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Comparative evaluation of root filling after obturation with gutta-percha and 3 different sealers of minimally instrumented root canals of the maxillary second molar

Dr. Richa Singh*
Reader (Department of Conservative Dentistry and Endodontics, Rama Dental College Hospital and Research Centre, Kanpur, India)
*Corresponding author

Dr. Asheesh Sawhny
Professor and Head of Department (Department of Conservative Dentistry and Endodontics, Rama Dental College Hospital and Research Centre, Kanpur, India)

Dr. Baljeet Singh Hora
Professor (Department of Conservative Dentistry and Endodontics, Rama Dental College Hospital and Research Centre, Kanpur, India)

Dr. Saurav Paul
Senior Lecturer (Department of Conservative Dentistry and Endodontics, Rama Dental College Hospital and Research Centre, Kanpur, India)

Dr. Debajit Sarkar
Post Graduate Student (Department of Conservative Dentistry and Endodontics Rama Dental College Hospital and Research Centre, Kanpur, India)

Dr. Viketounuo Vizo
Post Graduate Student (Department of Conservative Dentistry and Endodontics, Rama Dental College Hospital and Research Centre Kanpur, India)

***Abstract*---**Introduction: The purpose of this study was to compare the superiority of root fillings made with three different sealers after minimal instrumentation of maxillary Second Molar root canals utilising a modified single-cone method. The specimens were separated into three groups and filled with a size-fit gutta-percha master cone and Sealmax-R (MAARC), Ah Plus (Dentsply), and MTA Plus (PrevestDenpro) sealers. Before and after instrumentation, post-Gentle Wave, and after obturation, micro–computed tomographic images were collected. Starting at the top of the root, the mesiobuccal

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roots of the selected teeth were sectioned in 0.5-mm intervals. Light microscope was used to examine the cross sections. Results: In all three groups, was filled to 90%–99% of the canal space. Sealmax-R and Ah Plus groups used more filler material on average than MTA Plus group (P <.05). Apical, middle, and coronal thirds showed no significant differences. Cross-sectional scans indicated no obvious gaps in the Sealmax-R groups. After instrumentation, hard tissue debris was discovered in the root canal system in 49 of the 189 canal thirds (25.9%). After Gentle Wave cleaning, only 4 of 63 canals (6.3%) and 4 of 189 canal thirds (2.1%) contained debris. Conclusions: The MSC method with Ah Plus and Sealmax-R sealers generated high-quality root fillings after multisonic cleaning of minimally instrumented molar canals. The removal of debris by multisonic cleaning of minimally instrumented molars appears to be successful.

***Keywords*---**Micro–computed tomography, minimum instrumentation, molar, obturation, GentleWave, Sealmax-R sealers.

Introduction

Minimal instrumentation has sparked a lot of interest in clinical endodontics and, to some extent, in endodontic research in recent years[1,2]. According to a prominent counterargument to limited instrumentation, little canals as small as #15 and #20 can't be effectively watered, disinfected, or filled.As a result, the standard minimum size has been #25/04 or larger, with occasional attempts to clean and fill size #20 canals with a.06 or larger taper. New, noninvasive technologies like Photon Induced Photoacoustic Streaming (Fotona, Ljubljana, Slovenia) and the GentleWave (GW) System (SonendoInc, Laguna Hills, CA) have redirected the focus on the smallest canals, smaller than size #25 or #20[3–5].If small canals can be cleansed and disinfected appropriately, a root filling method or methods that can adequately and predictably fill such canals become necessary. Filling root canals in anatomically complex or very small root canal systems is technically difficult. This is reflected in the wide range of root filling techniques and materials available.The large array of root filling techniques and materials available reflects this. In most root filling treatments, a core substance and a sealer are used. Sealer is required for achieving a fluid-tight seal regardless of the type of core material[6]. Glass ionomer, zinc oxide–eugenol, resins, calcium hydroxide, silicone, and bioceramic materials are among the materials used in endodontic sealers. Bioceramic-based sealers including calcium silicate and/or calcium phosphate have sparked a lot of attention because to their physicochemical and biological properties. A hybrid bioceramic sealer is a resin-based sealer with a bioceramic component. Sealmax-R sealers may be well suited for root fills in narrow, tiny root canals due to their thixotropic qualities, although no published evidence is currently available[12]. The most common root canal obturation techniques are warm vertical compaction, cold lateral compaction, and core carrier treatments. Because GP points of the same size and shape as the previous rotational file have been available, the single-cone (SC) technique has recently gained prominence. The SC approach has a number of advantages, including ease of use and a quick procedure time[13, 14]. Porosities in large quantities of sealer, likely setting contraction, difficulty removing bioceramic sealers, and material dissolution[15] are all potential disadvantages. This in vitro study looked at the quality of root fillings created with a modified SC method and three different sealers after minimal #15/.04 instrumentation and noninvasive canal cleaning. The volume and probable porosity of root fillings in the mesiobuccal, distobuccal, and palatal canals of maxillary Second Molars were examined using micro–computed tomographic (micro-CT) scanning and light microscopy.

Materials and Methods

3 Root Canal Sealers' Radiopacity According to updated ISO 6876/2012[16], the radiopacity values of three sealers (Ah Plus, Sealmax-R, and MTA Plus) were investigated. All sealants were blended and adjusted according to the manufacturers' instructions. The sealers were placed in moulds with a diameter of 10 mm and a thickness of 1 mm and allowed to set. The specimen was in the centre of the X-ray film (ScanX Intraoral Phosphor Plates; Air Techniques, Melville, NY) next to the aluminium step wedge (purity of 99.99 percent) with a thickness ranging from 1–12 mm in 1 mm steps. The specimen, step wedge, and X-ray films were irradiated at 65 kV at a target film distance of 300 mm.The density of the specimen's picture was compared to that of an aluminium step wedge, and the specimen's radiopacity was measured in millimetres of aluminium.

Selection and Preparation of Specimens

Human second maxillary molars with mature apices were extracted from a pool of teeth removed for reasons unrelated to this study. The teeth were preserved in 0.01 percent sodium hypochlorite (NaOCl) at 4° C until usage after external soft tissue remnants and surface debris were removed. Teeth having decay or fractures beneath the cement enamel junction, internal or external resorption, open apices, or recent root canal therapy were all ruled out in the study. The teeth were chosen using two-dimensional buccolingual and mesiodistal radiography, as well as micro-CT scanning (initial scanning) (Scanco-Medical micro-CT 100 system; Scanco Medical, Bassersdorf, Switzerland). The scanner was operated at 90 kV and 88 mA with a resolution of 30 mm and a resolution of 30 mm. Three distinct roots with discrete apical foramina and a 15° –35° curvature were seen in all of the teeth. Eighteen teeth were chosen for the examination. After restoration of the pictures, teeth were divided into three groups (n = 6) based on root canal architecture and baseline root canal volume, as indicated in Table 1.

TABLE 1 - The Mean (± Standard Deviation) Values of the Volume of the Different Root Canals and P Values in the 3 Groups

Group	Mesiobuccal	Distobucccal	Palatal
	Sealmax-R, Ah Plus, MTA Plus	Sealmax-R, Ah Plus, MTA Plus	Sealmax-R, Ah Plus, MTA Plus
Volume (mm3)	2.0 ± 0.5, 1.9 ± 1.2, 2.1 ± 1.0	1.9 ± 0.7, 1.3 ± 1.0, 1.2 ± 0.6	3.2 ± 1.4, 4.1 ± 3.4, 4.2 ± 2.0
P value	>.05	>.05	>.05

Each group comprised of six teeth: three teeth having a second mesiobuccal root canal and three teeth with only one mesiobuccal root canal. The pulp chambers were accessible in a traditional manner. To achieve apical patency, size 10 K-files (DentsplyMaillefer, Ballaigues, Switzerland) were introduced 1mm beyond the apical foramen through the root canals. Size 10K-files and radiography were used to establish canal lengths. The working length (WL) was set at 1mm below the apical foramen.

Root Canal Instrumentation and Irrigation

In continuous torque controlled rotation to the WL, all canals were instrumented using a size 15/.04 Profile Vortex Blue file (Dentsply) Tulsa Dental Specialties, Tulsa, OK. The pulp chamber was half-filled with 5% NaOCl during instrumentation, and the canals were irrigated with the same irrigant using a syringe needle (30-G) before and after the use of the 15/.04 rotary file. The irrigation needle was placed 1–4 mm short of the WL, depending on the initial canal size and size after instrumentation. The same skilled operator performed all root canal preparation. After the 15/04 file, the GW System was used to clean the root canals according to the manufacturer's suggested protocol, as previously described[15,17]. 3 percentNaOCl was used in the GW cleaning (5 minutes) 1 litre of water (15 seconds) EDTA (ethylenediaminedithiothreitol (2 minutes) 1 litre of water (15 seconds) [17,18].

TABLE 2 - The Mean (± Standard Deviation) Values of the Percentage Volume of Gutta-percha + Sealer and P Values at Different Canal Levels in the 3 Experimental Groups

	Coronal	Middle	Apical
Group	P, DB, MB, Total	P, DB, MB, Total	P, DB, MB, Total
Sealmax-R	98.2 ± 1.4, 98.5 ± 0.6, 98.9 ± 1.3,98.5 ± 1.1	98.7 ± 1.1, 97.7 ± 0.8, 98.0 ± 1.1, 98.1 ± 1.1	98.1 ± 1.6, 96.9 ± 1.4, 97.8 ± 0.9, 97.6 ± 1.4
Ah Plus	97.4 ± 1.1, 97.5 ± 1.2 97.1 ± 1.5, 97.3± 1.8	97.0 ± 1.7, 96.9 ± 1.4 94.7 ± 2.1, 96.2 ± 2.0	95.8 ± 2.5, 95.9 ± 1.4, 96.1 ± 2.3, 96.0 ± 2.0
MTA Plus	95.4 ± 2.7, 93.8 ± 2.4, 95.0 ± 1.6, 94.7 ± 2.3	92.9 ± 0.9, 92.5 ± 2.5, 91.4 ± 3.9, 92.2 ± 2.7	92.7 ± 1.4, 89.5 ± 2.8, 89.8 ± 4.4, 90.7 ± 3.3
P value	>.05, <.05, <.05, <.05	<.05, <.05, <.05, <.05	<.05, <.05, <.05, <.05

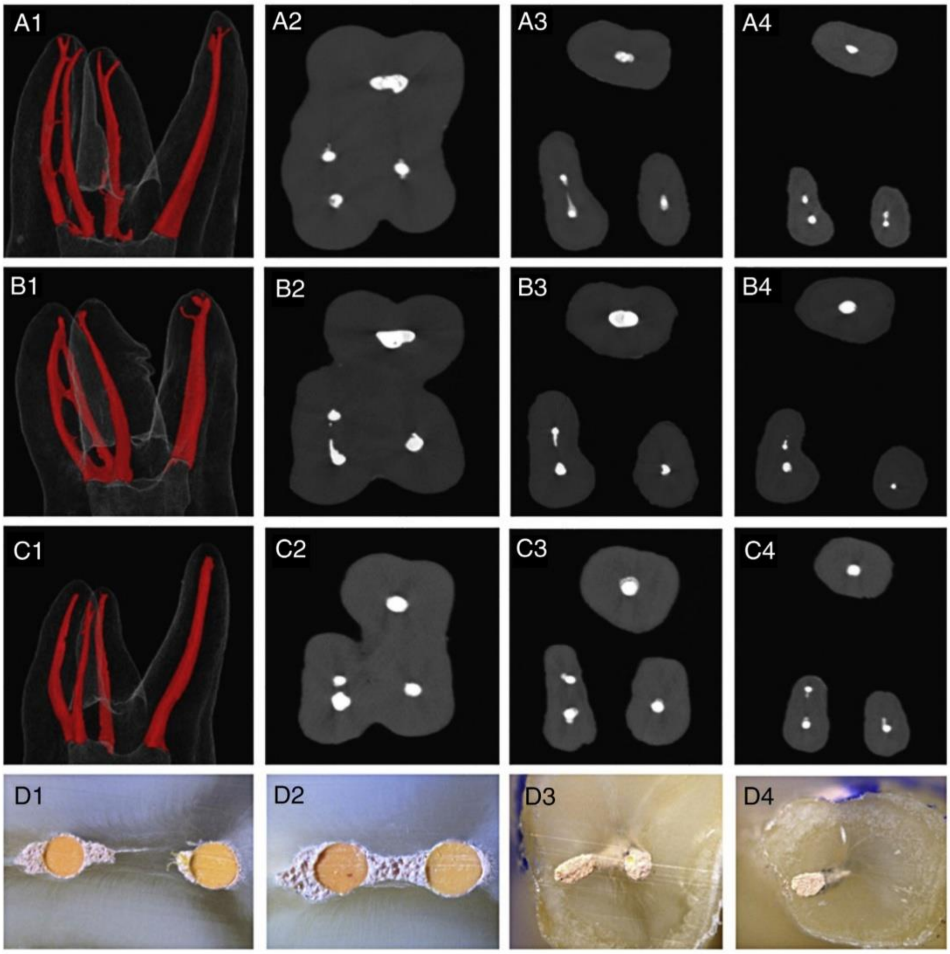

Figure 1 – Representative 3-dimensional reconstructions of maxillary second molars filled by GP with (A1) Sealmax-R, (B1) Ah Plus, and (C1) MTA Plus sealers. Micro-CT scans of the cross section of root canals at the (A2, B2, and C2) coronal, (A3, B3, and C3) middle, and (A4, B4, and C4) apical thirds. Microscopic images of the sectioned root surface (Ah Plus group) from (D1) 4 mm, (D2) 3 mm, (D3) 1 mm, and (D4) 0.5 mm away from the apex (the WL was set at 1 mm short of apex).

Root Canal Obturation

The canals were dried using size fine and medium paper points (DiaDent Group International Inc, Tianjin, China) to the WL after instrumentation and GW cleaning. Because larger than #15/04 instruments were not used, the single GP point for each canal was chosen as follows to avoid the potential of overfilling: GP points with a 4 percent taper were put into the canals to the WL in increasing diameters (15, 20, 25, 30, 35, and so on) until tug back was detected at 0.5–1.0 mm short of the WL (Vortex GP, Dentsply Tulsa Dental Specialties).The filling was done at this GP point. After that, the root ends were coated with a tapered, opaque celluloid film that was individually moulded and glued to each root surface, leaving the apical foramen exposed. During root filling, the operator couldn't see the apex because of the cover. The sealer was applied in the following manner: silicone sealers and MTA Plus were placed into the canal, filling about half of it. The GP point was then coated with a thin layer of sealant and pushed slowly into the canal to the WL without using any pumping motion. An additional GP point that extended into the pulp chamber was removed using a hot tool. Root canal pluggers were pre-selected in various sizes for root filling compaction; the largest was slightly smaller than the coronal canal diameter, allowing the plugger to penetrate 2–3 mm into the canal. The second plugger was smaller, allowing for 4 mm of penetration in an empty canal, and the third plugger around 6 mm. Cold vertical compaction was applied to the cut coronal surface of the GP point for 5 seconds. Then, the other two pluggers were utilised for 5 seconds each at a constant, light pressure. Injectable warm GP was used to backfill the coronary arteries when needed (Calamus Dual; DentsplySirona, York, PA). All three groups' samples were kept in an incubator for 5 days at 100 percent humidity and 37° C to allow the sealers to fully set before micro-CT scanning.

Micro-CT Scanning and Measurements

A micro-CT system was used to scan the teeth

1. for tooth selection,
2. after instrumentation,
3. after GW, and
4. after obturation.

The analyzer software (SkyScan; Bruker micro-CT, Kontich, Belgium) and VGStudio MAX 4.0.0 (Volume Graphics GmbH, Heidelberg, Germany)[17] were used to perform three-dimensional reconstruction, analysis, and quantitative measurement. The amount of debris-holding channels was shown in scans taken after instrumentation and after GW. The volume of filling materials, gaps, and voids was calculated using data from the third (after GW) and fourth (after obturation) images. The data was generated separately for the coronal, middle, and apical thirds of each canal (N = 189 thirds). The difference between the volume of empty canal space (third scan) and the volume of root fills was used to compute the volume of gaps and voids (fourth scan).In the apicocoronal direction, the root canal volume was divided into three equal-length pieces in each root. Mesiobuccal roots were sectioned in 0.5-mm increments starting at the apex of the root with a slow-speed diamond blade and water cooling (IsoMet 5000; Buehler, Lake Bluff, IL).Under a microscope with a magnification of at least 40, the cross sections were examined and photographed. The statistical differences between groups were analysed using one-way analysis of variance with a significance level of 5% using SPSS 16.0 for Windows. (Chicago, IL: SPSS Inc.)

Results

The radiopacity of all three sealers was within ISO 6876 guidelines (. 3 mm Al). The radiopacity of Ah Plus (9.41 ± 0.09 mm Al) was the greatest, followed by Sealmax-R (8.33 ± 0.13 mm Al) and MTA Plus (4.98 ± 0.10 mm Al) (P, .05). According to micro-CT scanning, 49 of the 189 canal thirds (25.9%) showed hard tissue debris in the root canal system after minimal instrumentation

(15/.04).Only four of the 63 canals (6.3 percent) and four of the 189 canal thirds (2.1 percent) contained debris after the GW cleaning. The volumetric percentages of the filling materials were determined after the volumes of the filling materials were measured. At three canal levels, the results were compared between the root filling sealer groups and within each group. The Sealmax-R (96.9% –98.9%) and Ah Plus (94.7 percent 97.5 percent) groups had greater mean filling material volumes than the MTA Plus group (89.4 percent –89.5 percent) (P,.05) (Table 2).There were no significant differences between the apical, middle, and coronal thirds. Photomicrographs of representative hard tissue cross sections, as well as micro-CT scan sections from the apical and central areas of the first and second mesiobuccal canals of maxillary molars, are shown. Seals, including fins and the isthmus, were discovered near to canal walls. In the sliced parts of Sealmax-Rand Ah Plus groups, there were no evident gaps or voids.

Discussion

The quality of root fillings performed using a modified SC root filling process with three different sealers was evaluated after minimal instrumentation and GW cleaning. The SC method requires the use of a precisely fitted cone in conjunction with a root canal sealer to completely fill the channel. It is a simple and time-effective treatment approach that may reduce the risk of dentinal wall damage from lateral condensation forces and, to a lesser extent, warm vertical condensation[15]. The traditional SC approach was compared to two minor filling procedure adjustments. The new, updated approach required extra caution in picking the master GP point because no instruments larger than #15/.04 were used in the canal. Second, cold vertical condensation was investigated using three prematched root filling pluggers of progressively smaller sizes to produce optimal apical pressure while avoiding plugger contact with canal walls. The pluggers were then subjected to a 5-second constant pressure test. Pilot testing, as well as a variety of radiographs and visual examinations of the apical foramen, demonstrated that maintaining the plugger pressure for several seconds rather than a series of quick taps on the coronal end of the root filling increased the sealers' apical canal flow. Overfilling was not identified in the study, which could be attributable to the following variables:

1. using the tug back test, carefully pick the master cone size to ensure a proper apical fit,
2. Only half of the canals had been sealed before the GP point,
3. The GP cone, which had been covered with extra sealer, was progressively introduced to the WL, with no painting or pumping done with the point, and
4. Cold vertical compression was performed at or near the pulp chamber floor level.

The pilot test revealed that when#15/04 GP point is used in all canals, overfilling with the GP point is typical in canals that are naturally larger at the WL than size 15/04.The Sealmax-R and Ah Plus groups had a greater filling quality than the MTA Plus groups. Sealmax-R and Ah Plus's thixotropic characteristic may contribute to the reduced incidence of gaps and voids[19]. Because thixotropic sealers become less viscous under pressure, they can easily permeate narrow tubes and their ramifications.When Ah Plus is set[19], it expands somewhat, which could lead to less gaps and voids in the filled canals. The current results with the two Sealmax-R sealers plus a master cone were exceptionally high in comparison to previous studies of the percentage root canal volume filled with root filling materials; the average volumes filled in different parts of the three canals (mesiobuccal, distobuccal, and palatal) ranged from 94.7 percent to 98.9 percent in the current study. In comparison to other studies[20–22], this is a fantastic result. However, it's worth noting that the number of micro-CT research on this subject is still small[20–22]. In cone-beam computed tomographic and micro-CT scans, radiopacity affects the distinguishability of the filler materials. The high radiopacity of the two Sealmax-R sealers may have played a role in the outcomes produced with these two sealers, but no specific comprehensive data on this has been found thus far. More empty canals, gaps, and voids were found in canals filled with the master cone and MTA Plus sealer. It's probable that different types of sealers will require different optimizations for the SC method in narrow canals. More research is needed to better understand the parameters that influence the quality of fillings made with various sealers. The ability of the sealer to flow into tight places and around the core material is determined by its viscosity. Lacey et al23 looked studied the influence of temperature on the viscosity of traditional sealers at both room temperature (25° C) and body temperature (37° C). There is currently no information on the influence of temperature on the viscosity of the three sealers. Because natural variations in the morphology of maxillary Second Molars are well-known, efforts were made to ensure that the groups were comparable in terms of root canal morphology. In the same way as previous research has been done, A micro-CT scan of each specimen's volume and root canal structure was done on days [24–26].Each group received an equal number of teeth with similar morphology based on these measurements. Statistical analysis revealed an effective balance between the groups in terms of canal volume, potentially boosting the study's internal validity by removing significant anatomic biases that could have influenced the outcome. Cleaning uninstrumented or slightly instrumented canals has been problematic, which has hampered research of root fillings in these canals. The physical and hydrodynamic limitations imposed by this unique anatomic site must be taken into account when irrigation of the apical root canal[27].Previous research has shown that the GW System can clean root canals effectively, including peripheral locations such as the apical delta[17,28]. In a recent histologic analysis, GW outperformed syringe-needle irrigation for removing soft tissue from the root canals of removed teeth[28].Only 2.1 percent of the canal thirds showed radiopaque debris following cleaning in this investigation. When rotary or manual instruments are used in conventional preparation sizes to #30 and higher[29], dentin debris forms nearly in all canals. Dentin debris was identified only in 49 of the 189 (25.9%) canal thirds after instrumentation and in 4 of the 189 canal thirds (2.1%) (4 of 63 canals) following GW cleaning before root filling in the current investigation, in which the l5/.04 rotary file was the greatest size used. Another advantage of minimal instrumentation is the lesser occurrence of dentin debris, which is difficult to remove using normal cleaning and irrigation protocols and may inhibit the penetration of disinfecting solutions and root filling materials, according to multiple previous studies[30,31]. Finally, in the Sealmax-Rand Ah Plus groups, the quality of the root fills by a modified SC method was outstanding, and it was higher than in the MTA Plus group. The procedure presented here appears to be promising for root filling in maxillary molars with small, minimally instrumented but clean root canals.

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