Introduction

Successful root canal treatment requires elimination of all pulp tissue, debris, and bacteria from the root canal system, enlargement of the canals, and creating a three dimensional hermetic seal to avoid infection and re-infection of the surrounding vital tissues. Many studies revealed that two major causes of endodontic failure were imperfect instrumentation and a probable sequence of incomplete obturation(1).

Schilder stated that preparation of root canal system to receive gutta-percha filling should result in a continuously tapering conical form, which follows the plane of the original canal without altering the position of the apical foramen.(2)

Different techniques have been suggested for filling the canal space like vertical compaction and thermoplasticized gutta-percha, by softening the gutta-percha to increase its flow and penetration in the canal system.

Among all the new obturation techniques, newly developed materials were also introduced for better flow and adaptation of the filling material inside the canal space, thus creating better obturation and better apical seal.

Two materials were recently introduced for this purpose, one of which is GuttaFlow. It is a new self-curing filling system that combines a gutta-percha particles form (less than 30μm)

and sealer making it the first gutta-percha/sealer combination that is flowable at room temperature.

The other material is EndoRez, a root canal resin sealer, which is used with a single cone gutta-percha according to the recommendations of the manufacturer instructions.

Evaluation of these two materials in regard to their adaptability, sealability and compaction of the root canal space is necessary. Several techniques have been used to test the sealing ability and the degree of micro-leakage of different endodontic filling materials. These techniques include dye penetration, dye extraction, bacterial penetration, fluorometry, compressed air, electrochemical, scanning electron microscopy, isotope penetration and fluid filtration method. The data obtained from these techniques may be qualitative, semiqua-litative or quantitative, thus lacking the way comparison between the results of different microleakage studies.

Review of Literature

The objectives for successful endodontics are total debridment of the pulpal space, development of fluid tight seal at the apical foramen and total obturation of the root canal system.

Complete obturation of the root canal with an inert filling material and creation of hermetic apical seal have been proposed as goals for successful endodontic treatment. Since the main cause of failure is the lack of apical seal of the root canal filling, many different obturation techniques have been introduced specially to increase the quality of the apical seal.[3,4]

Many types and commercial brands of endodontic sealer are commercially available, to date, they can be divided into: zinc-oxide-eugenol based sealers, calcium hydroxide, glass-ionomer and plastic resin sealers. A new silicone-based sealer has been introduced as alternative root canal filling material.

I- GuttaFlow:

GuttaFlow is a cold fluid obturation system that combines sealer and gutta percha particles in a single material. It consists of a polydimethylsiloxane matrix which is highly filled with very finely ground gutta-percha particles. It contains also nanosilver particles which is distributed uniformly on the surface of the material. The chemical type and concentration of the nano-silver

do not cause corrosion or color changes of the material but are sufficient to prevent further spread of bacteria.

Adaptability and sealing ability of GuttaFlow:

Roggendorf et al. (2003)[5], evaluated the microleakage of polyvinylsiloxane-based endodontic filling material using various methods. 32 extracted single-rooted teeth were instrumented to0.04/#45. Irrigation of the root canal was performed with 1mL 40% citric acid, followed by 1mL 5% NaOCl and 1mL 70% ethanol. Teeth were divided into four groups of eight teeth each. Root canals were filled with RoekoSeal Automix , (RSA) and a masterpoint (group 1), GuttaFlow (GF) and masterpoint 0.04/#45 (group 2), GF and masterpoint 0.02/#45 (group 3) and GF exclusively used without any gutta percha point (group 4). GF was inserted into the root canal using a lentulo filler. Linear dye penetration was determined by two independent investigators using a stereomicroscope. Statistical analysis regarding dye penetration showed no significant differences were detectable between all four groups. GuttaFlow used exclusively as root canal filling material showed microleakage similar to root canal fillings with low viscous materials using an additional masterpoint of various tapers.

ElAyouti et al. (2003)[6] assessed unfilled areas and the adaptation of a gutta-percha filling material to root canal walls. Ninety one human teeth with 169 root canals were divided into three groups. The middle and coronal third were shaped with

6% taper rotary HERO instruments and the apical third with rotary LightSpeed instruments to a minimum size of 42.5. Group LC was filled using cold lateral condensation, group VC using warm vertical condensation (Obtura, and System B). Group GF was obturated with a new gutta-percha paste using a lentulo filler. Instrumentation and filling of root canals were performed under clinical conditions in a phantom head. The teeth were sectioned at five levels and the photographed root sections were traced under a stereomicroscope (30 x magnification). The percentage of unfilled areas (PUA) and adaptation to root-canal walls were evaluated. The new gutta-percha paste is a promising filling material. When applied with a lentulo, it was well adapted to the canal wall although the incidence of unfilled areas was higher.

Taranu et al. (2005)[7], evaluated the apical seal of root canal fillings with Gutta flow, Epiphany and Rely X unicem after 90 days of storage. After instrumentation the teeth were divided into 3 groups each one was obturated with a different material. Then the teeth were stored in 100% humidity at 37°C for 90 days. Microleakage was evaluated using a dye penetration test (methylene blue). After cross sectioning in steps of 1mm specimens were evaluated for linear dye penetration under a stereo-microscope. The values were calculated. Gutta flow exhibited the lowest leakage values. Epiphany allowed gross leakage to occur. RelyX unicem offered the potential for an adhesive root canal sealers, through modifications of handling characteristics are required.

Elayouti et al. (2005)[8], evaluated a new flowable root canal filling material (GuttaFlow). Under simulated clinical conditions, the middle and coronal thirds of 90 human teeth with 169 root canals were shaped with 6% taper rotary HERO instruments and the apical third with rotary LightSpeed instruments. The root canals were divided into three similar groups and were filled with GuttaFlow (GF), conventional cold laterally condensed gutta-percha (LC), and warm vertically condensed gutta-percha (VC). Roots were sectioned at five levels, digitally photographed and traced. The percentage of voids area showed a statistically significant difference between GF and both LC and VC. In most sections, GuttaFlow completely filled the prepared root canal, but small voids were frequently present within the core of the filling material.

Leski et al. (2005)[9],compared the penetration of Roeko Seal, AH Plus and GuttaFlow into dentinal tubules. 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 was used as a sealer in groups 2 and 3 Roeko Seal and Gutta Flow 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 3mm, 6mm and 9mm 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. Statistical analyses revealed that in comparison with AH plus, the other two sealers had significantly more sealer penetration. There was no significant difference in sealer penetration between Roeko Seal and Gutta Flow. AH plus sealer had less penetration into dentinal tubules than Roeko Seal and Gutta Flow.

Mayer et al. (2005)[10] evaluated the influence of sealer placement technique on apical sealer extrusion of GuttaFlow and AH Plus. Sixty single-rooted teeth were randomly assigned to six groups (n= 10) and the root canals prepared up to size 60, 0.02 taper. Apical patency was ensured with size 10 Ktype reamers. After rinsing and drying root canals were filled with GuttaFlow (GF) or AH Plus (AH) using a single gutta-percha cone size 55, 0.02 taper. Freshly mixed sealers were inserted into insulin syringes (Terumo U-40 Insulin, Belgium) to inject well-defined amounts of 0.05mL 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). The conclusion was that placement of AH and GF by a syringe does not lead to greater weight of extruded sealer than with the use of a lentulo.

Brackett et al. (2006)[11], compared the sealing ability of polydimethylsiloxane-based sealer (GuttaFlow) when it is used for filling single-rooted teeth with four obturation techniques. Prefitted gutta-percha master-cones were employed in groups 1 to 3 with backfilling of the sealer. Apical third of the roots were first filled with GuttaFlow, and sealer-coated master cones were seated with up-and-down motion (group 1) or rotated to place (group 2). Master-cones were used as carriers for introducing GuttaFlow into the canals (group 3). Canals were filled with GuttaFlow without master-cones (group 4). Canals were filled with AH Plus/gutta-percha using warm vertical compaction (control group 5). All obturated canals were tested for leakage after 1, 6, and 12 weeks using the fluid filtration technique. All groups exhibited equivalent seal regardless of time except for more extensive leakage in group 3. The use of

GuttaFlow with a single gutta-percha master cone creates an apical seal that is equivalent to that produced with gutta-percha/AH Plus sealer using warm vertical compaction.

Monticelli et al. (2007)[12], compared the sealing properties of root canals filled with two single-cone obturation systems and a warm vertical compaction technique. Forty-two single-rooted teeth were decoronated to obtain 17mm-long root segments. The root canals were cleaned and shaped to size 40, 0.06 taper and filled with: (i) warm vertical compaction with AH plus (ii) ActiV GP and (iii) GuttaFlow with single master cones. Leakage was evaluated by fluid filtration method before root resection, and after 3, 6, 9, and 12mm apical resections. The two single-cone techniques examined were effective in sealing the apex as AH plus when the latter was used with vertical compaction. It was further hypothesized that the inferior coronal seal of these single-cone techniques may be improved with the placement of accessory cones to reduce sealer thickness or an immediate coronal adhesive restoration.

De-Deus et al. (2007)[13] compared the sealing ability provided by four endodontic cements: AH plus, pulp canal sealer EWT, Roekoseal and GuttaFlow. One hundred human mandibular incisors with oval shaped canals was selected, the root canals in 80 teeth were prepared and filled by the same operator using cold lateral condensation technique with one of the following cements: AH Plus; Pulp canal sealer EWT; RoekoSeal

and GuttaFlow. Ten teeth with intact crowns served as negative controls and 10 that were not root filled served as positive controls. All teeth were mounted in a two chamber apparatus and then exposed to human saliva. The number of days over a 9-weeks-period was recorded for the appearance of turbidity in the BHI broth. A log-rank test was used to analyze the leakage data. The silicone based sealers revealed the best results throughout the experimental period. Leakage patterns of AH plus and pulp canal sealer were statistically similar.

Monticelli et al. (2007)[14] evaluated the sealing efficacy of three root-filling systems/techniques in preventing bacterial leakage. Instrumented single-rooted root segments were filled with (1) warm vertical compaction gutta-percha/AH Plus; (2) single-cone technique with ActiV GP; and (3) single-cone technique with Gutta-Flow. A dual-chamber leakage model using streptococcusmutans as a microbial marker was used for leakage evaluation. Bacterial penetration was monitored over a 100-day period. Leakage was recorded when turbidity was observed in the lower chamber. Gutta-percha warm vertical compaction exhibited the best seal with bacterial leakage observed in only 16.7% of the specimens between 59 and 100 days. All ActiVGP specimens leaked between 7 and 100 days; 50% of the Gutta-Flow specimens leaked between 22 and 100 days. The two contemporary single cone techniques did not insure a durable apical seal against bacterial leakage. A warm vertical compaction technique using thermoplasticized gutta-

percha and AH Plus sealer appears to be more effective in minimizing bacterial leakage.

Kontakiotis et al. (2007)[15] evaluated and compared the contact angles of three different types of root canal sealers-Roth 801, AH26, and RoekoSeal RSA --with the contact angle of a newly developed silicone-based root canal filling material (Gutta-Flow) on dentin and gutta-percha surfaces at two different time periods. The contact angles were determined mathematically by measuring software and were calculated from base width and height of the droplet meniscus of each sealer. Under the conditions of this study, Roth 801 and AH26 recorded lower values of contact angles when root dentin surface was used as the substrate. RSA RoekoSeal and Gutta-Flow seem to spread similarly on dentin and gutta-percha surfaces, although the contact angles of these silicone-based sealers were found to be significantly higher than the contact angles of Roth 801 and AH26 sealers. According to these findings, it can be concluded that conventional root canal sealers (Roth 801 and AH26) may passively have the potential for better wettability of dentin and gutta-percha surfaces than that of silicone-based sealers (RSA RoekoSeal and Gutta-Flow). This fact means that Roth 801 and AH26 may have a better spreading capacity under clinical conditions on the root canal walls and gutta-percha surfaces. Application of a sufficient load during lateral or vertical compaction seems to be needed for

RSA RoekoSeal and Gutta-Flow to satisfactorily wet gutta-percha and dentin under clinical conditions.

Kontakiotis et al. (2007)[16] performed an in vitro study to determine the short and long term sealing ability of a recently developed silicone-based root canal filling material (GuttaFlow). Sixty human upper central incisors were divided into 3 groups. The root canals were instrumented and obturated with laterally compacted gutta-percha and AH26 sealer (group1), continous-wave thermal compaction (system B technique) and AH26 sealer (group 2), and GuttaFlow technique (group 3). Leakage along entire root canal fillings was measured by the movement of an air bubble in a micropipette connected to the experimental root using a fluid-transport model. Short term leakage measurements were carried out for 3hrs after 24hrs of equilibrium establishment. Leakage was measured again at 3, 6, and 12 months after the initial measurement. At the 3hrs measurement, no statistical significant differences were found among the 3 experimental groups. Long term leakage study showed that at 3 and 6 months no significant differences were existed between the GuttaFlow and the 2 other groups. However, at 12 months, root canal fillings with GuttaFlow leaked significantly less than fillings of lateral compaction and system B techniques. GuttaFlow technique showed a similar sealing ability to either lateral compaction or system B technique. This comparison improved significantly over time. These findings may be related

to the possible expanding capacity of the material and the partial dissolution of the sealer over time in the other 2 groups.

Abeer Marzouk et al. (2007)[17] compared cold versus warm injectable types of gutta-percha. GuttaFlow, the new root canal filling paste and thermoplasticised obtura system were chosen to evaluate and compare surface area of voids and apical leakage after 24hrs and 6 months observation periods. Eighty human maxillary incisors with straight roots were selected. The roots were divided into 2 groups, forty teeth each. Group I was obdurated with GuttaFlow and Group II was obturated with Obtura. The samples in each group were further subdivided into 2 subgroups, 20 teeth according to observation periods, 24 hours and 6 months. Ten teeth from each subgroup were used to measure surface area of peripheral and central voids of the obturating material at cervical, middle and apical portion. Surface area was automatically measured using image analysis software. The other ten teeth were used to measure apical linear dye penetration of India ink. The results of voids surface area after both observation periods showed that GuttaFlow had significantly higher voids at all 3 levels when compared to Obtura. It was also noticed that apical third had the highest percent of voids for both materials than middle third and cervical third which recorded the least amount of voids. Regarding leakage, GuttaFlow also recorded significantly higher means of linear dye penetration than Obtura after both observation periods. Statistical analysis to evaluate change by

time in overall void surface area and linear dye penetration,proved a direct relation for both tested materials.

Donnelly et al. (2007)[18] evaluated the water sorption and solubility characteristics of three contemporary meth-acrylate resinbased endodontic sealers, EndoREZ, Epiphany, and InnoEndo, were compared with those obtained from Kerr EWT, Ketac-Endo (positive control), GuttaFlow, and AH Plus (both negative controls). Ten disks of each material were dehydrated in Drierite for 24hrs and weighed to constant dry mass. They were placed in water and weighed periodically until maximum water sorption was obtained. The disks were dehydrated again to determine their mass loss (solubility) at equilibrium. Epiphany exhibited the highest apparent water sorption (8%) followed by Ketac-Endo (6.2%), InnoEndo (3.4%), EndoREZ (3.0%), AH Plus (1.1%), GuttaFlow (0.4%), and Kerr EWT (0.3%). Significantly higher solubility (3.5-4%) were observed for all three methacrylate resin-based sealers and Kerr EWT (3.95%), compared with Ketac-Endo (1.6%), AH Plus (0.16%), and GuttaFlow (0.13%). American Dental Association specifications require less than 3% solubility for endodontic sealers. Only Ketac-Endo, AH Plus, and GuttaFlow met that criterion.

Roggendorf et al. (2007)[19] evaluated the sealing properties of four root canal sealers using a bacterial penetration model. Root canals of 50 premolars were prepared to size 45, 0.04 taper were randomly assigned to one of the following groups: group 1 (AH Plus/gutta-percha); group 2

(Epiphany/Resilon); group 3 (FibreFill/gutta-percha); group 4 (GuttaFlow/gutta-percha). Five teeth served as positive controls, five as negative controls. Teeth were decoronated resulting in a canal length of 10 mm. Canals were filled and allowed to set for 7 days (100% humidity/37°C). After filling, teeth were mounted in a two-chamber set-up and gamma sterilized. Lactobacillus rhamnosus was used for the penetration test. Bacterial leakage was recorded when turbidity within the apical chamber was recognized. Epiphany allowed a penetration of Lactobacillus rhamnosus to the apex in the shortest time when used in combination with Resilon cones. The other sealers prevented bacterial leakage to the apex for at least 2 weeks.

Hammad et al. (2008)[20] studied the polymerization shrinkage behavior of newly introduced root canal sealers. Three recently developed sealers; EndoRez (dual cure resinbased), RealSeal (dual cure resin-based), and GuttaFlow (silicon-based) were tested and compared with TubliSeal (zinc oxide-eugenol-based). The bonded disk method was used. Sixty specimens were tested at body and room temperatures. Dual cure resin-based sealers were tested as chemically cured only and as dual cured. Samples were tested for 24 hours. It was found that there were statistically significant differences between the tested sealers. EndoRez had the highest shrinkage-strain value, followed by RealSeal, whereas TubliSeal had the lowest. GuttaFlow exhibited expansion on