil had the least leakage, but no statistically difference was found between Thermafil, Quick-Fill, Soft-Core and SystemB techniques ($P > 0.05$).
Conclusions In the present study, Thermafil, Quick-Fill, Soft-Core and System B techniques had significantly less apical leakage than Microseal and lateral condensation techniques.

R29

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Comparative study of sealing ability of a new resin-based root canal sealer

Aim To compare the sealing ability of three root canal sealers: Epiphany (Jeneric/Pentron, USA), Tubliseal (Kerr, USA) and Sealapex (Kerr).
Methodology Sixty single-rooted human teeth were used. The root canals were prepared with the stepback technique. The working length was the same for all specimens and a size 35 was used to prepare the apical end-point. NaOCl (5%) was used as the irrigant solution after use of each instrument. All specimens were stepped back to a size 60. A final irrigation with 17% EDTA (3 mL/3 min) was used to remove smear layer. The teeth were divided into three groups. Teeth in group A were filled with laterally condensed gutta-percha using Epiphany (resin sealer), teeth in group B were filled with gutta-percha and Tubliseal (zinc-oxide eugenol sealer) and teeth in group C were filled with gutta-percha and Sealapex (calcium hydroxide sealer). Six additional specimens were used as controls. All the test sealers were mixed and used according to the manufacturers' instructions; the canals were filled by one operator. Microleakage was measured using a fluid transport system after 7 days and 1 month. Between measurements the specimens were stored in distilled water at 37°C.
Results At 7 days the group filled with the Epiphany system leaked less than those filled with Tubliseal and Sealapex ($P < 0.05$); no statistically significant difference was found between the Tubliseal and Sealapex groups. At 1 month the group filled with the Epiphany system leaked less than those filled with Tubliseal and Sealapex ($P < 0.05$).
Conclusions Epiphany sealer allowed significantly less leakage than Tubliseal and Sealapex.

R30

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The long-term sealing ability of two root canal sealers using different filling techniques

Aim To evaluate the long-term sealing ability of AH Plus (DeTrey, Germany) and RoekoSeal Automix (RSA) (Roeko Dental Products, Germany) when used with different filling techniques.
Methodology The experiment was conducted on sixty-six extracted single rooted teeth. The crowns were removed at the cementoenamel junction and root canals were instrumented using a stepback technique. Samples were divided into three groups of 20 teeth each and root canals were filled using either cold lateral condensation, the Touch'n Heat technique or the Thermafil technique. For each technique AH Plus was used as the sealer in 10 samples and in 10 samples RSA. Six sample were used as the control group. With the use of a fluid transport model leakage was measured repeatedly at 1 month, 6 and 12 months and recorded in microlitres per day.
Results Leakage was significantly greater ($P < 0.05$) after month 12 compared to month 1, for all techniques and with both sealers. There was no significant difference between sealing ability of AH Plus and RSA.
Conclusions RSA and AH Plus in combination with either cold laterally compacted gutta-percha, Touch'n Heat and Thermafil provided similar sealing ability. Both materials leaked more after 12 months.

R31

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Leakage analysis of three modern root filling materials after 90 days of storage

Aim To evaluate the apical seal of root fillings with GuttaFlow, Epiphany and RelyX Unicem after a storage time of 90 days.
Methodology Thirty extracted human single-rooted teeth were prepared up to size 45, .04 taper with FlexMaster (VDW, Germany) and ProFile (Dentsply Maillefer, Switzerland) instruments. Teeth were randomly assigned to three groups ($n = 10$): group 1: GuttaFlow (Coltène/Whaledent, Langenau, Germany), group 2: Epiphany (Pentron, Wallingford, CT, USA), group 3: RelyX Unicem (Maxicap) (3 M ESPE, Seefeld, Germany). Final irrigation sequences were performed as follows: group 1: 40% citric acid, 5% NaOCl, 70% ethanol; group 2: 5% NaOCl, 17% EDTA, sterile water; group 3: 40% citric acid, 5% NaOCl, sterile water (2 mL each). Canals were dried with absorbent paper points. Root canal filling materials were placed with a lentulo spiral. A single cone (size 40, .04) of gutta-percha or Epiphany (group 2) was inserted. Teeth were stored in 100% humidity at 37°C for 90 days. Microleakage was evaluated using a dye penetration test (methylene blue 5% / centrifuging at 30 g for 3 min). After cross sectioning in steps of 1 mm specimens were evaluated for linear dye penetration under a stereomicroscope (40×). The maximum leakage value possible was 9 mm.
Results Linear dye penetration (mm) resulted as follows (mean/SD): group 1 (2.2/0.42); group 2 (5.5/3.1); group 3 (3/1.82). Kruskal-Wallis-test showed a significant difference between groups ($P < 0.05$). Epiphany showed significantly higher leakage values than GuttaFlow and RelyX Unicem (Mann-Whitney test, $P < 0.05$).

Conclusions GuttaFlow exhibited the lowest leakage values. Epiphany allowed gross leakage to occur. RelyX-Unicem offers the potential for an adhesive root canal sealer, though modifications of handling characteristics are required.

R32

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Epiphany – influence of sealer placement and cone taper on microleakage

Aim To evaluate the influence of cone taper and placement technique on Epiphany root canal fillings.
Methodology Sixty extracted single-rooted teeth were randomly assigned to five groups of 12 teeth each and prepared up to size 45, .04 taper with FlexMaster (VDW, Germany) and ProFile (Dentsply Maillefer, Switzerland) instruments. Canals were flushed with NaOCl during root canal treatment and finally rinsed according to manufacturer's instructions with a sequence of NaOCl 5%, EDTA 17% and sterile water (2 mL each). Canals were dried with absorbent paper points (PP). Root canal filling was carried out with the Epiphany (Pentron, Wallingford, CT, USA) obturation system (Epiphany primer, sealer, and cones) as follows (cone taper/placement technique): group 1 (size 40, .04 taper/PP), group 2 (size 40, .02 taper/PP), group 3 (no cone/lentulo). Twelve teeth were filled with size 40, .04 taper lentulo and sectioned horizontally in the middle part of the root. Then specimens were assigned to group 4 (apical part) and group 5 (coronal part). Another 12 teeth were obturated with size 40 .02 taper and assigned to group 6 (apical part) and group 7 (coronal part). Microleakage was evaluated using a dye penetration test (methylene blue 5%/centrifuging at 30 g for 3 min). After cross sectioning in steps of 1 mm specimens were evaluated for linear penetration depth under a stereo microscope (40×). The maximum possible leakage value was limited to 6 mm.
Results Linear dye penetration (mm) (means/SD): group 1 (4.42/1.83); group 2 (5.92/0.29); group 3 (2.75/1.48); group 4 (5.67/.49); group 5 (5.58/1); group 6 (4.58/1.88); group 7 (3.83/1.75). Multifactorial ANOVA showed a significant influence ($P < 0.05$) of both cone taper and combination of taper and placement technique, but no influence of the coronal/apical part of the root or the placement technique ($P > 0.05$).
Conclusions Epiphany showed gross leakage in most groups.

R33

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Influence of sealer placement on apical sealer extrusion of two root canal sealers

Aim To evaluate the influence of sealer placement technique on apical sealer extrusion of GuttaFlow (Coltène/Whaledent, Germany) and AH Plus (Dentsply, Germany).
Methodology Sixty single-rooted teeth were randomly assigned to six groups ($n = 10$) and the root canals prepared up to size 60, .02 taper. Apical patency was ensured with size 10 K-type reamers. After rinsing and drying root canals were filled with GuttaFlow (GF) or AH Plus (AH) using a single gutta-percha cone size 55, .02 taper. Freshly mixed sealers were inserted into insulin syringes (Terumo U-40 Insulin, Belgium) to inject well-defined amounts of 0.05 mL sealer per canal. Sealers were placed as follows (sealer/placement technique): group 1: GF/lentulo, group 2: GF/masterpoint, group 3: GF/cannula, group 4: AH/lentulo, group 5: AH/masterpoint, group 6: AH/cannula. For groups 1 and 4 the exact volume of sealer was placed onto a glass slab, picked up two times with a lentulo and placed into the root canals. For groups 2 and 5 the whole volume of sealer was picked up with the master cone prior to insertion into the root canal. For groups 3 and 6 the volume of sealer was directly placed into the canals with the cannules of the GuttaFlow system. Extruded sealer was collected after setting and weighed using a precision balance (Sartorius CP124S, Sartorius, Göttingen, Germany).
Results The weight of apically extruded sealer was tendentially lower for GF (mg/SD): group 1: 3.62/2.04; group 2: 0/0; group 3: 1.43/2.24; group 4: 2.14/2.76; group 5: 0.07/0.22; group 6: 1.55/2.88. Univariate ANOVA displayed no significant influence of sealer type on apical extrusion ($P = 0.42$) but a highly significant influence of placement technique ($P < 0.001$). Insertion of AH displayed significantly less sealer extrusion within the masterpoint group compared to the other placement techniques (Mann-Whitney test, $P < 0.01$). For GF sealer extrusion was merely significant between groups 4 and 5 (Mann-Whitney test, $P < 0.05$).
Conclusions Placement of AH and GF by a syringe does not lead to greater weight of extruded sealer than with the use of a lentulo.

R34

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Adhesive coronal seal after different dentine pretreatment following use of AH plus sealer

Aim To find a suitable method for sealer removal prior to dentine bonding and restoration of the access cavity.
Methodology Fifty two teeth were selected for the study, 40 teeth with one root canal (four groups of 10 teeth) for a dye penetration test and twelve caries-free molars (two groups of 6 teeth) for a microtensile test. After preparation of standardized access cavities, root canals were prepared and then filled with AH plus and a single cone. Removal of excess sealer was performed with a foam pellet only (group 1), additionally by etching with 37% H3PO4-gel for 15 s (group 2), by preparation with an abrasive water-cooled diamond bur (group 3) or by preparation with a bur but after the placement of a temporary filling for 1 wk (group 4). An adhesive coronal filling on top of the root filling was performed with Syntac (Ivoclar-Vivadent, Liechtenstein) and Tetric flow (Ivoclar-Vivadent). For group 1 and 4, specimens for a microtensile test were prepared after the access cavity was filled with Tetric ceram (Ivoclar-Vivadent). Dye penetration was carried out by centrifugation for 3 min at 30 G within 5% methylene blue dye followed by examination under a stereo microscope (40×). Microtensile tests (group 1: $n = 25$; group 2: $n = 25$; ~1 mm^2) were performed with a universal testing machine (Zwick, Germany) at a cross head speed of 1 mm/min. Linear dye penetration was measured from crown to apex in teeth with root canal fillings and an adhesive coronal seal. Microtensile bond strength of the adhesive coronal seal was assessed only in groups 1 and 4. The statistical unit was the tooth.
Results Linear dye penetration (mm) was: (means/SD) group 1 (1.15/0.82); group 2 (0.17/0.6); group 3 (0/0); group 4 (0/0). Groups 2, 3 and 4 had significantly less leakage than group 1 ($P < 0.01$; Mann-Whitney-test). In terms of micro tensile strength, no significant differences could be detected [group 1 (5.18/0.99); group 4 (5.07/1.22) results in Mpa]. Thus, differences in sealing ability could not be attributed to differences regarding the strength of the dentine bonding.
Conclusions Acid etching or bur preparation of dentine prior to dentine bonding following the use of AH Plus sealer is recommended.

R35

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Long term evaluation of coronal leakage of root filled teeth, using different sealers

Aim To evaluate *in vitro* using a fluid filtration model coronal leakage along root fillings completed with 4 different root canal sealers.
Methodology The crowns of 100 extracted human maxillary central incisors were removed leaving roots 11 mm in length. After instrumentation by hand K-files using a stepback technique and smear layer removal, the 100 roots were divided randomly into four groups of 20 roots each, leaving 20 roots to serve as positive and negative controls. All groups were filled with cold lateral condensation of gutta-percha and a different sealer in each group: AH26 (Dentsply De trey, Germany), Roth 601 (Roth International, USA), Epiphany (Pentron, USA), or RoekoSeal Automix (RSA) (Roeko, Germany). The specimens were stored in 100% relative humidity for 12 months and then measured for leakage with a fluid filtration model at a pressure of 0.3 atm. Results were expressed in microLitres/hour and categorized in a scale of no leakage (NL), slight leakage (SL) and gross leakage (GL), and then subjected to statistical analysis using Fischer's exact test.
Results For each sealer, the results were: AH-26: NL 2, SL 11, GL 7, Roth 601: NL 1, SL 5, GL 14, Epiphany: NL 8, SL 7, GL 5, RSA: NL 8, SL 5, GL 7. Statistical analysis revealed that when compared to AH-26, RSA ($P < 0.05$) and Epiphany ($P < 0.05$) were significantly different. No statistical differences were found between AH-26 and Roth 601.
Conclusions When a fluid filtration model was used for leakage evaluation, RSA and Epiphany leaked significantly less compared to AH-26 and Roth 601.

R36

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Leakage of bovine serum albumin in root canals filled with IRM and SuperEBA, with or without orthograde filling: an *in vitro* study using spectrophotometry

Aim To determine quantitatively the leakage of two apical root-end filling materials: SuperEBA (Staident International, UK) and IRM (DeTrey, Dentsply, Germany) in root canal samples with or without orthograde filling, by evaluating Bovine Serum Albumin (BSA) microleakage using a spectrophotometric method.
Methodology Thirty five single-rooted teeth were instrumented and divided into five groups. The apices of all teeth were resected. Root-end cavities in the samples from the first two groups, without orthograde root canal filling, were filled with SuperEBA (Group 1) and IRM (Group 2). The samples from the Groups 3, 4 and 5 were filled conventionally with gutta-percha and sealer, and after setting for 24 hours, the apices were resected. The teeth from Group 3 did not receive a root-end cavity preparation and filling. In the samples from Groups 4 and 5 root-end cavities were prepared and filled with SuperEBA (Group 4) and IRM (Group 5). Each sample was mounted in the glass vial and exposed to the BSA protein solution. Two sets of spectrophotometric measurements were conducted, after 7 and 60 days.
Results After 7 days microleakage was observed in only two specimens. After 60 days microleakage was recorded for all specimens. The greatest mickroleakage was observed in Group 2 ($0.0041 \pm 0.0000011\,\mu g$), then in Group 3 ($0.0034 \pm 0.0000064\,\mu g$) and Group 1 ($0.0026 \pm 0.0000019\,\mu g$). Samples from group 4 and group 5 leaked the least and to the same extent ($0.0007 \pm 0.0000014\,\mu g$). ANOVA analysis showed that there was a significant difference between the groups ($F = 7.054$; $p = 0.0000428$) and the Turkeys analysis showed statistically significant difference ($P < 0.05$) between Groups 2 and 4, Groups 2 and 5, Groups 3 and 4, and Groups 3 and 5.
Conclusions Significantly less leakage occurred in samples filled with orthograde and root-end fillings than in the samples filled only with a orthograde approach and the samples with IRM root-end fillings.

R37

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Capillary Flow Porometry to assess the seal provided by root-end filling materials in a standardized and reproducible way

Aim To compare the root-end sealing ability of warm Gutta Percha (Obtura II, Obtura-Spartan, USA) + AH26 (Dentsply De Trey, Germany) (GP), Ketac-Fil Capsules (Espe, Germany) (KFil), Fuji IX Capsules (GC-Corporation, Japan) (FIX), Pro Root MTA Tooth-Coloured Formula (Dentsply, USA) (MTA) and IRM Caps (Dentsply Caulk, USA) (IRM) in standard bovine root sections.
Methodology One hundred standard bovine root sections were prepared each 3 mm high with a diameter of 7 mm and an internal diameter of 2.5 mm. The sections were divided into 5 groups at random and each group was filled with a different root-end filling material. The filled sections were stored in an environment of 37°C and 95–100% humidity for 24 h, then exposed to distilled water and 24 h later submitted to capillary flow porometry (CFP) (PMI, USA) in order to assess the minimum, mean and maximum through-pore diameters of each root section. The results of the tests were statistically evaluated by Kruskal-Wallis and Dunn tests. The level of significance was set at 0.05.
Results Significant differences were demonstrated for the mean and maximum pore diameters, not for the minimum pore diameters. For the mean and the maximum pore diameters, the results could be noted in the following order: FIX > KFil > MTA > GP > IRM. From the two by two analyses, it appeared there was a significant difference between FIX and the other materials for the mean diameters. For the maximum diameters, a significant difference between FIX and MTA, GP and IRM and between KFil and IRM was demonstrated.
Conclusions Under the conditions of this study, glass ionomer cements (GICs) demonstrated more leakage after 48 h than other root-end filling materials. It also appears there is a difference between GICs. Future measurements will have to show whether these results will remain equal as a function of time.

R38

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Comparison of sealing ability of three different root-end filling materials

Aim To compare *in vitro* the sealing ability of Mineral Trioxide Aggregate (MTA) (DeTrey Dentsply, Germany), Super EBA (Staident International, UK), and IRM (DeTrey Dentsply) in root end cavities prepared by Er:YAG laser.

Methodology After root canal instrumentation and filling the apices of sixty single-rooted teeth were resected. Root-end cavities 3 mm deep, were prepared with an Er:YAG laser. Laser beam parameters were: a pulse of very short duration (100 μs), energy of 280 mJ, and repetition rate of 10 Hz. Cavities within each group of 10 samples were filled with either mineral trioxide aggregate (MTA), Super-EBA or IRM. After 7 days in ink the teeth were cleared and the maximum degree of dye penetration for each specimen was measured with a stereomicroscope. The results were analysed statistically using Kruskal Wallis analysis of variance and Mann-Whitney *U* tests.
Results MTA (0.14 ± 0.08 SD) had significantly less dye penetration ($P < 0.05$) in comparison with Super EBA (0.41 mm ± 0.23 SD) and IRM (0.87 ± 0.21 SD). There was no statistical difference between Super EBA and IRM.
Conclusions All three root end fillings allowed leakage to occur. Leakage with MTA was significantly lower than with Super EBA and IRM.

R39

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Radiopacity of root fillings in simulated canals: the effect of sealer

Aim To investigate the effect of root canal sealers on radiopacity of root fillings in simulated canals by means of digital radiography.
Methodology Thirty simulated root canals in transparent acrylic blocks were instrumented with HERO 642 (Micro-Mega, France) rotary instruments. Each canal was prepared to size 25 and a 4% taper. A single 4% tapered size 25 gutta-percha cone (Roeko, Germany) was inserted into each canal. Standardized images of the canals with an aluminium step-wedge were obtained using Digora (Soredex, Finland) storage phosphor plates. Then, three root canal sealers (RoekoSeal, Roeko, Germany; Diaket, 3M Espe, Germany; Pulp Canal Sealer, Kerr, USA) were mixed according to the instructions of the manufacturers. The gutta-percha cones were completely coated with one of the sealers ($n = 10$ per group) and placed in the identical canal to the full working length. Then, standardized images of the obturated canals were obtained. The mean gray values (MGVs) of gutta-percha cones with and without sealer at three different levels (1 mm, 6 mm, 11 mm from apex) was measured using Image Tool program (UTHSCSA, USA). Each MGV measurement was then converted to aluminium equivalent using step-wedge values. The differences between pre- and post-filling measurements were analyzed statistically with one-way analysis of variance and Bonferroni post-hoc tests.
Results At the 1 mm- and 6 mm-levels, RoekoSeal caused a reduction in radiopacity of the filled canals ($P < 0.05$). Radiopacity was increased from 0.3481 to 2.087 mm equivalent Al in Diaket and Pulp Canal Sealer specimens. There was no statistically significant difference between Diaket and Pulp Canal Sealer at any level ($P > 0.05$).
Conclusions Root canal sealers can influence the radiopacity of root fillings. Radiopacity of sealer-gutta-percha combinations should be re-evaluated and standardized for improved clinical detection.

R40

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Apical control of gutta-percha root fillings using the ultrasonically energised thermocompaction technique

Aim To determine the influence of duration of activation, number of activations, and extent of penetration of an ultrasonically energised file on apical extension and voids in root fillings.
Methodology Root canals ($n = 360$) were prepared to a standard .06 taper and randomly allocated to a control group or one of eight test groups. Each group was divided between a general dental practitioner (GDP) and a postgraduate (PG); each filled 180 canals using cold lateral condensation (CLC, control, $n = 20$) or an ultrasonically energised technique (UET, 8 test groups, $n = 20$ each). An ultrasonically energised file was placed into gutta-percha once or twice, 1 or 3 mm from working length then either withdrawn immediately or after 2 seconds. The apical extent of root filling and voids were assessed by standard radiography and visual examination. The data were analysed using logistic regression models.
Results Roots with two canals were excluded, leaving 340 for analysis. Most root fillings (72.1%) were 'flush', 19% were 'short' and only 9% were 'long'. The GDP produced 'long' root fillings 36× more frequently than the PG ($P < 0.001$). CLC resulted in 3.8× more 'flush' root fillings than UET ($P = 0.014$). Penetration of the energised file closer to the canal terminus resulted in 1.8× more extruded or short root fillings ($P = 0.017$). Voids were present in 54% of cases. The GDP produced 2× more voids than the PG ($P < 0.001$). Deeper penetration of the energised file reduced the odds of prevalence of voids by 50% ($P = 0.015$).
Conclusions 'Operator' and 'depth of energised file penetration' significantly influenced both apical extent of root filling and presence of voids, whilst the filling technique only affected the former.

R41

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Analysis of shrinkage of different gutta-percha treatments using an optical triangulation method

Aim To compare the shrinkage of two different gutta-percha treatments (alpha- and beta-gutta-percha of the Multi-Fill-System (Loser & Co GmbH, Germany) in comparison to commercial gutta-percha (Roeko, Germany).
Methodology The optical triangulation-method was used to assess shrinkage. Speckle Pattern Shearing Interferometry was used to test whether trapped air or material defects affected shrinkage. The three gutta-percha specimens were examined after heating to 90°C and cooling down to 35°C. Statistical analysis was performed by means of the Kruskall-Wallis test and the Wilcox test. Level of significance was set at $P < 0.05$.
Results The commercial gutta-percha shrank by 6.5%, while alpha-gutta-percha shrank by 7.2% and beta-gutta-percha by 7.3%. Shrinkage of the commercial gutta-percha was less pronounced and had a different temperature-dependency. In the range of 90°C to 55°C and 40°C to 35°C all 3 gutta-percha sticks shrank almost linearly. Between 55°C and 40°C the commercial gutta-percha plates did not show the rapid shrinkage noted with alpha- and beta-gutta-percha.
Conclusions Commercial gutta-percha had less shrinkage than the alpha- and beta-gutta-percha.

R42

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Apical adaptation of root fillings completed using a soft resin canal filling system

Aim To compare apical quality of root fillings completed using cold lateral compaction (LC) and a soft resin canal filling system (Epiphany, USA).

Methodology Twenty four human single-rooted mandibular teeth were instrumented with System GT rotary files (Dentsply Maillefer, Switzerland) using a crowndown technique. Following removal of smear layer, teeth were randomly divided into two groups: Group 1: teeth were filled with the soft resin root filling system and Group 2 (control) with a cold lateral compaction technique using standard gutta-percha points. Epiphany root canal sealer was used in both groups. Horizontal sections were obtained from 1 mm up to 5 mm from the apex, using a low-speed saw. Digital colour images of sections were obtained at 40× under a stereomicroscope and transferred to an IBM compatible PC. Calculation of the canal area (in per cent) filled by material or sealer was performed by use of an image processor software (AutoCAD). The data were analyzed using unpaired Friedman Test and Mann Whitney-*U* tests.
Results There was no significant difference in apical filling adaptation between the groups.
Conclusions The new soft resin canal filling system was similar in terms of the apical adaptation of root filling in comparison with the conventional cold lateral compaction technique.

R43

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Microleakage of root filled teeth after cyclic loading when restored with Glassix posts and metal crowns

Aim To evaluate *in vitro* the microleakage of root filled teeth after cyclic loading when restored with Glassix posts and metal crowns.
Methodology In 30 filled root canals of central maxillary incisors Glassix posts (Harald Nordin sa, Chailly/Montreux, Switzerland) were cemented with either Harvard (Richter & Hoffmann, Harvard Dental GmbH, Berlin, Germany), Fuji PLUS (GC Corporation, Tokyo, Japan) or Variolink II cements (Vivadent, Schaan, Lichtenstein) in three groups of ten canals each. The coronal restoration consisted of composite cores (Clearfil core, Kuraray, Osaka, Japan) and metal cast crowns. Specimens were embedded in acrylic resin and loaded on a special testing machine. A load was applied at an angle of 135° to the long axis of the tooth, with forces oscilating from 0 to 35 N. Each specimen was exposed to 700 000 cycles through a period of 148 h. After performing cyclic loading, specimens were prepared for testing of microleakage. The acrylic bases were removed and the crowns were sectioned along with the composite cores and the coronal aspect of the Glassix posts to leave 15 mm long roots. Coronal microleakage was evaluated using a fluid transport system. The movement of an air bubble in a capillary glass tube connected to the apex of the experimental root section was measured over 5-min periods. Measurements were performed four times for each specimen and the mean values recorded. Analyses of variance were performed.
Results The highest values of microleakage (μL) occurred in the group cemented with Harvard cement (0.67), followed by Fuji PLUS (0.55) and Variolink II (0.22) cements. Results among the groups were significantly different ($P < 0.05$).
Conclusions Canals with Glassix posts cemented with Variolink II cement had the least leakage after cyclic loading.

R44

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A comparison of the penetration of three sealers into dentinal tubules: a SEM study

Aim To compare the penetration of Roeko Seal, AH Plus and Gutta Flow into dentinal tubules.
Methodology Fifteen single rooted extracted human teeth were used. The crowns of all teeth were sectioned and removed at the cemento-enamel junction. All canals were prepared chemo-mechanically up to a size 60 K-file and irrigated with 5.25 NaOCl, 30% citric acid and isopropyl alcohol. All teeth were randomly divided into 3 groups and filled with a single gutta-percha cone and sealer. In group 1 AH Plus (Dentsply DeTrey, Germany) was used as a sealer in groups 2 and 3 Roeko Seal (Coltene Whaledent, Germany) and Gutta Flow (Coltene Whaledent) were used respectively. The sealers were introduced into the root canals with a lentulo spiral. After setting the roots were grooved, longitudinally split and examined under a scanning electron microscope. The penetration of the sealers into the dentinal tubules was examined 3 mm, 6 mm and 9 mm from the root apex at 1500 and 3000 magnification. The focus of observation was the interface between the dentine and the sealing material. The numbers of examinations with positive sealer penetration were noted for each sealer and compared using Kruskal-Wallis and Mann-Whitney tests.
Results Statistical analyses revealed that in comparison with AH plus, the other two sealers had significantly more sealer penetration ($P < 0.05$). There was no significant difference in sealer penetration between Roeko Seal and Gutta Flow.
Conclusions AH plus sealer had better penetration into dentinal tubules than Roeko Seal and Gutta Flow.

Research Posters – Materials Science

R45

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Physical characteristics and surface analysis of grey and white MTA and Portland Cement

Aim To analyze and compare the pH value, the conductivity, the particle size distribution and the surface characteristics of grey and white Mineral Trioxide Aggregate (ProRoot MTA, Dentsply, USA) and Portland Cement (PC).

Methodology pH value and conductivity were measured in suspensions produced after mixing material specimens that were allowed to set for 4 h with 50 mL of distilled water. Initial measurements were taken and subsequently repeated after 24 h, 48 h and 7 days. Particle size distribution of white MTA powder was measured using a CILAS device (Companie Industrielle de Lasers, France). This equipment counts the percentage of particles of different size in the material. Surface characteristics of material specimens, stored at 100% humidity and 37°C, were analyzed by profilometry (Diavite DH-5, Switzerland) at time intervals of 72 h, 7, 15 and 30 days. The values of Ra, Rz, Rmax, R3z, Rt and Rq were calculated and Abbott-Firestone curves were plotted for each specimen.