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Micro Apical Placement System (MAPS)

- A new instrument for retrograde root canal filling -

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Abstract

ILGENSTEIN B, JÄGER K: Micro Apical Placement System (MAPS)

- Ein neues Instrumentarium zur retrograden Wurzelfüllung

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A retrograde radicular preparation in the axis of the root canal as well as an excess-free obturation of the canal is surgically very demanding due to the complex anatomical structures and to the limited intraoral operative field. As from the early 1990s, advisable methods for the retrograde root canal obturation under minimal place requirements have been implemented thanks to ultrasonic- and sonic-driven microinstruments.

This publication presents a new microsurgical instrument, the "Surgical-Retro" Micro Apical Placement System (MAPS), which facilitates in a large extent the retrograde obturation with a plastic root canal filling material. The device provides an unrestricted access to the retrograde cavity, allowing thus an accurate obturating technique whilst avoiding the dispersion of the root canal filling material in the surrounding bone. Thanks to the "Surgical-Retro" Micro Apical Placement System, a further gap in the improvement of the quality and, thus, of the success of the treatment by apical resection has been filled.

1. Introduction

The use of ultrasound in apicectomy was described as early as the middle of the last century by BERTRAND et al. (1957) and RICHMAN (1976), but the technique of root canal preparation using ultrasound was initially forgotten. To improve the prognosis of success for root tip resections, researchers concentrated on the development of retrograde root canal filling materials (KELLER 1985, 1988, KHOURY & STÄHLE 1987, KHOURY 1992, HICKEL 1988, BLACKMAN et al. and BONDRA et al. 1989, MICHALCZIK et al. 1993, MCDONALD et al. 1994). It was not until the work by CARR (1992a) that retrograde root canal preparation by ultrasound was developed into a standard operating procedure. Together with new biocompatible root canal filling materials (TORABINEJAD et al. 1993, ILGENSTEIN et al. 1995) and optics such as the illuminated binocular loupe, operation microscopes (CARR 1992b) or endoscopy, the microsurgical operating techniques had resulted in a considerable improvement in the quality of retrograde root canal fillings and significantly improved the success statistics. The preparation of the retrograde cavity and the quality of the retrograde root canal filling was particularly important (GULDENER 1994). This is because retrograde root canal filling requires a subtle microsurgical operating technique taking axial preparation into account. It is difficult to access the fundus of the cavity, which is why very often cavities are not filled completely. Therefore, in 1994, working together with the Kavo company (KaVo-Sonicflex Retro tips, KaVo GmbH, Biberach, Germany), diamond-coated sonoabrasive instruments to be mounted on an ultrasonic unit, together with suitable condensers were developed by the main author (ILGENSTEIN 1994, VON ARX, ILGENSTEIN et al. 1997, 1998, ILGENSTEIN et al. 1998). For the first time, these bent and diamond-coated instruments, right- or left-angled, provided better access to the retrograde cavity as well as an exact and defined retrograde cavity preparation to a depth of 3-4 mm (Fig. 1, 2, 3). With retrograde root canal fillings of less than 3 mm, special tips enable undercuts to be made to avoid loss of retention (Fig 4).



Fig. 1 KAVO Sonicflex Retro® tips; connecting piece for sterile fluid, angled condensers



Fig. 2 Anatomical access with KAVO Sonic Retro® tips

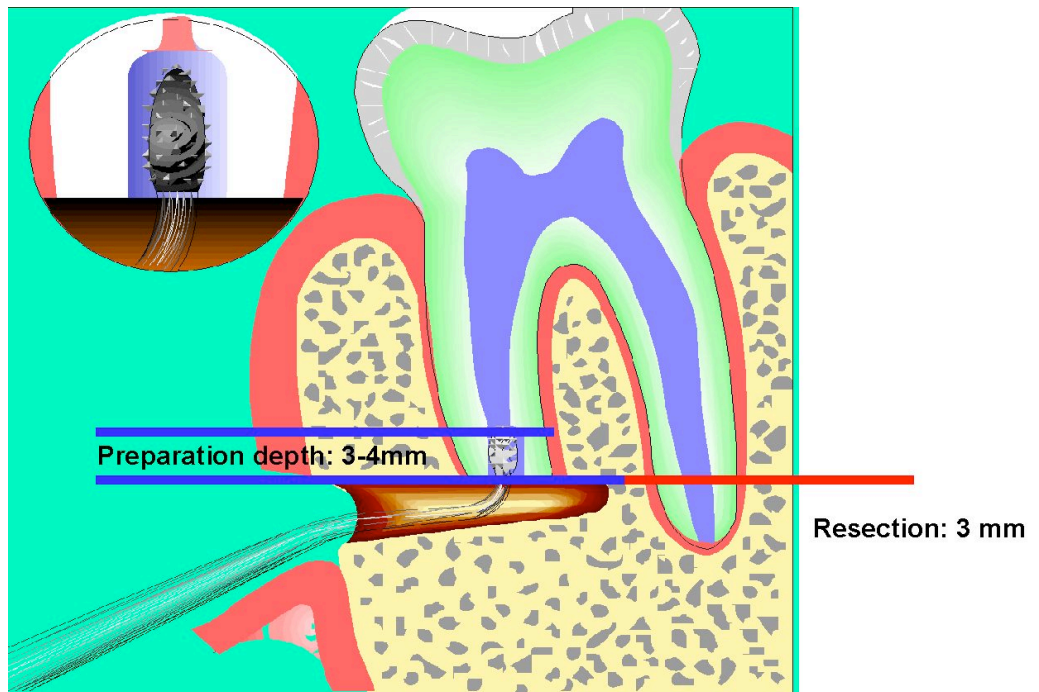


Fig. 3 The principles of retrograde root canal filling

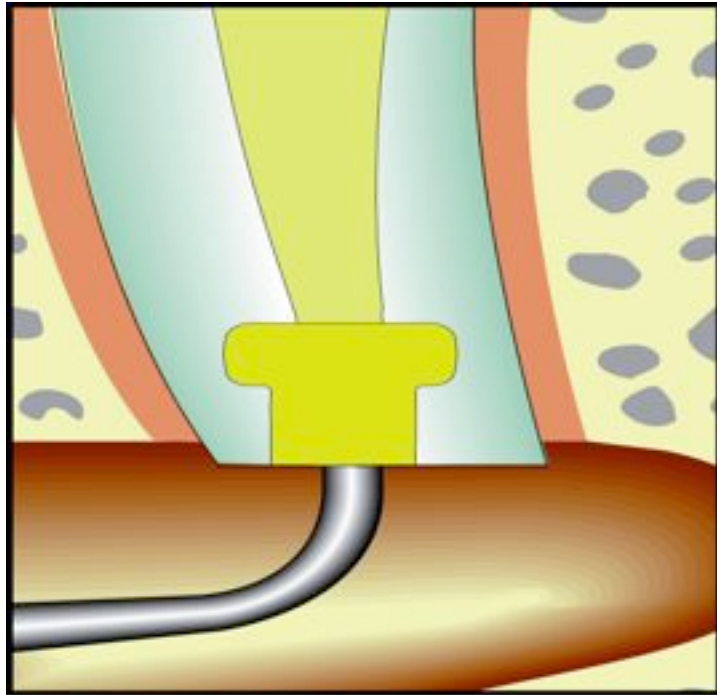


Fig. 4 Retrograde root canal filling with undercut

But as well as an axial retrograde cavity and the retrograde root canal filling material, the success of retrograde root canal filling depends to a very large extent on the quality of the retrograde obturation. In our mind, the retrograde root canal filling must be hermetically sealed, filled completely and without inclusions of air up to the orthograde connecting root canal filling (Fig. 3-8).



Fig. 5 Intra-operative control X-ray. Apical bone defect due to cysts in the antro. Retrograde root canal filling with MTA with no dispersion of root canal filling material into the maxillary sinus. Axial retrograde preparation, undercut. Orthograde connecting filling is achieved.

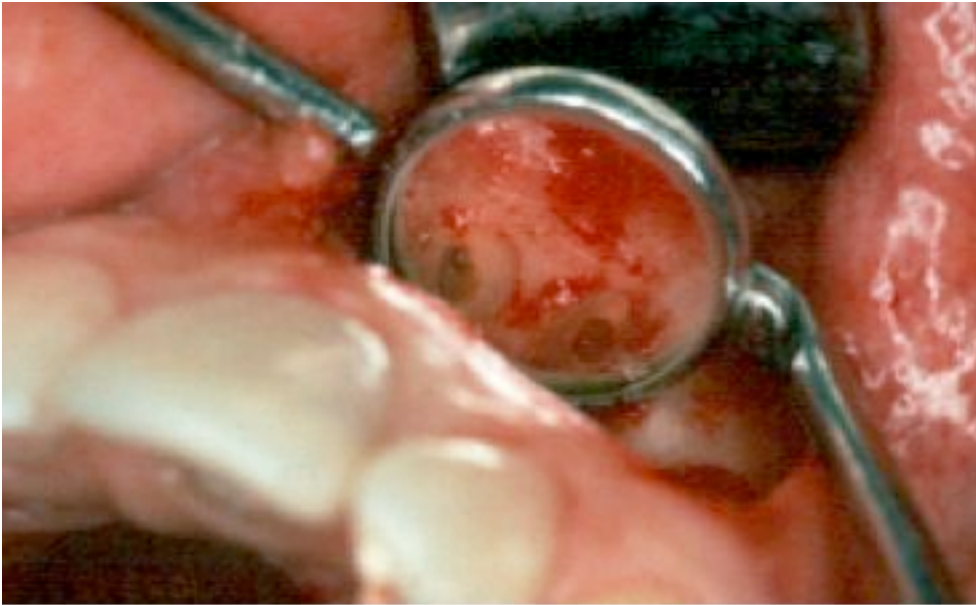


Fig. 6 Retrograde cavity after preparation with KAVO Sonicflex Retro® tips. Note: Orthograde connecting filling with gutta percha and AH26 is achieved.



Fig. 7 Retrograde root canal filling with MTA using MAPS, sagittal section with undercut (retention). The cavity is completely filled.

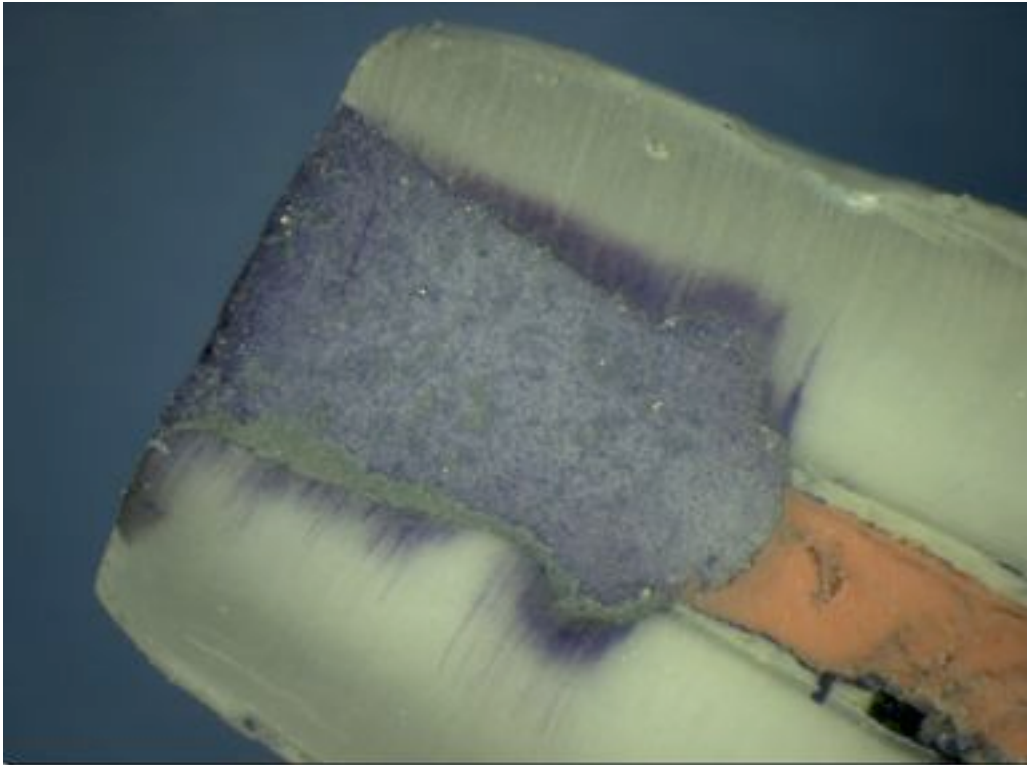


Fig. 8 Tightness penetration test with fuchsin: Sagittal section, magnification x 30. Retrograde root canal preparation with undercut (retention). Retrograde root canal filling with MTA. Orthograde connecting filling with gutta percha is achieved.

The Surgical Micro Apical Placement System (MAPS) instrument set presented in this paper was developed in 2001 by the company Produits Dentaires S.A. (CH-1800 Vevey, Switzerland) in cooperation with the principal author in order to make it easier to insert a plastic root canal filling material into a retrograde cavity (Fig. 9, 10), and to achieve satisfactory obturations of the root canal also in those teeth that are not readily accessible. A further aim was to prevent root canal filling material from dispersing into the periapical bone tissue.

The aim of the paper is to present the system and to assess its suitability for clinical use. The following parameters are to be investigated under clinical operating conditions:

- the handling of the instruments, particularly in anatomically tricky regions (molars, mandibular canal, maxillary sinus)
- access to the operating area and the apical region
- the obturation of the retrograde cavity
- dispersion of retrograde root canal filling material into the periapical region

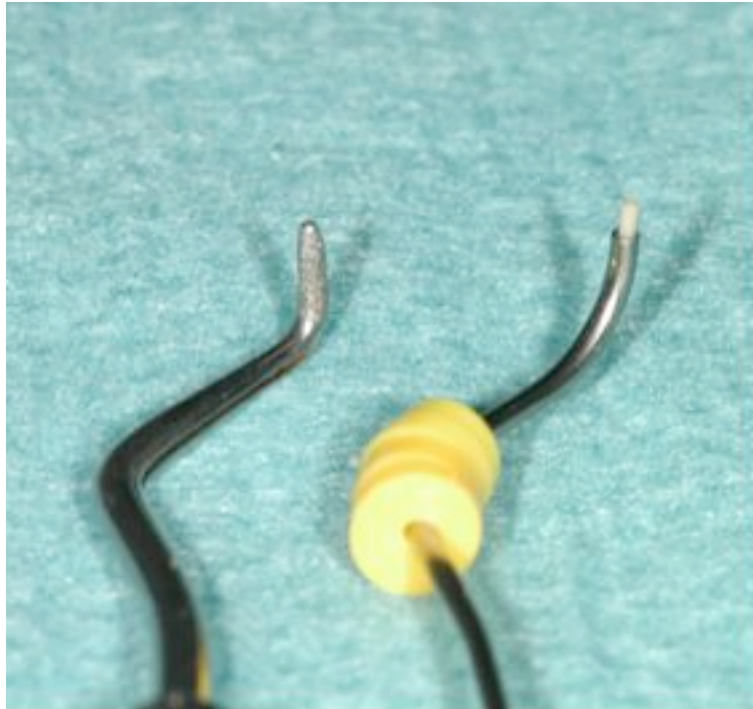


Fig. 9 MAPS instrument for retrograde root canal filling (right). KAVO Sonicflex Retro® tips for retrograde preparation (left)



Fig. 10 MAPS instruments box

2. Material

Over the last four years the instrument set has been tested extensively clinically and has been continuously improved particularly in terms of the materials used.

2.1 . Instruments

The complete instrument set (Fig. 10, 11) consists of a stainless steel applicator syringe (Fig. 12) with a bayonet catch for six exchangeable applicator cannulas (needles). The small diameter of the application needles means that the root canal filling can be applied directly into the root canal prepared apically (Fig. 13). In view of the anatomy, the root canal is accessed for the first time with triple-angled stainless steel cannulas (Fig. 14). The cannulas are available in two variants, right-angled and left-angled, each with two external diameters, 0.9 mm (marked yellow) and 1.1 mm (marked red). The internal diameter of the cannulas is 0.6 mm (marked yellow) and 0.8 mm (marked red), as a result of which sufficient portions of the retrograde filling material can be applied successively (Fig. 11, 14). The intracannular plungers (Fig. 13) are made of PEEK (polyether ether-ketone), a polymer for medical purposes (Fig. 15). The filling material can be taken from a dispenser/well (Fig. 16). Residues of material inside the cannulas can be easily removed with a cleaning curette (Fig. 17).

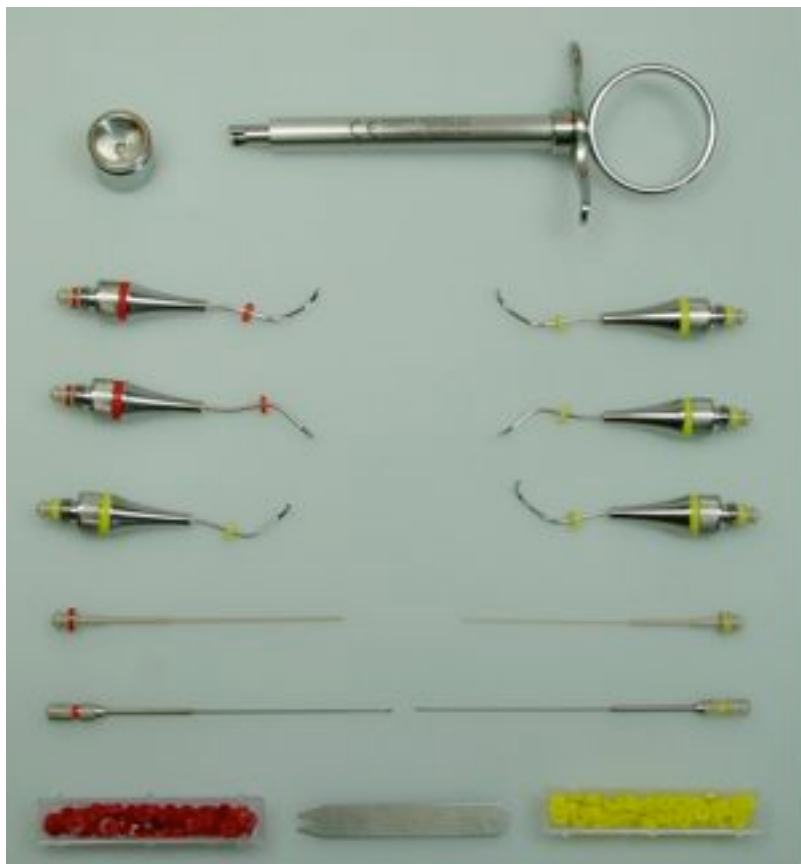


Fig. 11 Set of instruments with applicator syringe (contents of box)



Fig. 12 Assembled applicator syringe

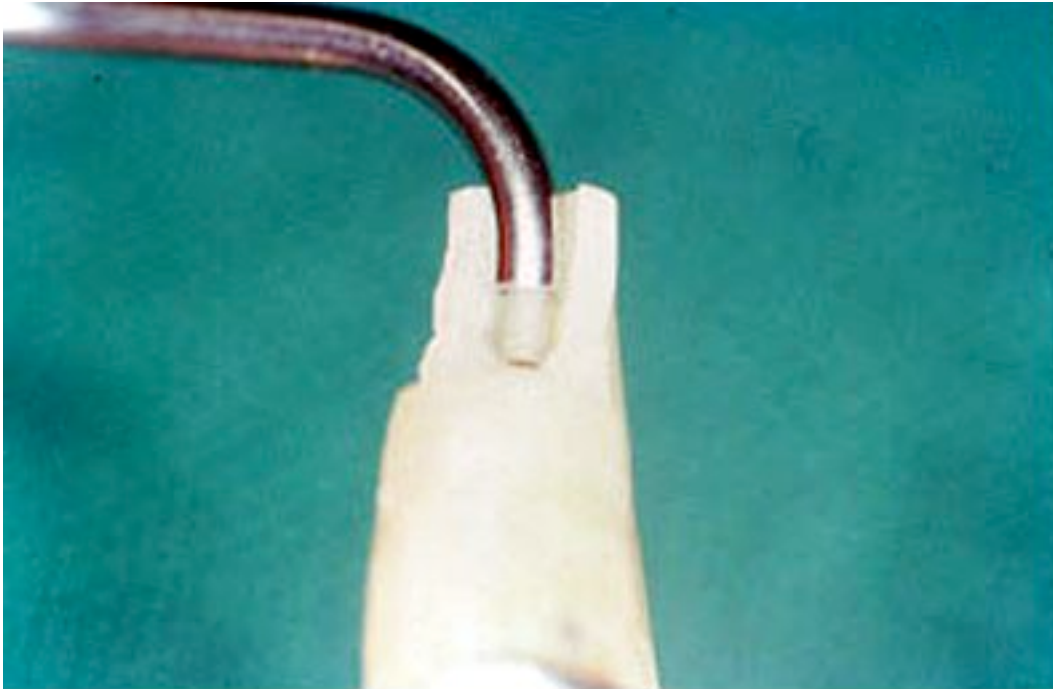


Fig. 13 Applicator needle/cannula in prepared cavity in situ (with PEEK plunger in the cannula)



Fig. 14 Triple-angled needle left and right



Fig. 15 Intra-canal plunger for applying (PEEK)



Fig. 16 Dispenser (well) for filling material



Fig. 17 Cleaning curette

After the retrograde filling material has been taken up, a ring remover (Fig. 18) enables the application cannula to be cleaned, thereby enabling excess filling material to be removed before being inserted into the operating cavity. This prevents the operating area being contaminated by the retrograde filling material (Fig. 19, 20). Pro Root MTA (Dentsply ProRoot MTA, Instruments Maillefer SA, CH-1338 Ballaigues) was used as the retrograde filling material (TORABINEJAD 1993). Alternatively, other plastic materials can also be applied with the instruments. It is not necessary to further finish the retrograde root canal filling at the resection cross-section.

The quality of the retrograde root canal filling was checked post-operatively with individual apical X-ray images using the right-angle technique (long cone tubus) (Fig. 5, 21). Periapical reossification after the application of MTA was assessed according to the classification modified according to LINK (1935) and MAYR (1967). Radiological check-ups were carried out after three, six and nine months.

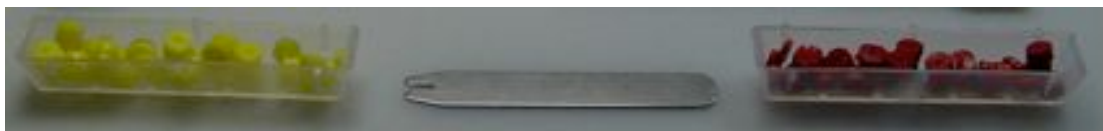


Fig. 18 Ring remover plus key

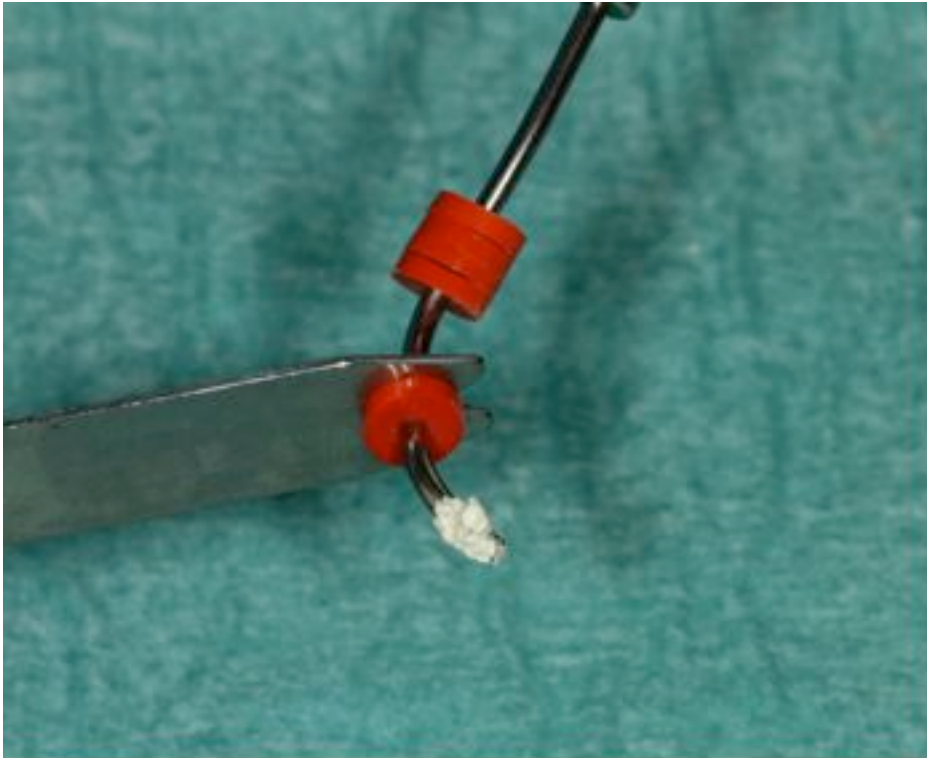


Fig. 19 Root canal filling material receiver (here MTA) with MAPS and cleaning with ring remover



Fig. 20 After cleaning with ring remover

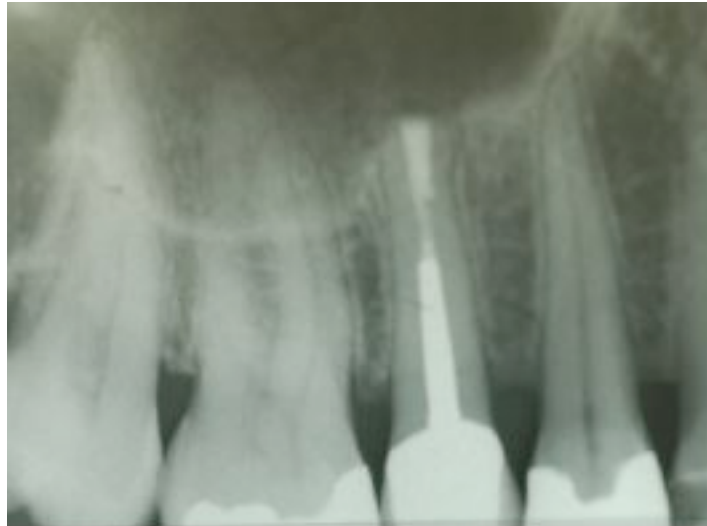


Fig. 21 X-ray six months after the operation. Continuous periodontal space apically shows periapical reossification defined to the lumen of the maxillary sinus

2.2. Operating procedure

The operating technique in apical resection was carried out in accordance with microsurgery guidelines (e.g. micro-scalpel, suture materials 5 x 0 to 7 x 0). Bleeding must be controlled very effectively for there to be sufficient dryness in the operating area. As well as anaesthesia with a sufficient administration of adrenaline, haemostatics applied locally are often needed as well. The orientation of the cut depends largely on the condition of the crown of the tooth (natural tooth or crown restoration, dehiscences) and the width of the epithelialised marginal mucosa. After exposure of the apical region, depending on the shaping of the apical delta the apices were resected about 2-3 mm (Fig. 3, 22), prepared retrogradely with KAVO SONICretro® tips (Fig. 1, 2) and filled retrogradely with Pro Root MTA and the new applicator system (MAPS) (Fig. 10, 11). In most cases, the root canal filling material that had been applied was compacted with the SONIC Retro condenser (Fig. 1) after the first portions.

The main feature of the new instrument is an applicator syringe (Fig. 11, 12) with which plastic filling materials are held and can be metered incrementally into the previously prepared retrograde cavity.

2.3. Study method

Between 2001 and 2004, root tip resections were performed in 117 patients on 139 teeth (maxilla 119/mandible 20) (Fig. 23) and with the new instrument Surgical-Retro MAP System, 155 retrograde root canal fillings carried out with MTA.

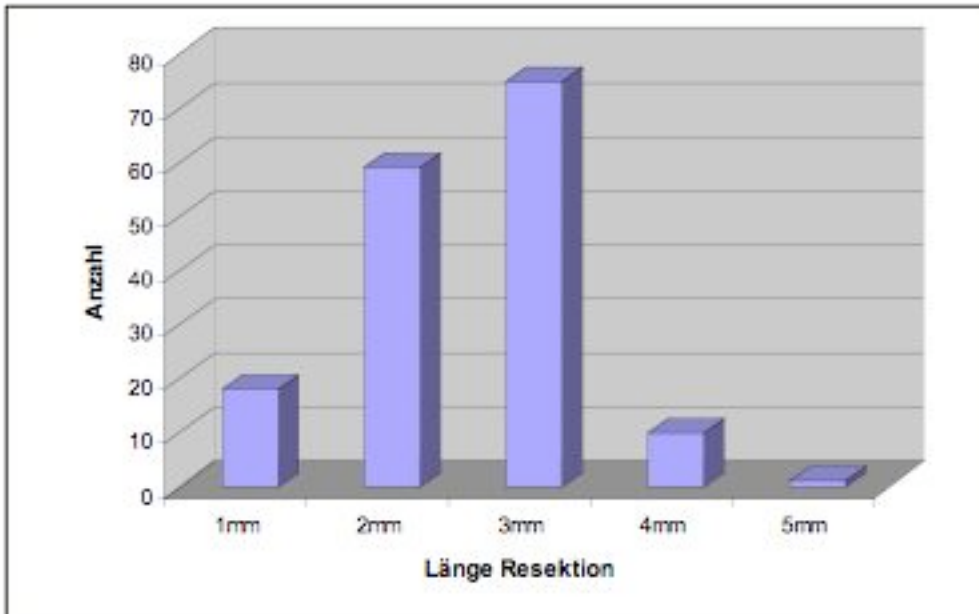


Fig. 22 Resection lengths of the apical delta in mm
 [x-axis = Length of resection in mm, y-axis = Number]

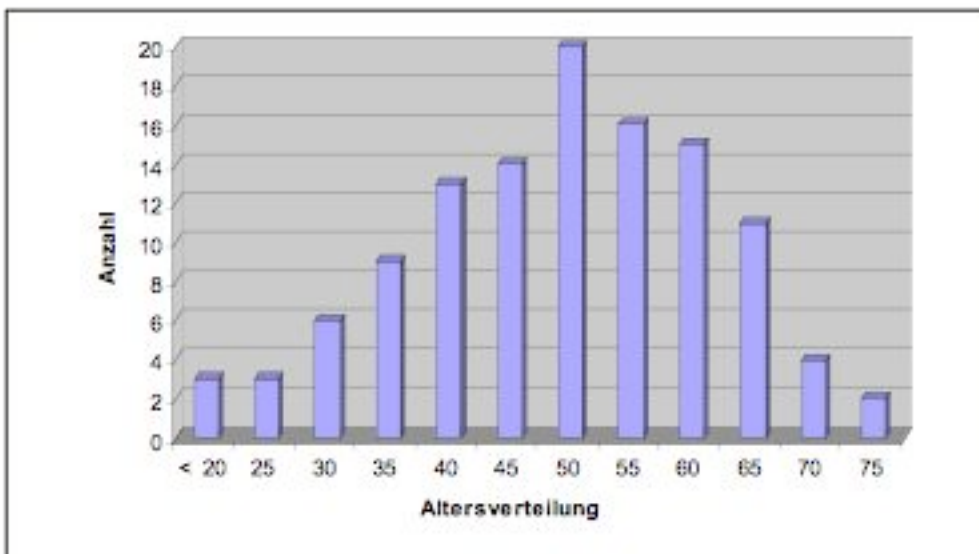


Fig. 23 Age distribution of a patient population of 117 patients
 [x-axis = Age distribution, y-axis = Number]

3. Results

Root tip resection was indicated most frequently in the groups of 40 – 65 year-olds, with a significant increase in 50 year-olds. The average age was 48.9 years. The largest group was central and lateral incisors of the maxilla with 69 teeth, or 49.7%. The second largest group was maxillary premolars with 21.6%, followed by the upper canines (7.2%) and the maxillary molars (6.5%). In all, 11% molars were resected (Fig. 24). The apical delta was resected by 2-3 mm in more than 82% of the teeth. Shortened by 4 mm in 6% and by 1 mm in 11%. One root had

to be shortened by 5 mm (Fig. 3, Fig. 22). Of the 155 prepared cavities, retrogradely a filling of 3-4 mm could be achieved in 66.5%. In the five cases of retrograde cavity preparations of less than 2 mm (7.8%), usually undercuts were made (Fig. 25).

In clinical and X-ray follow-up checks after one, three, six and nine months primarily it was the bone healing process that was assessed. In six to nine months average reossification of 88% was achieved (Fig. 5, 21). This shows the clear reduction in check-ups needed as a function of the healing of the bone defect (reossification) (Fig. 26). 23% of patients had to be checked for longer than six months, 12% of patients were given X-ray checks for more than nine months, but clinically were free of irritation. There was failure with five teeth (3.2%), two teeth had to be extracted and three teeth were successfully restored. The failure rate (tooth loss) was therefore 1.3%. In no cases did retrograde root canal filling material disperse into the apical region.

In 80% of cases retrograde preparation was possible to a depth of 4 mm. In 76%, retrograde root canal filling could be laid to a depth of 3-4 mm (Fig. 25). In one case insufficient root canal filling with gap formation that could not be corrected was established. Access to the prepared retrograde cavity was assessed as being very good in 88.4%, good in 9% and difficult in 2.6% (Fig. 27). Due to anatomy, access to the individual teeth in the maxilla is easiest with the incisors, the premolars and the molars (buccal roots), while in the mandible access is easier with the premolars and molars (mesiobuccal and distal roots) (Fig. 28, 29). Three-root resections are considered as being equally difficult in the mandible and the maxilla.

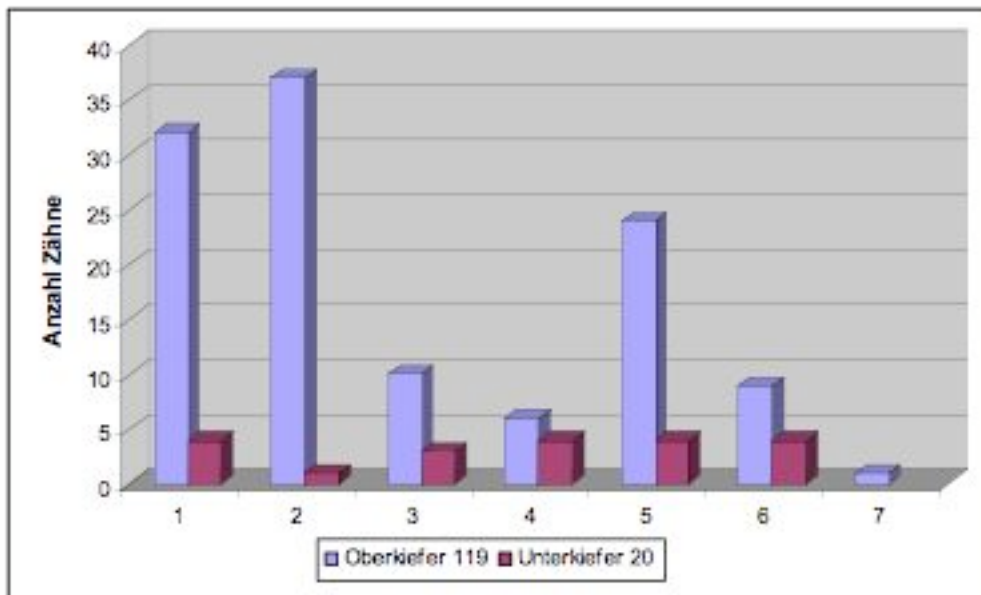


Fig. 24 Frequency of location by groups of teeth (n = 139), (1 = incisor, 3 = canine, etc.)
[x-axis = {Maxilla | Mandible}, y-axis = Number of teeth]

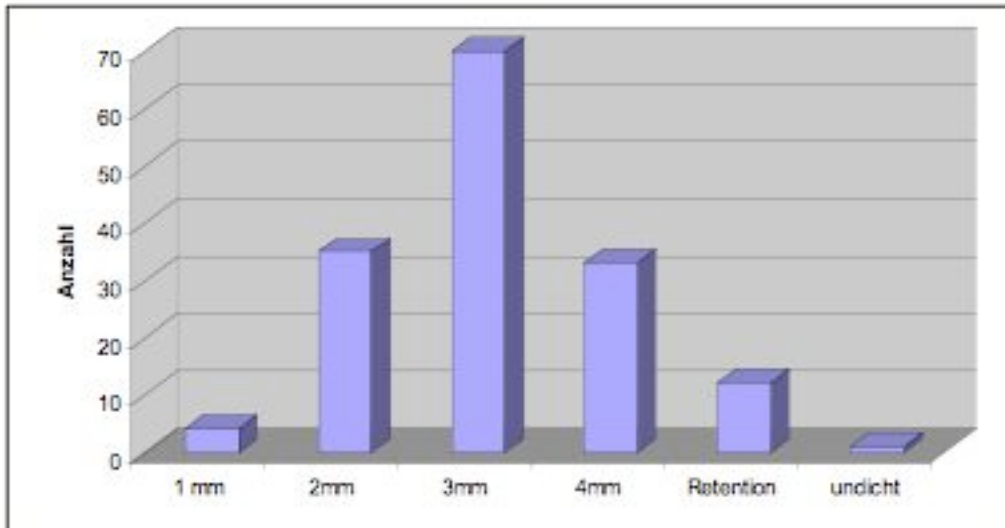


Fig. 25 Wherever possible, a sufficiently deep retrograde root canal filling of 3-4 mm was made. Below 2 mm, retentions were prepared [x-axis = {1mm | ... | 4mm | Retention | not tight}, y-axis = Number]

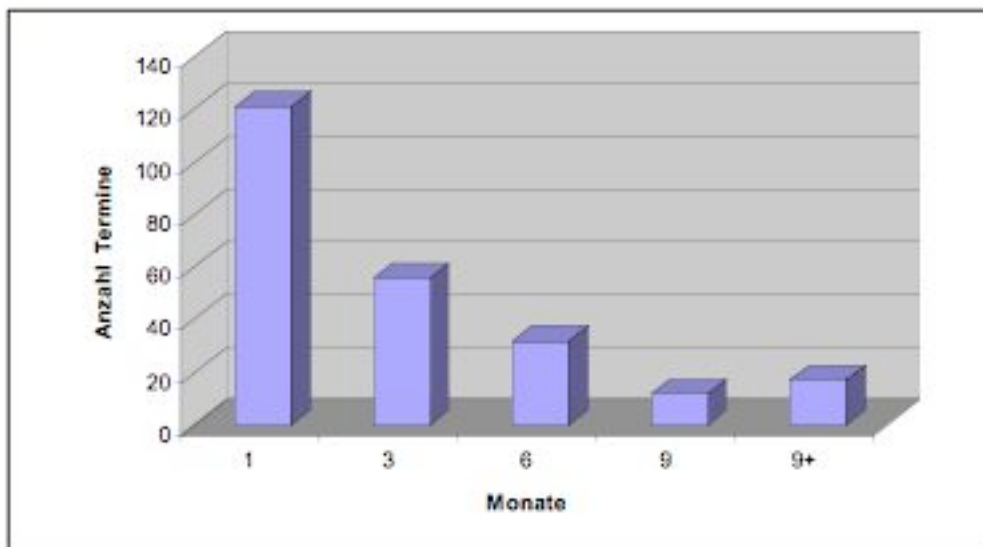


Fig. 26 Decrease in follow-up checks needed due to reossification of apical defects from month 3 [x-axis = Months, y-axis = Number of visits]

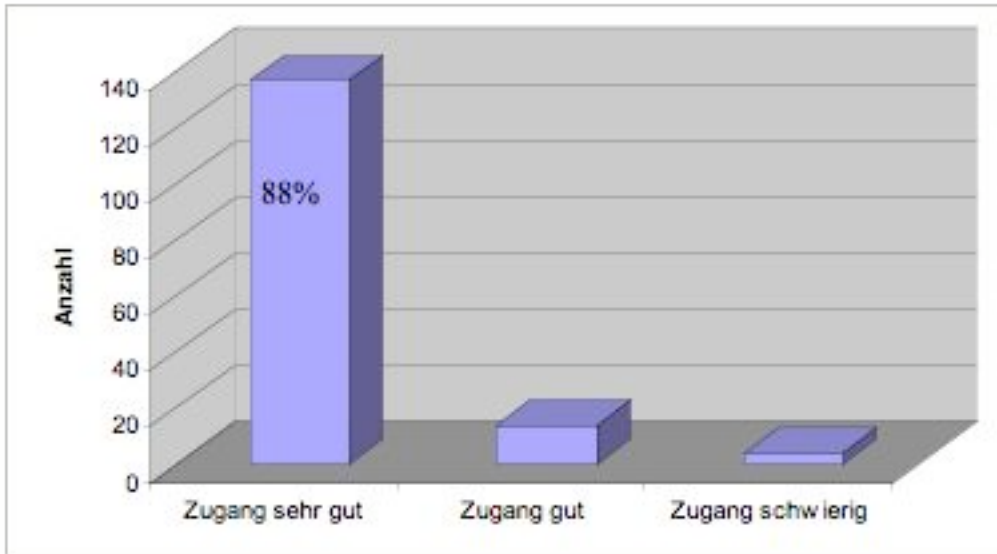


Fig. 27 Evaluation of access to cavity. 88.4% very good access, 9% good, 2.6% difficult (n = 155)
 [x-axis = {Very good access | Good access | Difficult access}, y-axis = Number]

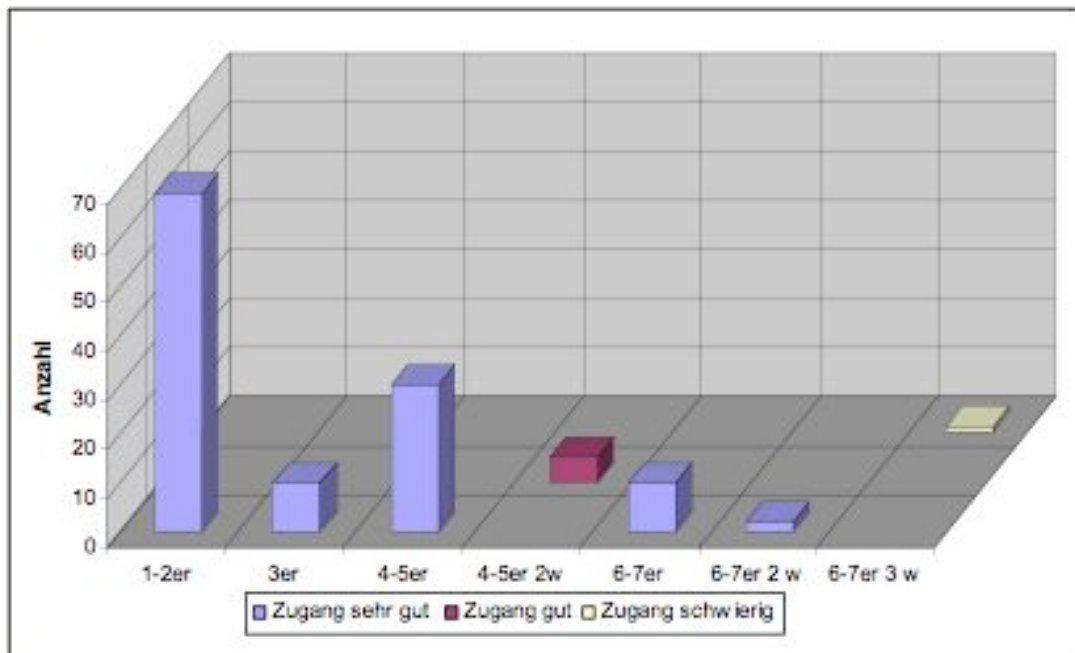


Fig. 28 Evaluation of access to the retrograde cavities. Assessment of 126 maxillary cavities by groups of teeth
 [x-axis = {Very good access | Good access | Difficult access}, y-axis = Number]

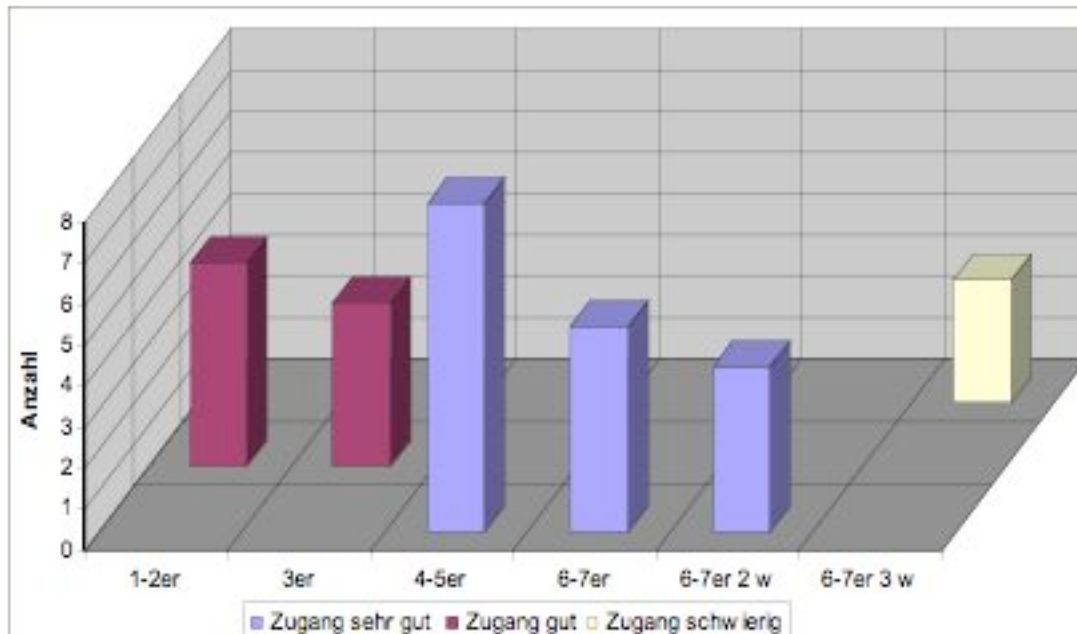


Fig. 29 Evaluation of access to the retrograde cavities. Assessment of 29 mandibular cavities by groups of teeth
 [x-axis = {Very good access | Good access | Difficult access}, y-axis = Number]

4. Discussion

The new instrument was developed in order to improve the quality of retrograde root canal filling. It was shown that inserting plastic retrograde root canal filling material is made easier with the new applicator syringe and therefore sufficient obturation of the root canal can be achieved without material dispersing into the periapical region.

This is because, as well as the right indication, successful retrograde root canal filling depends on a suitable operating technique in accordance with the principles of microsurgery (type of cut, suitable optics, suture material), the preparation instruments used for the retrograde cavity and the retrograde root canal filling material. While even at the beginning of the nineties in the last century many questions still remained unanswered, by now for root tip resection most requirements regarding instruments and filling materials have been resolved satisfactorily, as also shown by the results of many studies (KELLER 1988, BONDRA et al. 1989, CARR 1992a+b, KHOURY 1992, TORABINEJAD et al. 1993, GULDENER 1994, ILGENSTEIN et al. 1995, 1998, VON ARX et al. 1997, 1998, SCHULTZ et al. 2005).

From 1989-1998 the retrograde root canal filling material used in our practice was Biocem® (ILGENSTEIN et al. 1995) and from 1999 MTA (Mineral Trioxide Aggregate) (TORABINEJAD et al. 1993) and from 2005 also Retroplast™ (adhesive technique) (RUD et al. 1991). As a retrograde root canal filling material, MTA has the advantage of being the only material that due to its hydrophilic properties under moist conditions (blood/wound exudates) can achieve adequate hardening of the retrograde root canal filling and therefore sufficient compaction. In the presence of moisture, hydrophilic particles become hard (TORABINEJAD et al. 1993, TORABINEJAD & CHIVIAN 1999). A considerable advantage of MTA lies in the fact that insufficient retrograde root canal filling

occurring immediately post-operatively and which can be radiologically demonstrated can be repeated, as MTA has a setting time of 20 minutes. Torabinejad's studies show high biocompatible acceptance of the material with adequate compaction of the root canal filling. Therefore it is not necessary to finish the retrograde root canal filling at the resection cross-section.

Since 1994 we have been using KAVO Sonicflex Retro® tips for retrograde root canal preparation, which due to the sonoabrasive preparation technique enable excellent preparation on the neapex as regards the necessary depth of cavity and also the diameter of the cavity. Due to doubly angled tips, even under difficult anatomical conditions the instruments allow an axial direction of preparation and simplified access to the tip of the root. As well as a gentle operating technique, avoiding extended osteotomies, the geometry of the tips enables a much improved post-operative healing process to take place (von Arx, Ilgenstein et al. 1997) and optimises not only the surgical procedure, but may also be regarded as being a contributing factor to the high success rate of root tip resections (von Arx et al. 1998). The diamond-coated tips produce clean and precise retrograde cavities (Schultz et al. 2005).

Hitherto, incomplete filling of the retrograde cavity carried the risk of air inclusions and with it the risk of the retrograde root canal filling not being compacted (Fig. 30).

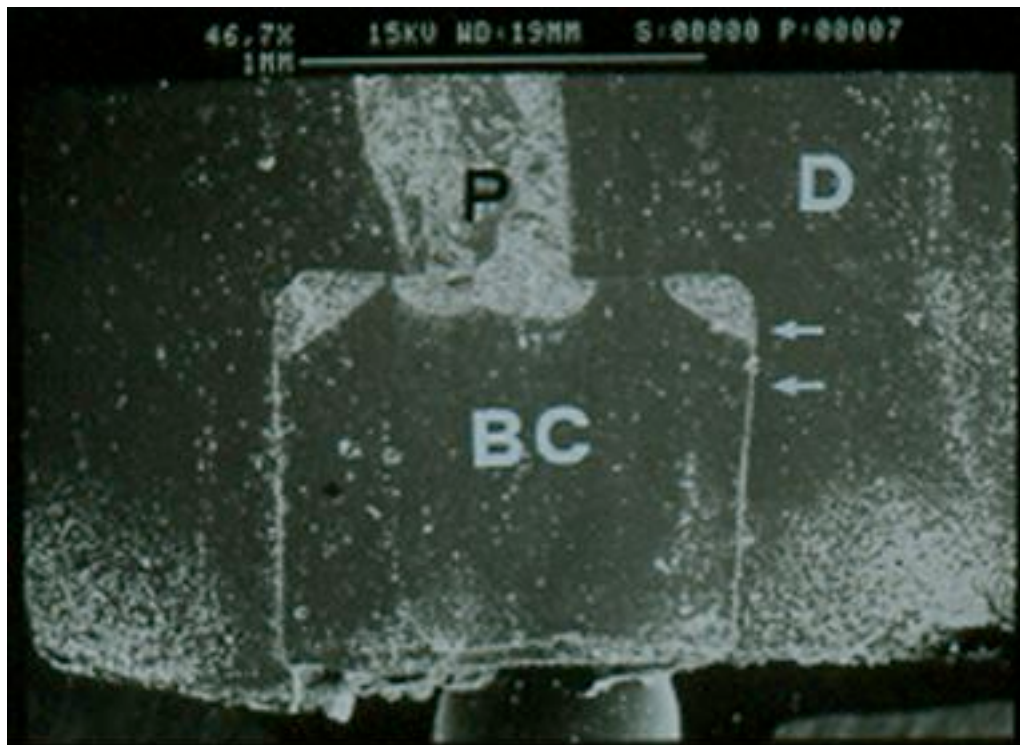


Fig. 30 Biocement. The filling material could not be condensed into the cavity completely (hollow space). Magnification x 46

In particular, it was not possible to avoid the dispersion of retrograde root canal filling material with any instrument. A retrograde root canal filling instrument must provide ready access to the tip of the root even under difficult anatomical conditions so that with the correct retrograde preparation there cannot be any loss of quality due to the retrograde root canal filling. Perfect retrograde root canal filling is based on an axial preparation with microinstruments to a depth of

at least 3 mm (KVIST et al. 1989, GULDENER 1994, BAUMANN & GERHARDS 1996, ILGENSTEIN et al. 1995). It is essential that foreign bodies are prevented from becoming embedded in the surrounding bone and soft tissue.

The excellent experiences with the KAVO Sonicflex Retro® tips as regards access to the neopex led to the development of the MAPS system. Due to the special geometry of the instrument, the root canal filling material can be introduced directly as far as the fundus of the cavity, in a controlled way and with the whole procedure being clearly visible (Fig. 13). Studies have shown that 66.5% of retrograde fillings reached the required filling depth of 3-4 mm.

However, 22.6% of all retrograde root canal fillings could be prepared only to a depth of 2 mm and a further 2.6% to 1 mm. These were predominantly cases which due to long pin structures did not enable further preparation. Canal obliterations with a limited indication, via falsa or revisions of root treatments were other reasons. This once again reinforces the need for retrotips, with which an undercut can be made in order with retrograde root canal fillings of less than 3 mm to be able to apply an additional retention if the shape of the root at the resection cross-section permits this.

Use and access with the applicator syringe was considered to be very good in 88% of cases. In 9% access was described as good. These cases involved 2 root premolars, molars with 2 resections, mandibular incisors and mandibular canines. The only cases described as difficult were first and second molars, on which 3 roots had to be resected. Access to the palatal roots in the maxilla and the lingual roots in the mandible is possible only axially, but is still difficult (Fig. 27, 28, 29).

The new Micro Apical Placement System (MAPS) ensures complete filling, in portions, of the retrograde cavity, meeting the need for a direct connection to the orthograde root canal filling or a root pin (Fig. 12, 5, 6, 7, 8, 13, 31-34).



Fig. 31 Cavity preparation with KAVO Sonicflex Retro® tips



Fig. 32 Retrograde cavity after preparation with KAVO Sonicflex Retro® tips

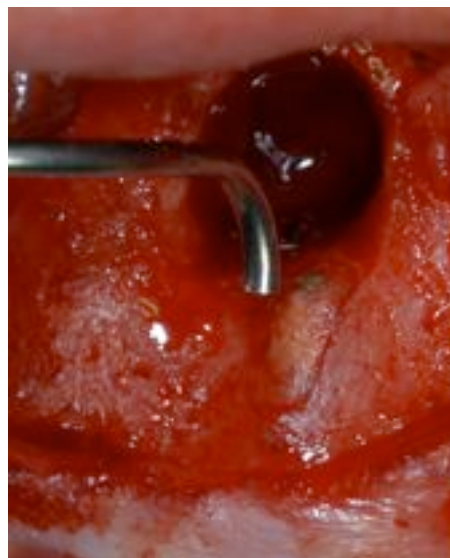


Fig. 33 Application of the root canal filling material with MAPS



Fig. 34 Retrograde obturation by MAPS (MTA)

5. Conclusions

The Micro Apical Placement System is recommended for retrograde root canal filling in hospital and in the practice. Access to the cavity is considerably improved due to the geometry of the instruments. A portioned sufficient retrograde root canal filling can be laid starting from the fundus of the cavity, thereby enabling a retrograde root canal filling to be made with no inclusions. Dispersion of root canal filling material can be avoided.

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