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Review article

Methods for removing metal obstructions from the root canal

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Abstract – The removal of metallic obstructions is an important part of endodontic retreatment procedures and encounters a number of serious problems. Sometimes removal procedures are extremely easy and can be performed in rather short time, but often it is a very tedious and time-consuming operation with a high number of failures, especially with fractured instruments. Using special devices such as the Masserannkit, the Canal-Finder-System, or ultrasonic systems some fractured instrument cases can be managed successfully. The retreatment of dowel-obturated root canals or failing silver cone cases has a good prognosis and a fairly good success rate. The Masserannkit, post pullers, the Canal-Finder-System and ultrasonic systems have been shown to be helpful devices in removal of root posts and silver cones. Additionally a large number of special devices and techniques for the removal of metal obstructions from the root canal have been described in the literature and will be critically reviewed.

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Key words: endodontic retreatment; post removal; silver cones; fractured instruments.

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It is well accepted that non-surgical retreatment of cases of previously failed endodontic therapy provides good results. Success rates between 70% and 90% have been reported in several investigations (1–9). Conversely, retreatment procedures often are tedious and time consuming so that practitioners may prefer apical surgery or non-intervention even in cases of evident failure of previous endodontic therapy (10–12). One of the main problems in retreatment is the removal of the insufficient root canal filling.

A great variety of metallic objects are introduced into root canals, some of these are inserted intentionally, for example silver cones and posts, and some are left in the root canal inadvertently, by the dentist or even by the patient, for example burs, fractured endodontic instruments, needles, pins, and many other objects. Retrieval of these intracanal obstructions may be extremely difficult, but be essential for non-surgical treatment or retreatment. Fortunately, a number of instruments and techniques have been developed which enable successful orthograde removal of foreign objects from the root canal. Some of these will be reviewed in this paper.

Fractured instruments

Fracture of root canal instruments is not an uncommon incident in endodontic therapy. Evaluations of endodontic recall radiographs have indicated that the frequency of remaining fragments ranges between 2 and 6% of the cases investigated (13–19). However, it has been shown that less than 1% of endodontic failures are due to instrument fractures (20).

Broken instruments seem to be the metal objects in the root canal which are most difficult to remove and significantly reduce the chances of successful

retreatment (21). An attempt to remove broken fragments should be undertaken in every case. Intentionally leaving a fragment in the root canal may be considered when nonsurgical removal has been attempted without success. The removal of instruments from the root canal in most cases is very difficult and time consuming and often is unsuccessful. No standardized procedures for the removal even in difficult cases exist, although various techniques and devices have been described in the literature.

Chemical methods

From the beginning of the century a number of techniques have been reported using chemical agents such as iodine trichloride, nitric acid, hydrochloric acid, sulfuric acid, crystals of iodine, iron chloride solution, nitrohydrochloric acid, concentrated iodine-potassium iodide solution (13, 22–25), in order to achieve intentional corrosion of the metal objects. Magneticism (13, 26) has been evaluated for this purpose as well as electrosoldering (27). The chemical methods, however, may be irritant to the periapical tissues when extruded through the apical foramen. A chemical method furthermore will be unreliable in all cases in which the part of the instrument, which grips the root canal wall will not be exposed to the solution. Moreover, the chemical method nowadays in most cases will fail since almost all endodontic instruments are made of stainless steel. Though some authors (28–30) advocate heavy irrigation and also have reported on single successful cases this procedure alone will mostly not result in fragment removal. Nevertheless, removal attempts should not be undertaken in a dry root canal. Heavy irrigation will reduce the risk of additional instrument fracture or blocking of the root canal with debris.

A suitable method for retrieval of fragments must be based on an armamentarium delicate enough to enter the roots of posterior teeth and yet rigid enough to loosen and pull out the fragment. At present, none of the mechanical methods and devices that are recommended fulfill these objectives sufficiently. Many authors recommend to start the removal procedure working along the fragment with one or more fine hand instruments. If the fragment can be bypassed it is removed performing pulling motions with a file (14, 17, 25, 29, 31–34). The use of a chelating agent like EDTA may be helpful. If bypassing with endodontic instruments is possible the fragment may be removed by braiding two or more instruments and thus grasping the fragment (35, 36).

It seems important to create a sufficiently large access to the top of the fragment using long-shanked, pulp-chamber burs (Hager & Meisinger, Düsseldorf, Germany) or Gates-Glidden drills (35, 37). In the coronal third of the root canal an attempt may be undertaken to grasp the fragment with a forceps or a specially designed Castroviejos needle holder (Stille-Werner, Stockholm, Sweden) (37). The use of a fiber optics will enhance visual control (37).

The Masserannkit

The Masserannkit (Micro-Mega, Besancon, France) sometimes can be used for fragment removal with good results (17, 25, 32, 34, 37–40), but it requires a large loss of root canal dentin and cannot be used in narrow and curved canals. It also often cannot be used in the apical part of the root canal because of the extremely high risk of perforation. As the trephine has to be exactly centered around the top of the fragment the Masserann-technique works most successful on fragments broken in the coronal third of the root canal. Sano et al. (41) have reported a success rate of 55% using this device. Time needed for removal varied from 20 minutes to several hours. Ketterl (17) has reported successful retrieval of 29 fragments, Gundlach (38) on 25 cases.

The use of the Endo Extractor (Basseler Inc., Savannah, GA, U.S.A.) has been advocated as well (42). This device consists of a trepan bur to expose the end of the fragment and a hollow tube which fits over the exposed tip and may be bonded to it with cyanoacrylate adhesive.

Ultrasonic systems

In the past few years some authors have advocated the use of ultrasonic devices. The latter may be used if the fragment can be bypassed at least to some extent. Otherwise the fragment may be pushed through the apical foramen or blocked firmly in the root canal (43–51). Nagai et al. (50) present an in-vitro study comprising 42 cases. They could remove 33 fragments (79%) and failed in 9 cases (21%) using an ultrasonic device. In a second investigation using extracted teeth they were successful in 39 of 57 cases (68%). Sixteen fragments (28%) could not be removed, 2 were pushed out through the apex. They reported 2 cases of secondary instrument fracture and 5 cases of perforation of the root canal wall. Removal was most successful in irregularly shaped root canals whereas failures occured most often in round canals. In the latter cases it proved to be difficult to insert the tip of the ultrasonic file alongside the fragment to achieve an adequate transfer of ultrasonic energy to the fragment (50). In a further clinical study 26 of 39 fragments were removed (50). In six teeth it was possible to bypass

the instrument although the fragment could not be removed. In seven failing cases secondary file fracture or perforation of the root canal wall occurred. The time for successful removal varied from 3 to 40 minutes (50). Thus, the effectiveness seems to be higher than with the Masserannkit. The ultrasonic method is applicable in most cases, and it is not restricted by the position of the fragment in the root canal.

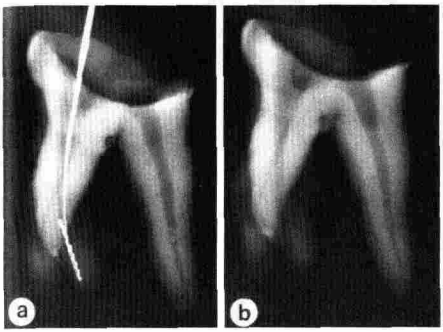

Fig. 1a, b. Bypassing and removal of a fractured instrument in an extracted tooth using the Canal-Finder-System.

The Canal-Finder-System

Also the Canal-Finder-System (Gesellschaft für Endotechnik, Olching, Germany) has been reported to be a suitable device to remove instrument fragments (52, 53). The system primarily makes an up- and down movement with a maximum amplitude of 1 mm. This amplitude decreases when the speed increases. If the instrument encounters friction inside the root canal an additional turning motion starts, which both together results in a flexible, helicoidale movement. In almost 50% of the cases the removal or at least bypassing of the broken fragment could be achieved after manual retrieval attempts had failed (Fig. 1, 2 a-b). This procedure should be undertaken with extreme care, starting with low speed. Speed may be increased if no depth is gained. Once the fragment is bypassed, a radiograph should be taken to assure that the instrument is not creating a new canal (Fig. 3). Now the Canal-Finder-System or an ultrasonic unit can be used to loosen the fragment (Fig. 4 a-b). The time required for fragment removal was up to 2 h.

A statistical analysis of removal procedures is given in Table 1: From a total of 62 fractured instruments 23 could be removed and 13 bypassed, which makes a success rate of 58%. Twenty-six cases (42%) failed.

Of course, in many instances only the combined use of different techniques and devices will result in retrieval or at least bypassing (Fig. 5 a-c). Also, the

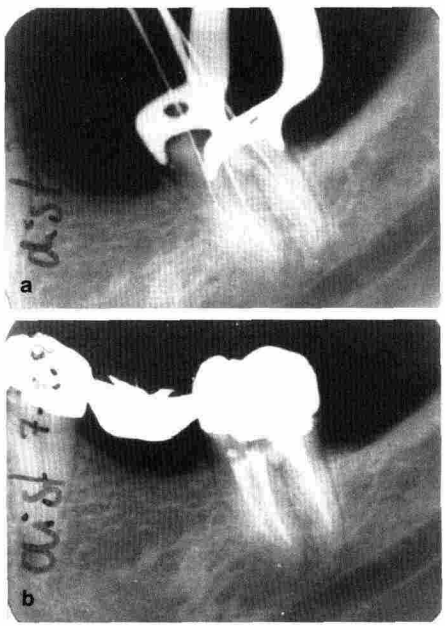

Fig. 2a. The fragment cannot be bypassed with hand instruments. *Fig. 2b.* Radiographic control one year after retreatment: the fragment could be bypassed by the Canal-Finder-System but not be removed completely.

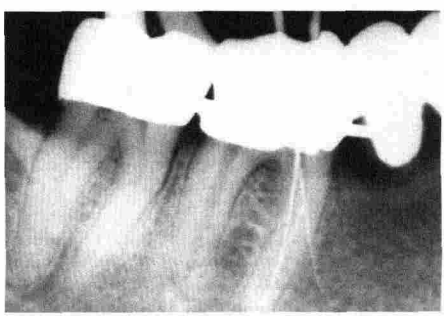

Fig. 3. Root canal perforation after use of the Canal-Finder-System: the tip of the instrument was directed outward by the top of the fragment.

Table. Success rates for the retrieval of metal objects from the root canal

Author	Ref.	Subject and results: Removed		Bypassed	Failure	Total		Technique
I. Posts								
Hülsmann (1992)	111	Manual 9 (16%)	Ultrasonics (42 (75%)		5 (9%)	56	in vivo	Manual/Ultrasonics
II. Silver cones								
Hülsmann (1990*)	52	Manual	Canal Finder	Ultrasonics				Manual/Canal/Finder/
	82	71 (58%)	21 (17%) 109 (89%)	17 (14%)	2 (2%)	12 (10%)	123	in vivo Ultrasonics
III. Fractured instruments								
Gundlach (1972)	38		25		?	?	?	in vivo Masserannkit
Sano (1974)	41		55			45	?	in vivo Masserannkit
Ketterl (1975)	17		29		?	?	?	in vivo Masserannkit
Nagai (1986)	50		33 (79%)			9 (21%)	42	in vitro Ultrasonics
			39 (68%)			18 (32%)	57	in vitro Ultrasonics
			26 (67%)		6 (15%)	7 (18%)	39	in vivo Ultrasonics
Hülsmann (1990*)	52		23 (37%)		13 (21%)	26 (42%)	62	in vivo Canal Finder/Ultrasonics
Hülsmann (1990*)	53		7 (32%)		6 (27%)	9 (41%)	22	in vitro Canal Finder

* Results updated from original publication

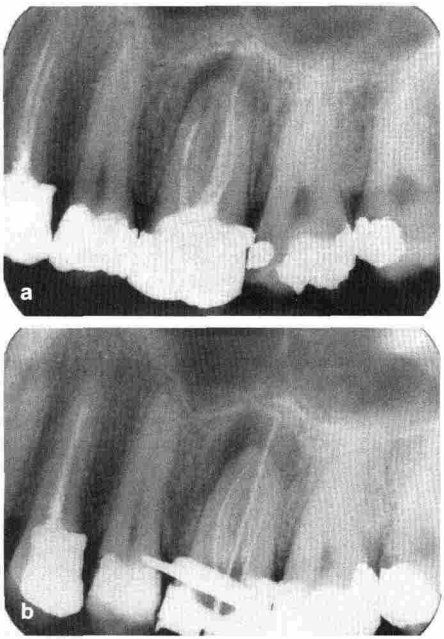

Fig. 4a. Fragment in the middle of the mesiobuccal root canal of the first maxillary molar.
Fig. 4b. After bypassing of the fragment using the Canal-Finder-System this could be removed by an ultrasonic device.

outcome of retrieval attempts highly depends on the operator's skills, experience and patience.

Handling of failing removal cases

In teeth where removal or at least bypassing of the fragment can not be achieved further treatment should be considered carefully. If the fragment is firmly blocked in the apical part of the root canal and no signs of periapical pathosis are present, the fragment may possibly serve as a root canal filling. A number of clinical reports have shown that the prognosis of teeth obturated with endodontic instruments intentionally or inadvertently is nearly as good as success rates from properly filled canals (20, 54–56) (Fig. 6). Leaving the fragment inside the root canal and obturating only the coronal portion may be considered a compromise (37, 57).

Periapical surgery is advocated for cases with the fragment extending into the periapical tissue (14, 17, 20, 33, 36, 39, 55, 58–62). During apical surgery an attempt should be undertaken to loosen the fragment and push it upward (34, 35, 63). Moreover, intentional replantation has been suggested for selected cases as a last resort to save an otherwise lost tooth (64). Root amputation or hemisection may be important treatment alternatives to save at least a part of the tooth (34, 35, 65).

Silver cone removal

The use of silver cones for root canal obturation has been introduced by Jasper in the 1930s (66). Because of their stiffness and rigidity they can easily

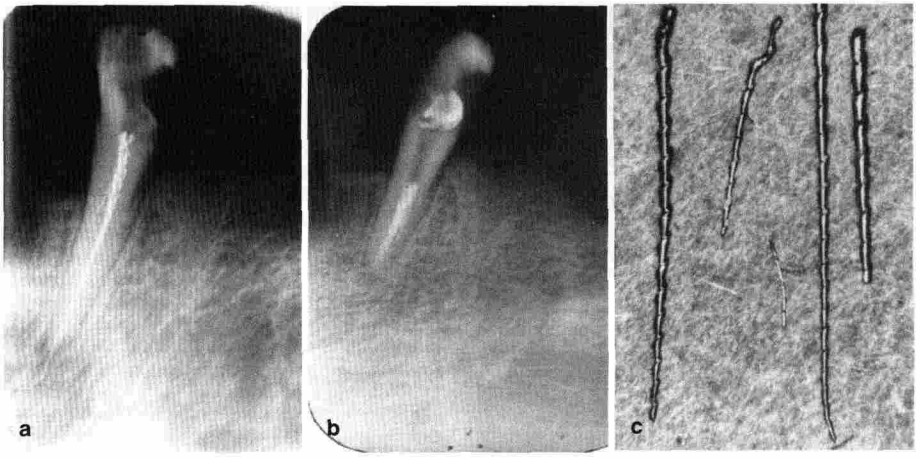

Fig. 5a. Mandibulary canine with several fractured instruments, one of them extending beyond the apical foramen.
Fig. 5b. Control radiograph after completion of retreatment: all fragments are removed.
Fig. 5c. A total of five fragments, all of them Hedström-files, could be removed by combined use of the Canal-Finder-System and ultrasonics. Working time was about 1 h 20 min.

be forced into narrow and curved root canals which have been only minimally enlarged. As they cannot be adapted closely to the root canal wall there is a high risk of apical leakage. Although this method provides an easy technique the use of silver points in endodontics has declined. After several decades of use and overuse (Fig. 7 a-b) the method has been reported to be ineffective and unsafe. It has been shown that silver cones corrode inside the root canal, do not provide a sufficient apical seal and subsequently produce periapical lesions, root resorption, tooth discoloration and pain (67–77). Performing apical surgery without removing the cone is not proper, since the problem causing the need for retreatment is not corrected. Sometimes silver cone removal can be achieved easily and quickly due to the poor fit of small cones in large canals. Stewart (28) recommends heavy irrigation which sometimes will float the cones out of the canal.

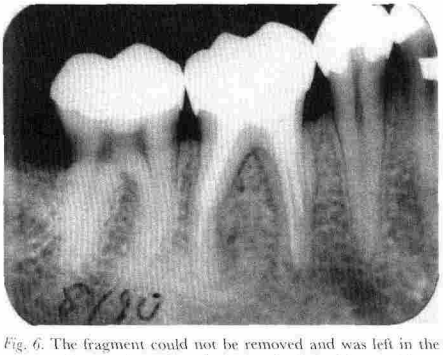

Fig. 6. The fragment could not be removed and was left in the root canal as no signs of periapical pathosis had been evident. The three-year control radiograph still shows no signs of retreatment failure.

Manual retrieval techniques

Even more than in post removal cases the filling material has to be removed with extreme caution from the top of the silver cone. Any notching of the cone must be avoided in order to prevent intracanal breakage which will create additional complications. Retrieval starts with an attempt to pull out the cone with a plier, a forceps – for example a Steiglitz forceps (Union Broach Corp., New York, NY, U.S.A.), a gold foil plier, a splinter forceps, or a Mosquito hemostat (Union Broach Corp., New York, NY, U.S.A.) (35, 36, 78–81). When a grasping instrument is used, the cone may be slightly rotated in an attempt to loosen the cement bond in the root canal. The cone should not be twisted or worked rigorously, as this may cause fatigue of the metal with a high risk of separation of the cone inside the canal (36). The retentive grip of these devices can be increased by supplementary use of a needleholder

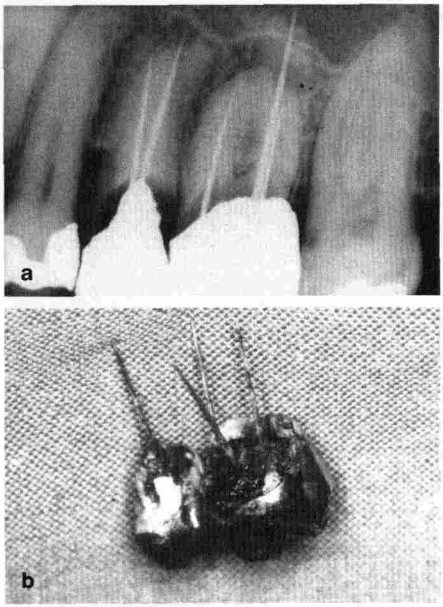

Fig. 7a. Five-year-old silver cone root canal fillings resulting in acute pain and apical periodontitis.
Fig. 7b. The root canal fillings proved to be "removable".

compressing the beaks of the plier or forceps (35). The use of a forceps of course becomes difficult in deep and narrow cavities or when the cone does not extend far enough into the pulp chamber. In those cases silver cones often may be removed with hand instruments, spoon excavators, or Caufield silver point retrievers (Union Broach Corp., New York, NY, USA) (35, 79, 82) (Fig. 8 a-b, Fig. 9). However, the removal with these devices may be extremely difficult or even impossible (36).

An attempt can be made to bypass the silver cone with fine endodontic instruments. Chelating agents or solvents may be used additionally. If this is successful the cone sometimes can be worked out of the root canal with Hedström files (35, 36, 83).

The needle-sleeve-technique as described by Taintor and co-workers (79) uses a hollow gauge needle which is bonded to the silver point with cyanoacrylate (Fig. 9). A modification of this technique is the use of a large hollow gauge needle that is fitted over the silver cone with a Hedström file wedged between needle and the silver point (44) (Fig. 9).

A similar technique uses an orthodontic wire that is worked through a hollow gauge needle like a lasso. The silver point then is elevated from the root canal (36, 79, 84) (Fig. 9). These techniques may be useful when the top of the silver cone extends into the pulp chamber, it will be difficult to use when the point has been cut off or broken below the root canal orifice.

Recently a new device has been presented: the Endo Extractor (Brasseler Inc., Savannah, GA, U.S.A.). With a trepan bur the end of the silver point is exposed and a hollow tube which fits over the exposed tip is bonded to it with cyanoacrylate adhesive. With an overlap of 2 mm adhesive strengths of 2 to 5 kg may be achieved. This might be adequate for cone removal under clinical conditions. Clinical cases demonstrating the benefit of this technique have been presented by Spriggs et al. (85).

Silver cones that have been inserted with a paste can be bypassed with three or more endodontic instruments. The handles of these instruments are braided around the cone and the cone is pulled out. Only small files with good torsional properties may be used for this technique, called the braiding tech-

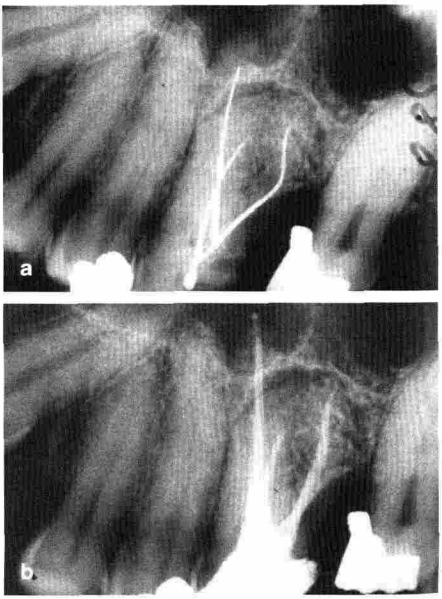

Fig. 8a. Three silver cones in a first maxillary molar, all of them extending into the pulp chamber.
Fig. 8b. Radiograph following retreatment. Removal could be managed using a spoon excavator and a diamond-coated plier.

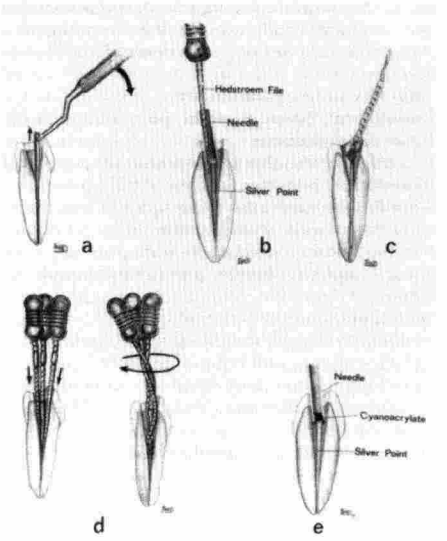

Fig. 9. Techniques for removal of silver cones: a: Caufield silver point remover, b: modified needle-sleeve technique, c: lasso- or wire-loop-technique, d: braiding technique, e: needle sleeve technique.

nique or multiple-files-technique and first described by Glick (20, 35, 36, 79, 86). This, of course, is only practible if the cone can be bypassed to a sufficient depth. As silver cones commonly are inserted with sealers, the use of solvents may be helpful. The braiding technique also has been recommended for the retrieval of sectional silver cones (35) (Fig. 9).

The Canal-Finder-System

If manual retrieval of the cone is unsuccessful a mechanized device for root canal preparation may be used. Good results have been reported using the Canal-Finder-System, which is working with a flexible, non-rigid motion (52, 82). The Canal-Finder-System cannot be used until an instrument can be worked some millimeters along the silver cone into the root canal. Beginning with the finest instruments and using various speeds and heavy irrigation, an attempt is made to penetrate the sealer and bypass the cone. If bypassing to some depth is possible the handpiece is worked circumferentially around the cone in order to gain space and loosen the cone. Using higher speed the instrument begins to vibrate which may support the loosening (52, 82) (Fig. 10 a-b).

Fig. 10a. First mandibulary molar with three silver cones.
Fig. 10b. The silver cone in the distal root canal separated during retreatment in the middle of the root canal but could be removed by an ultrasonic endodontic instrument. The cone in the mesiobuccal canal only could be bypassed using the Canal Finder. Unfortunately overfilling occurred. The third cone could not be removed or bypassed by any device.

The Masserannkit

Another device for silver cone retrieval is the Masserannkit. With a trepan bur the cone-top is prepared free to some depth. Then the extractor tube is put onto the top of the cone and fixed to it. The attempt to pull the cone out of the canal may be supported by an ultrasonic scaler which is held against the extractor tube. Additionally a cyanoacrylate-adhesive can be used to fix the tube to the cone top (35, 36, 45, 79, 81, 87–89) (Fig. 11).

Ultrasonic devices

In cases of silver cone retrieval ultrasonic devices should be used with care, as ultrasound vibrations may cause intracanal separation of thin and corroded points. They are working best with endodontic instruments inserted, which can be introduced into the root canal to some depth. Working circum-

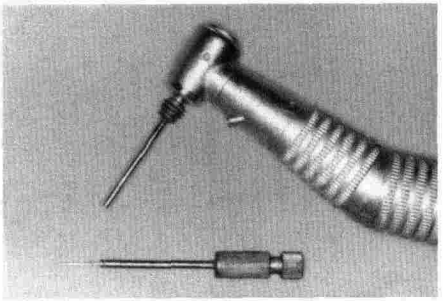

Fig. 11. The Masserann trepan bur and the extractor tube with a removed silver cone.

ferentially around the silver cone this may be loosened and finally removed (36, 45, 46, 81–83, 86, 90–93) (Fig. 10 a-b).

Success rates

Again there are no statistical data on the success rate of silver cone removal and of the time required for this procedure. A survey on patients treated in the Department of Operative Dentistry in Göttingen shows, that from 123 silver cones 71 could be removed with hand instruments, that is endodontic instruments, spoon excavators or a forceps, 21 were removed by support of the Canal-Finder-System, two cones could be bypassed completely by the Canal-Finder-System but not removed. In 17 teeth the use of ultrasonics was successful and 12 cases failed. Removal procedures for silver cones took between 1 minute and one and a half hours (Tab. 1) (82).

These methods of loosening and retrieving silver cones may not be applicable to any one case. Combination and integration of several different techniques and devices are sometimes required.

Post-removal

Intracanal posts are usually inserted for two reasons: strengthening of the root and retention for a coronal build-up. In the past few years a number of investigations have shown that intracanal posts do not strengthen the endodontically treated tooth but in fact weaken it (94, 95). Misuse of posts may even result in root fracture.

Nevertheless, this misunderstanding in restoration concept – which sometimes has led to massive overuse of posts – of course will continue for some time. Luu & Walker (96) have recently demonstrated, that some of these posts, fabricated from non-precious metals, undergo heavy corrosion in the root canal and finally may result in root fractures.

The following reasons may demand removal of intracanal posts:

- insufficient length of the post
- insufficient diameter of the post relative to the root canal diameter
- insufficient retention of the post in the root canal
- insufficient retention for the coronal build-up
- insufficient root canal filling apically, sometimes associated with asymptomatic or even symptomatic apical periodontitis. Sometimes we even find completely unfilled root canals beneath the post.

Contraindications to post removal are:

- extremely long, well-fitted posts, where the chance of successful removal is not too good
- extremely large posts with only thin dentinal walls around. Removal probably would weaken the root excessively

As post removal can jeopardize the remaining tooth structure many clinicians avoid that procedure and prefer surgical treatment (58). Discussing the advantages and limitations of endodontic surgery Chalfin et al. (97) point out that many factors should be considered before a post is removed for retreatment. The probability of successful retreatment must be weighed against the predictability of surgical management. Many teeth can be treated successfully either way, but there are situations when retreatment should not be attempted: unusual root canal anatomy or excessive overfil for example. Non-surgical retreatment would be advantageous when a previously undetected and therefore untreated and unfilled root canal is suspected as a retrofil will not allow complete cleansing and sealing of the root canal system. Block & Lewis (59) recommend a reverse instrumentation and filling technique or a retrograde amalgam technique for these cases. In many cases, however, orthograde endodontic retreatment is a better alternative than surgical intervention. A surgical approach may be compromised if irritants within the root canal system are not eliminated. Rud & Andreasen (98, 99) have shown that surgical success is more predictable when the cleanliness of the root canal and the quality of endodontic obturation had been improved prior to surgery. Additionally endodontic surgery may be inadvisable due to medical and anatomical considerations. Furthermore, endodontic retreatment is obviously less traumatic. There are a great variety of techniques and devices to remove posts. The objectives, however, are the same: the procedure should be simple, time saving and expedient and the integrity of the remaining tooth structure should not be jeopardized.

Prior to attempting post removal careful clinical

and radiographic diagnosis is mandatory. The radiograph should be examined regarding the length and the direction of the post, space between the post and the root surface and the type of post: custom-fitted post, prefabricated post or screw post. Differential diagnosis between the different types of posts sometimes is difficult. In general, prefabricated posts are easier to remove than cast posts because they are round and after loosening may be rotated carefully. Threaded posts are the most retentive type of posts, nevertheless they are the easiest to remove as they are screws. Using counterclockwise rotational force the cement bond can be broken and the post be screwed out of the root canal. Cast posts reproduce the irregularities of the root canal, are never completely round and thus should not be rotated.

The examination is followed by rubber dam isolation and trepanation or removal of the crown or the filling. Great care must be taken to avoid notching the post top during preparation with high speed instruments, as this may lead to fracture of the post top (Fig. 12 a-c). Conversely, high speed preparation may result in loosening of poorly adapted posts (100).

Gerstein & Weine (101) report on the use of specially prepared burs with cut off lateral flutes (Premier Dental, Norristown, PA, USA). This allows separating the top of the cone from the root canal wall without hurting the cone. Sometimes, after some space between the post and the root canal wall has been gained the remaining fragment even becomes loosened by the vibration of the drill (97). Nevertheless, it should be considered that drilling out the post is rather dangerous because the post is harder than the root dentin and, therefore, the risk of perforating or excessively weakening of the root is fairly high.

Once the post top is visible the diagnosis of the type of the post is ascertained. Further information on the type, the thickness, and the hardness of the cement is gained using an endodontic explorer. With fine endodontic instruments the space between post and root canal wall is probed. In teeth with an accessible cone top an attempt may be undertaken to remove the post using a Stieglitz plier or a hemostat (80, 81).

Relating to the type of post and design of coronal build-up it may be necessary to reduce the coronal part of the cone circumferentially to allow probing of the cementum or grasping with a post puller.

Post pullers

For the removal of posts several devices and techniques have been described in the literature. The first device was mentioned by Prothero in 1923 (102) and called the "Little Giant Post puller" (Yamazoe Dental Co., Kashigawa, Japan). Still there are some similar devices, for example the Post Puller (Star Dental, Conshohoken, PA, USA), described by Warren & Gutman in 1979 (103). The tooth and the post are reduced in height to allow for attachment of the post puller. The first set of the

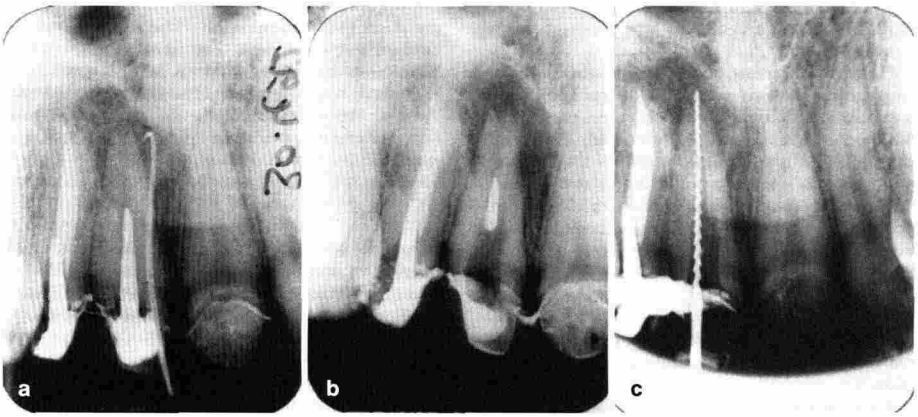

Fig. 12a. Unfilled root canal beneath a poorly adapted post. Note apical periodontitis with fistulation.
Fig. 12b. The post was notched during preparation and subsequently fractured occured during removal procedure.
Fig. 12c. The post fragment finally could be removed using ultrasonics.

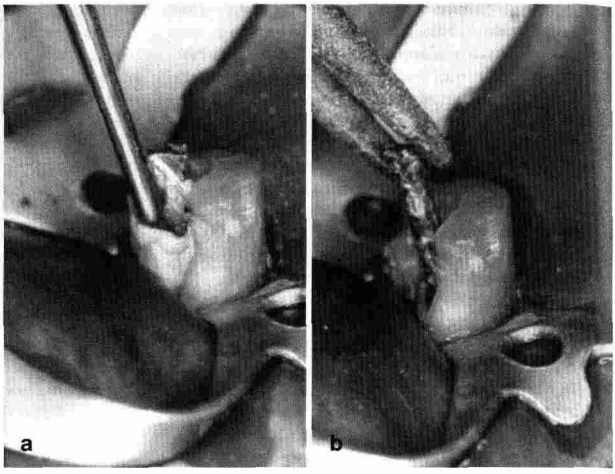

Fig. 13a. After preparation of a sufficient coronal access an ultrasonic scaler is worked circumferentially around the post top in a counterclockwise direction.
Fig. 13b. Finally, the post is loosened and can be removed with a diamond-coated plier.

jaws of the post puller are fastened onto the post while the second set of jaws push away from the tooth in line with the long axis of the tooth lifting the post out of the canal. The advantages of this system include conserving root structure and reducing the risk of root fracture, root perforation, and root torquing. The system has been described as being safe and efficient for post removal in the anterior and posterior region of the mouth (103–106). Great care must be taken to undertake removal procedures strictly in line of the long axis of the tooth to prevent fracture or tourquing of the remaining tooth.

However, there are conditions in which this device cannot be used such as a discrepancy in the level of the remaining tooth structure, particularly on the mesial and distal portion or thin and brittle walls which might fracture or do not allow correct positioning of the post puller. For these instances the use of a supplementary device has been proposed. After taking an impression an individually waxed and cast baseplate is fixed covering both the tooth to be treated endodontically and the adjacent teeth. This device allows correct and firm positioning of the post puller (107). The use of post-pulling devices also may be supported by underlying a flat piece of metal, for example gold alloy (104, 106).

A similar system is the Gonon Post Remover (Ron Chige Inc., Boca Raton, FL, USA), presented by Machtou et al. (108): again the head of the post has to be prepared free from the coronal tooth structure and all restorations including crowns. The top of the post is reduced circumferentially and in height. A trephine is used to give the cone top the same size as the corresponding mandrel, which then is screwed onto the post. Extracting pliers are fixed to the mandrel. Finally, the jaws of the pliers are expanded by tightening a knurled knob, which will separate the cone from the tooth following the principle of a corkscrew. Of course, the use of these devices may become very difficult in molar areas, where the intermaxillary distance sometimes is limited and insertion of the mandrel and fixation of the pliers may be impossible. These devices cannot be used for screw posts. For screw posts a special kit of trephines and mandrels has been designed (Kit d'extraction de screw posts, Dental Cash, Paris, France). After fixation of the mandrel on the post top this may be extracted using counterclockwise rotation.

Masserannkit

In some cases the Masserannkit may be used for removal of small posts or posts fractured inside the root canal (38, 39, 81, 86, 97, 109). A similar device, the Endo Extractor, is a recently developed device consisting of a trepan bur, which is used to prepare a space around the metal obstruction. A hollow tube extractor is placed around the post top with an overlap of about 2 mm. Additionally an adhesive may be used to improve the fit of the extractor tube (42).

Dimaskieh (110) has presented a device consisting of a cutting tube with a hand-held mandrel that

cuts a parallel side access around the top of the cone. A matching guiding sleeve is firmly fitted to the cone. Finally a matching twist drill is inserted into the hollow tube of the guiding sleeve and the top may be drilled out.

With respect to the development of these devices there seem to be better instruments and techniques available today.

Cemented posts

Retreatment starts with preparation of the access cavity. It should be considered that the following procedures need some space and, therefore, the access cavity should be prepared large enough. Sometimes it seems to be better to remove the complete crown or filling.

Using fine, long-shanked, round burs the cement should be removed as deep as possible without damaging the post or perforating the root. With a diamond coated plier or a forceps the friction of the post is evaluated and a careful attempt may be undertaken to pull the post outward from the root canal. Only slight rotational force is allowed. No lateral force must be used as this may result in dentinal cracks or even root fracture.

The key to success in removal of cemented posts is to break the cement bond, which is facilitated by ultrasonics. Prior to the use of ultrasonics some depth beside the post should be gained, this provides a better transfer of the ultrasonic energy to the post. An ultrasonic scaler is inserted into the gap between post and root canal wall and is worked circumferentially around the post (Fig. 13 a-b). Again no lateral force or pressure in an apical direction must be used although this is recommended in some manufacturers booklets as this may lead to root fractures or cracks. After some minutes of working circumferentially around the post a new attempt is undertaken to remove the post with a forceps with a pulling motion and only slight and careful rotational forces. Both an ultrasonic instrument or an ultrasonic scaler may be used for removal attempts (35, 43, 83, 89, 90, 100). Ultrasonic energy also can be directed to the foreign object with a hemostat, a Masserann extractor tube, or an endodontic file (100). Ultrasonic scalers seem to be the most suitable device for the removal of cemented posts. Nevertheless, some cements and composites resist even the use of ultrasonics. In cases with extremely long and well adapted posts the ultrasonic vibrations seem not to be strong enough to break the cement throughout the whole length of the post so that removal will fail and surgery become inevitable.

For some types of cement or root canal sealer the additional use of solvents may be helpful. Problems

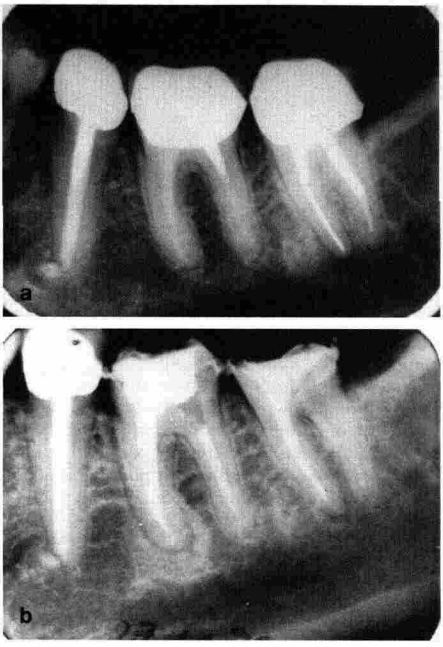

Fig. 14a. Screw post in the distal root canal of the first mandibulary molar. Cast post and core and a silver cone in the second molar.

Fig. 14b. Radiographic control after completion of retreatment. The screw post in the first mandibulary molar was removed after 2 min of ultrasonic scaling circumferentially around the post in a counterclockwise direction. The cast post and core in the second molar could be removed in one piece using ultrasonics. Sometimes it may become necessary to separate the build-up prior to removal. The silver cone in the second molar could be removed using the Canal-Finder-System and a spoon excavator.

may arise when a rather soft material was used for the fabrication of the cones or if heavy corrosion has weakened the post. The use of ultrasonics then may result in intracanal separation of the post.

Screw posts

Sometimes screw posts can be removed easily by screwing them out counterclockwise using a forceps. Screws with a tight fit again are best removed with an ultrasonic scaler which is inserted into the pulp chamber and circumferentially worked around the post in a counterclockwise direction. Only slight lateral pressure against the cone top may be used to avoid root fractures. This procedure may be very time consuming but it is our experience that most

of the posts – cemented or screwed – can be removed with ultrasonics in 10–20 min (Table 1) (111). Once the post is loosened it can be screwed out with a forceps or a plier (Fig. 14 a-b).

Cast posts

Individually fabricated cast posts seem to be the most difficult to treat. They usually have only a minimal gap between core and canal wall filled with cement, and have excellent friction in the root canal. They often are used in teeth with a small amount of remaining tooth structure, thin root canal walls and are sometimes fabricated from rather soft metals, which do not respond well to ultrasonic energy. In these cases it is important to retain the coronal build up so that it can be used as a foundation for a new crown if removal fails.

In cases of cores with more than one post – especially if the posts are extremely parallel – it may be necessary to separate the two posts with a bur prior to ultrasonic treatment (Fig. 14 a-b).

Fig. 15a. Needle fractured by the patient himself.
Fig. 15b. The fragment was removed using the Canal-Finder-System in a few seconds.

Success rates

Until now there are no statistical data available on the success rate of post removal and on the time used for removal. The preliminary results from own investigations show that 51 of 56 posts could be removed, only 5 cases failed (111). Ultrasonic devices proved to be effective and successful in removal procedures, which in most cases could be performed in a relatively short time (Table 1).

Metal root canal obturators

Although the problems with silver points were thought to become less frequent, as this material has become more and more unpopular, new problems will arise with a similar device, the SuccessFil-obturators (Hygenic Corp., Akron, OH, USA) and the Thermafil obturators (Tulsa Dental Products, Tulsa, OK, USA). These are root canal filling systems using metal obturators coated with guttapercha. These obturators may be used to fill the whole root canal or in a sectional technique to fill only the apical portion. As the metal core is coated with a large mass of guttapercha there seems to be a good chance to dissolve the guttapercha using heat or solvents and then bypass and remove the metal core.

In vitro investigations by Wilcox et al. have shown that most of the metal carriers can be removed in an average time of about 7 min using heat and solvents (112, 113).

Other metallic objects

A great variety of metallic objects – broken by the dentist or even by the patients themselves – already has been discovered in root canals: needles, pins, dressmakers pins, hat pins, amalgam and gold particles, spreaders, burs, spoon excavator tips, and more (89, 92, 114–118). The procedure for the removal of such metallic obstructions is similar to the techniques mentioned before. The procedure mainly depends on the form, the friction and the site of the foreign body. In all cases a careful examination with a fine endodontic instrument should be the first step. A gap between the metal object and the canal wall, which will exist in most cases, should be explored. If it can be detected, this already is half the success, and endodontic instruments are worked alongside the foreign body as deep as possible using heavy irrigation. Finally, techniques as discussed before may be used to loosen the object and remove it, such as ultrasonics, the Canal-Finder-System or the braiding technique (Fig. 15–16).

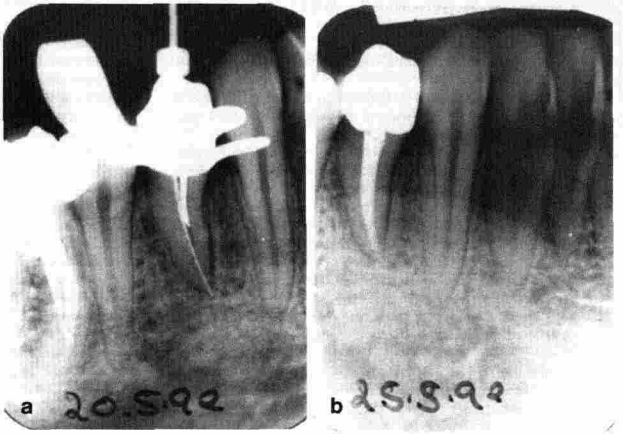

Fig. 16a. Broken spoon excavator that already can be bypassed with hand instruments.
Fig. 16b. Removal was achieved in 2 min using an ultrasonic endodontic device.

References

1. Grahnen H, Hansson L. The prognosis of pulp and root canal therapy. *Odont Revy* 1961; *12:* 146–65.
2. Taatz H, Seiter G. Klinische und röntgenologische Nachuntersuchungen der in den Jahren 1955 bis 1960 an der Klinik und Poliklinik für Stomatologie der Martin-Luther-Universität Halle -Wittenberg durchgeführten Wurzelbehandlungen. *Dtsch Stomatol* 1968; *18:* 522–33.
3. Molven O. The frequency, technical standard and results of endodontic therapy. *Thesis* 1974, University of Bergen.
4. Selden H. Pulpoperiapical disease. Diagnosis and healing. A clinical endodontic study. *Oral Surg Oral Med Oral Pathol* 1974; *37:* 271–83.
5. Bergenholtz G, Lekholm U, Milthon R, Heden G, Ödesjö B, Engstroem B. Retreatment of endodontic fillings. *Scand J Dent Res* 1979; *87:* 217–24.
6. Bergenholtz G, Lekholm U, Milthon R, Engstroem B. Influence of apical overinstrumentation and overfilling on re-treated root canals. *J Endod* 1979; *5:* 310–14.
7. Molven O, Halse A. Success rates for gutta-percha and Kloroperka N-O root fillings made by undergraduate students: radiographic findings after 10–17 years. *Int Endod J* 1988; *21:* 243–50.
8. Allen RK, Newton CW, Brown CE. A statistical analysis of surgical and nonsurgical endodontic retreatment cases. *J Endod* 1989; *15:* 261–6.
9. Sjögren U, Hägglund B, Sundquist G, Wing K. Factors affecting the long-term results of endodontic treatment. *J Endod* 1990; *16:* 498–504.
10. Smith J, Crisp J, Torney D. A survey: controversies in endodontic treatment and retreatment. *J Endod* 1981; *7:* 477–83.
11. Reit C, Gröndahl H. Endodontic retreatment decision making among a group of general practitioners. *Scand J Dent Res* 1988; *96:* 112–7.
12. Hülsmann M. Retreatment decision making by a group of general dental practitioners in Germany. *Int Endod J* (in press).
13. Klammt W. Frakturen an Wurzelkanalinstrumenten – ihre Ursache, Verhütung und Beseitigung. *Thesis*. Berlin 1941.
14. Castagnola L, Alban J. Über das Abbrechen von Instrumenten bei der Wurzelbehandlung. *Schweiz Mschr Zahnheilk* 1955; *65:* 855–93.
15. Strindberg LZ. The dependence of the results of pulp therapy on certain factors. *Act Odontol Scand* 1956; *14* (suppl 21): 78–93.
16. Engstroem B, Lundberg M. The correlation between positive culture and the prognosis of root canal therapy after pulpectomy. *Odontol Revy* 1965; *16:* 193–203.
17. Ketterl W. Instrumentenfraktur im Wurzelkanal. Dtsch Zahnärztekalender. Munich: Hanser-Verlag, 1975; 71–81.
18. Plathner CH. Komplikationen bei der Wurzelkanalbehandlung. In: Plathner CH, Taatz H (eds.): Grundlagen der Kariologie und Endodontie. 2nd ed.; Munich: Hanser-Verlag, 1975; 603–6.
19. Kerekes K, Tronstad L. Long-term results of endodontic treatment performed with a standardized technique. *J Endod* 1979; *5:* 83–90.
20. Ingle JI, Beveridge EE. (eds.) *Endodontics*. 2nd ed., Philadelphia: Lea & Febiger; 1976, 34–57 & 606.
21. Friedman S, Stabholz A. Endodontic retreatment – case selection and technique. Part 1: Criteria for case selection. *J Endod* 1986; *12:* 28–33.
22. Waas MJ. Trichlorid of iodine in dentistry. *Dent Cosmos* 1918; *60:* 908–10.
23. Warner GR. Broken root files. *Oral Hyg* 1929; *19:* 1746.
24. Helbig W. Unsere Wurzelbehandlungs-Instrumente, ihre Gefahren und deren Verhütung. *Thesis*, Würzburg 1937.
25. Nicholls E. Endodontics. 2nd ed., Bristol: J. Wright & Sons, 1977; 257–7.
26. Filderman J. Die Beseitigung von Bruchstücken von in den Wurzelkanälen abgebrochenen Instrumenten. *Zahnärztl Rdsch* 1935; *44:* 559–60.
27. Fuhrer G. Entfernung von Metallfragmenten aus Wurzelkanälen durch elektrisches Mikroschweissen. *Schweiz Mschr Zahnheilk* 1947; *57:* 73–5.
28. Stewart GG. Chelation and flotation in endodontic practice: an update. *J Am Dent Assoc* 1986; *113:* 618–22.
29. Cattoni M. Common failures in endodontics and their correction. *Dent Clin North Am* 1963; *7:* 383–99.
30. Sternberg RN. Retrieval of broken instruments from root canal. *Oral Surg Oral Med Oral Pathol* 1977; *44:* 325.

31. Cathey GM. Molar endodontics. *Dent Clin North Am* 1974; *18:* 345–66.
32. Feldman G, Solomon C, Notaro P, Moskowitz E. Retrieving broken endodontic instruments. *J Am Dent Assoc* 1974; *88:* 588–91.
33. Zeigler PE, Serene TP. Failures in therapy. In: Cohen S, Burns RC (eds). Pathways of the pulp. 4th ed., St. Louis: C. V. Mosby, 1987; 723–53.
34. Wesselink P. Therapiemöglichkeiten nach Fraktur endodontischer Instrumente im Wurzelkanal. *Endodontie* 1992; *1:* 131–40.
35. Lovdahl PE, Gutmann JL. Problems in non-surgical root canal retreatment. In: Gutmann JL, Dumsha TC, Lovdahl PE (eds.). Problem solving in endodontics. Chicago: Year Book Med. Publ.; 1988, 73–100.
36. Gilbert BO, Rice T. Re-treatment in endodontics. *Oral Surg Oral Med Oral Pathol* 1987; *64:* 333–8.
37. Fors UGH, Berg JO. Endodontic treatment of root canals obstructed by foreign objects. *Int Endod J* 1986; *19:* 2–10.
38. Gundlach W. Die Entfernung von Fragmenten aus dem Wurzelkanal mit Hilfe des Instrumentariums nach Masserann. *Zahnärztl Welt/Reform* 1972; *81:* 803–12.
39. Rocke H., Guldener PH. Obstruktionen des Wurzelkanals. In: Guldener PH, Langeland K. (eds.) Endodontologie. 2nd ed., Stuttgart: Thieme-Verlag; 1987; 338–55.
40. Stock CJR, Nehammer CF. Negotiation of obstructed canals. *Br Dent J* 1985; *158:* 457–62.
41. Sano S, Miyake K, Osada T. A clinical study on the removal of the broken instrument in the root canal using Masserann Kit. *Kanagawashikagu* 1974; *9:* 50–7.
42. Gettleman BH, Spriggs A, Eldeeb M, Messer H. Removal of canal obstructions with the Endo Extractor. *J Endod* 1991; *17:* 608–11.
43. Gaffney JL, Lehman JW, Miles MJ. Expanded use of the ultrasonic scaler. *J Endod* 1981; *7:* 228–9.
44. Johnson WB, Beatty RG. Clinical technique for the removal of root canal obstructions. *J Am Dent Assoc* 1988; *117:* 473–6.
45. Krell KV, Fuller MW, Scott GL. The conservative retrieval of silver cones in difficult cases. *J Endod* 1984; *10:* 269–73.
46. Sieraski SM, Zillich RM. Silver point retreatment; Review and case report. *J Endod* 1983; *9:* 35–9.
47. Moriya K, Osada T. Ultrasonic preparation of the root canal system. *Dent Outlook* 1984; *64:* 1–11.
48. Chenail BL, Teplitsky PE. Endosonics in curved root canals. *J Endod* 1985; *11:* 369–74.
49. Souyave LC, Inglis AT, Alcalay M. Removal of fractured instruments using ultrasonics. *Br Dent J* 1985; *159:* 251–3.
50. Nagai O, Tani N, Kayaba Y, Kodoma S, Osada T. Ultrasonic removal of broken instruments in root canals. *Int Endod J* 1986; *19:* 298–304.
51. Haikel Y, Allemann C. Technologie und Anwendung von Endoschallfeilen. *Phillip-Journal* 1992; *9:* 393–404.
52. Hülsmann M. The removal of silver cones and fractured instruments using the Canal-Finder-System. *J Endod* 1990; *16:* 596–600.
53. Hülsmann M. Die Entfernung frakturierter Wurzelkanalinstrumente mit Hilfe des Canal-Finder-Systems. *Dtsch Zahnärztl Z* 1990; *45:* 229–32.
54. Fox J, Moodnik RM, Greemfield E, Atkinson JS. Filling root canals with files. Radiographic evaluation of 304 cases. *N. Y. State Dent J* 1972; *38:* 154–7.
55. Weine FS. Endodontic therapy. 3rd ed., St. Louis: C. V. Mosby Co.; 1982, 454–5.
56. Tamse A, Katz A. Separating instrument technique for root canal filling: a case report. *Int Endod J* 1987; *20:* 295–7.
57. Crump MC, Natkin E. Relationship of broken root canal instruments to endodontic case prognosis: a clinical investigation. *J Am Dent Assoc* 1970; *80:* 1341–7.
58. Luebke RG, Glick DH, Ingle JI. Indications and contraindications for endodontic surgery. *Oral Surg Oral Med Oral Pathol* 1964; *18:* 97–113.
59. Block RM, Lewis RD. Surgical treatment of iatrogenic canal blockages. *Oral Surg Oral Med Oral Pathol* 1987; *63:* 722–32.
60. Lautenbach E. Auswirkungen frakturierter Wurzelkanalinstrumente. *Zahnärztl Welt/Reform* 1956; *57:* 143–6.
61. Hoefig W. Über Komplikationen bei der Wurzelkanalbehandlung einschließlich forensischer Konsequenzen. *Dtsch Zahnärztl Z* 1975; *30:* 329–35.
62. Barsekow F, Schmelzeisen R. Endodontische Komplikationen als Indikation zur Wurzelspitzenresektion. *Dtsch Zahnärztl Z* 1987; *42:* 231–4.
63. Ausubel H. How to remove a broken broach from a root canal. *Dent Cosmos* 1926; *68:* 1114–15.
64. Grossman LI. Intentional replantation. *J Am Dent Assoc* 1982; *104:* 63–9.
65. Löst C. Grenzfälle der Zahnerhaltung. *Dtsch Zahnärztekalender.* Munich: Hanser-Verlag; 1988, 92–105.
66. Jasper EA. Root canal therapy in modern dentistry. *Dent Cosmos* 1933; *75:* 823–9.
67. Seltzer S, Green DB, Weiner N, De Renzis F. A scanning electron microscopy examination of silver cones removed from endodontically treated teeth. *Oral Surg Oral Med Oral Pathol* 1972; *33:* 589–605.
68. Macintyre EH, McClatchy JK, Rudolph H, Kraushaar JJ. Identification of silver in a periapical lesion of a tooth. *Am J Clin Pathol* 1973; *60:* 613–5.
69. Brady JM, Del Rio CE. Corrosion of endodontic silver cones: a scanning electron microscopic and X-ray microprobe study. *J Endod* 1975; *1:* 205–10.
70. Zielke DR, Brady JM, Del Rio CE. Corrosion of silver cones in bone: a scanning electron microscope and microprobe analysis. *J Endod* 1975; *1:* 356–60.
71. Goldberg F. Relation between corroded silver points and endodontic failure. *J Endod* 1981; *7:* 224–7.
72. Block RM, Pascon EA, Langeland K. A histological and clinical study of silver cone retreatment cases. *J Dent Res* (spec. issue) 1983; *62:* AADR-abstr. 426, 216.
73. Zmener O, Dominguez FV. Corrosion of silver cones in the subcutaneous connective tissue of the rat: a preliminary electron microscope, electron microprobe, and histological study. *J Endod* 1985; *11:* 55–61.
74. Handtmann S, Lindemann W, Hüttemann H, Schulte W. Korrosionserscheinungen an Silberstiften im Wurzelkanal I. *Dtsch Zahnärztl Z* 1987; *42:* 362–7.
75. Lindemann W, Handtmann S, Schulte W, Hüttemann H. Korrosionserscheinungen an Silberstiften im Wurzelkanal II. *Dtsch Zahnärztl Z* 1987; *42:* 639–46.
76. Zmener O, Dominguez FV. Silver accumulation in periapical granulomas: report of five cases using the scanning electron microscope, the electron microprobe, and other complementary methods. *Oral Surg Oral Med Oral Pathol* 1988; *65:* 94–100.
77. Zmener O. An unusual case of silver cone disintegration. *J Endod* 1989; *15:* 319–22.
78. Abou-Rass M. Evaluation and clinical management of previous endodontic therapy. *J Prosth Dent* 1982; *47:* 528–34.
79. Taintor JF, Ingle JI, Fahid A. Retreatment versus further treatment. *Clin Prevent Dent* 1983; *5:* 8–14.
80. Weisman ME. The removal of difficult silver cones. *J Endod* 1983; *9:* 210–1.
81. Friedman S, Stabholz A, Tamse A. Endodontic retreatment – case selection and technique. Part 3. Retreatment techniques. *J Endod* 1990; *16:* 543–9.

82. Hülsmann M. The retrieval of silver cones using different techniques. *Int Endod J* 1990; *23:* 298–303.
83. Stabholz A, Friedman S. Endodontic retreatment – case selection and technique. Part 2: Treatment planning for retreatment. *J Endod* 1988; *14:* 607–14.
84. Roig-Greene JL. The retrieval of foreign objects from root canals – a simple aid. *J Endod* 1983; *9:* 394–7.
85. Spriggs K, Gettleman B, Messer HH. Evaluation of a new method for silver point removal. *J Endod* 1990; *16:* 335–8.
86. Masserann J. L'extraction des fragments de tenons intraradiculaires. *Actualites Odonto-stomatologiques* 1966; *75:* 392–42.
87. Weine FS, Rice RT. Handling previously treated silver point cases: removal, retreatment and tooth retention. *Comp Cont Educ Dent* 1986; *7:* 652–8.
88. Lewis RD, Block RM. Management of endodontic failures. *Oral Surg Oral Med Oral Pathol* 1988; *66:* 711–21.
89. Stamos DE, Haasch GC, Chenail B, Gerstein H. Endosonics – Clinical impressions. *J Endod* 1985; *11:* 181–7.
90. Glick DH, Frank AL. Removal of silver points and fractured posts by ultrasonics. *J Prosth Dent* 1986; *55:* 212–5.
91. Martin H, Cunningham WT. Endosonics – the ultrasonic synergistic system of endodontics. *Endod Dent Traumatol* 1985; *1:* 201–6.
92. Chenail BL, Teplitsky PE. Orthograde ultrasonic retrieval of root canal obstructions. *J Endod* 1987; *13:* 186–90.
93. Imani A, Barkhodar RA. Retrieval of silver points: a report of a case. *Quintess Int* 1988; *19:* 515–6.
94. Glantz PO, Nilner K. Root canal posts – some prosthodontic aspects. *Endod Dent Traumatol* 1986; *2:* 231–6.
95. Stokes AN. Post crowns – a review. *Int Endod J* 1987; *20:* 1–7.
96. Luu KQ, Walker RT. Corrosion of nonprecious metal post: a case report. *Quintess Int* 1992; *23:* 389–92.
97. Chalfin H, Weseley P, Solomon C. Removal of restorative posts for the purpose of nonsurgical endodontic retreatment. *J Am Dent Assoc* 1990; *120:* 169–72.
98. Rud J, Andreasen JO. Operative procedures in periapical surgery with contemporaneus root filling. *Int J Oral Surg* 1972; *1:* 297–310.
99. Rud J, Andreasen JO. A study of failures after endodontic surgery by radiographic, histologic and stereomicroscopic methods. *Int J Oral Surg* 1972; *1:* 311–28.
100. Krell KV, Jordan RD, Madison S, Aquilino S. Using ultrasonic scalers to remove fractured root posts. *J Prosth Dent* 1986; *55:* 46–9.
101. Gerstein H, Weine FS. Specially prepared burs to remove silver cones and fractured dowels. *J Endod* 1977; *3:* 408–10.
102. Prothero JH. Prosthetic Dentistry. 3rd ed., Chicago: Medico-Dental Publ. Co., 1923; 844.
103. Warren SR, Gutmann JL. Simplified method for removing intraradicular posts. *J Prosth Dent* 1979; *42:* 353–6.
104. Neaverth EJ, Kahn H. Retreatment of dowel obturated root canals. *J Am Dent Assoc* 1968; *76:* 325–8.
105. Gerstein H. Modifications and special hints. In: Gerstein H. (ed.): Techniques in clinical endodontics. Philadelphia: W. B. Saunders; 1983, 324–46.
106. Kahn H. Making endodontics a little easier. *Dent Clin North Am* 1984; *28:* 953–80.
107. Bando E, Kawashima T, Tiu IT, Kubo Y, Nakano M. Removing dowels in difficult teeth. *J Prosth Dent* 1985; *54:* 34–6.
108. Machtou P, Sarfati P, Cohen AG. Post removal proir to retreatment. *J Endod* 1989; *15:* 552–4.
109. Williams VD, Bjorndal AM. The Masserann technique for the removal of fractured posts in endodontically treated teeth. *J Prosth Dent* 1983; *49:* 46–8.
110. Dimashkieh MR. The management of obstructed root canals. The hollow tube technique. *Br Dent J* 1975; *138:* 459–63.
111. Hülsmann M. Unpublished data.
112. Wilcox LR, Juhlin JJ. Endodontic retreatment of Thermafil vs. laterally condensed gutta-percha. *J Endod* 1991; *17:* 195 (abstr.).
113. Wilcox LR. Thermafil retreatment with and without chloroform solvent. *J Dent Res* 1992; *71:* 231 (AADR abstract 1000).
114 Harris WE. Foreign bodies in root canals: a report of two cases. *J Am Dent Assoc* 1972; *85:* 906–11.
115. Lamster IB, Barenie JT. Foreign bodies in the root canal. *Oral Surg Oral Med Oral Pathol* 1977; *44:* 483–6.
116. Zillich RM, Pickens TN. Patient-induced blockage of the root canal. *Oral Surg Oral Med Oral Pathol* 1982; *54:* 689–90.
117. Turner CH. An unusual foreign body. *Oral Surg Oral Med Oral Pathol* 1983; *56:* 226.
118. Meidinger DL, Kabes BG. Foreign object removal using the Cavi-Endo ultrasonic instrument. *J Endod* 1985; *11:* 301–4.