A REVIEW OF OBTURATING MATERIALS AND OBTURATION TECHNIQUES USED IN CURRENT ENDODONTIC THERAPY WITH SPECIAL REFERENCE TO THE WESTERN CAPE

by

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This thesis is dedicated to

my parents,

DR. AND MRS. P.W. VENTER

"A vital asymptomatic pulp has always been and will always be, the best root canal filling available."

Professor F.X. Prins (1972)

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PART 1

CHAPTER 1

SCOPE OF THE REVIEW

1.1. The assumption was made by the author that a wide variety of obtu= rating materials and obturation techniques are being used in cur= rent endodontic practice. The assumption was made as a result of clinical observations over a number of years in private practice and in an academic capacity at the Dental Faculty of the University of Stellenbosch. It was further based on personal communications on many occasions with different dental practitioners.

1.2. This review was undertaken in order to gain insight as to why this wide variety of obturating materials and obturation techniques exist.

1.3. A survey was conducted in the form of a questionnaire which was circulated to members of the Cape (Western) Branch of the Dental Association of South Africa.

1.4. All available scientific literature concerning obturating materials and obturation techniques will be reviewed.

1.5. Regarding obturating materials specific attention will be given to the composition and to the physical, chemical and sealing proper= ties of the material, as well as adverse tissue reactions.

1.6. Concerning obturation techniques, attention to special peculiari=ties (if any) of the root canal preparation, with regard to form, will be considered for each technique. The success, or failure rate, advantages and disadvantages will be considered. However, as the basic principles of successful endodontic therapy, such as, diagnosis, radiographic techniques, access preparation, canal lo=cation and determination of the root canal length are not relevant to this study, no consideration has been given to their inclusion.

1.7. Should any significant conclusion materialise, changes to the cur=rent endodontic curriculum of the Dental Faculty, University of Stellenbosch could be implemented on the basis of this thesis.

CHAPTER 2

HISTORICAL PERSPECTIVE

In an ancient Babylonian tale, a worm comes crying to Ea, a goddess, about what is to be his food. When the worm is told to live off fruits, he cried out:

"Me! What are these ripe figs to me,
and soft pomegranates?
Lift me up, between the teeth and the
jaw bone set me,
That I may destroy the blood of the teeth,
And ruin their strength,
Grasp the prong and seize the root."

This tale is cited by Ring (1971) as an introduction to an article on the toothworm.

In reviewing the literature and finding tales and beliefs like these, the author realised the different misconceptions that scientists were working against in the earlier days.

Cruse and Bellizzi (1980) maintain that one should review and understand the accomplishments of one's predecessors in order to be able to evaluate the present and visualise scientific horizons.

Ring (1971) cites examples of persons who actually saw toothworms and even the founder of modern dentistry, Pierre Fauchard did not actually deny their existence. Fortunately Anton van Leeuwenhoek showed the true origin of organisms and disproved the toothworm theory.

Pierre Fauchard wrote the famous Le Chirurgien Dentiste in 1728, and this monumental work has definitely influenced the history of modern dentis= try. Cohen and Burns (1980) in describing the history of endodontics attributes various remedies for toothache to Fauchard. One which con= stitutes some form of obturation technique is where Fauchard opened ab= scessed teeth to drain and left the teeth open for two to three weeks, whereafter the pulp chamber was filled with lead foil. Other operators varied and bettered this technique, notably Pfaff in 1756 who placed a concave lead or gold covering over the exposure. Koecker in Philadelphia cauterised injured pulps, covered the exposure with lead and filled the cavity with gold.

McElroy (1955) states that the modern concept of root canal obturation dates back to 1840 and he mentions a host of different obturating mate= rials that were used. Numerous examples are mentioned such as gold foil; zinc oxide and hydrochloric acid; pulverised charcoal of animals plus iodoform; orange wood sticks dipped in various medicaments; dog dentin and ivory dust. He mentions that gutta-percha was the most popular ob= turating material at that stage.

Cruse et al (1980) describes how Bourdet in 1757 extracted carious teeth and filled the root canals with lead or gold and then replanted them. The same authors credit Wooferdale with the first endodontic procedure in the U.S.A. He came to New York in 1766 and relieved toothache by cauterising the pulp with a red hot wire and then filling the canal with cotton.

Cruse et al (1980) in the second part of their article on endodontic history, describes how Dr. Mills in 1883 extirpated a dental pulp by driving a tapered orange wood or hickory stick dipped in creosote or carbolic acid into the pulp. Fortunately for suffering patients Bowman introduced the gutta-percha and chloroform solution in 1895 and this was used in conjunction with gutta-percha cones to obturate a root canal. One should keep in mind that cocaine was only introduced at about the same time.

Gutman (1978) with the reprinting of an article by J.S. Dodge (1887) cites the philosophy of how "Listerian surgery" should be applied to endodontic therapy. After removal of a vital pulp, Dodge washed the canal with car= bolic acid and immediately filled the canal with gutta-percha. The gutta-percha was vertically condensed with warm wires. In a later paper, Kells according to Gutman (1978), went further and advocated immediate root canal obturation in all cases except those with profuse swelling or bleeding. Kells concludes his paper with the statement that after care= ful root canal therapy "we can safely trust our new friends, the phago= cytes of Metschnikoff to assist us in conserving the parts that we cannot reach."

Goodman, Schilder and Aldrich (1974) wrote an extensive review on the history and molecular chemistry of gutta-percha. According to their sources the early history of gutta-percha is obscure, but it is believed that the Malays and Chinese used it extensively long before it was intro= duced to Western civilisation by the Trandescant family. It was first called "mazer wood" and was brought to Europe as a curiosity. In 1840 it was introduced as gutta-percha and was primarily used for insulating telegraph cables. All kinds of commodities were subsequently fabricated from this material, including the fabrication of golf balls until 1920.

Cramm began using copper points to obturate root canals in 1890. He im= proved the points later by goldplating them according to Cruse et al (1980).

In the third part of the endodontic history review, Bellizzi and Cruse (1980) describes the incident that robbed modern endodontic therapy of almost twenty five years of progress. In October 1910 William Hunter, an English pathologist and physician, gave a lecture in which he attacked the septic conditions created by American dentists in the mouths of their patients. This lecture was subsequently published and eventually led to the focal infection theory which condemned a large number of pulpless teeth to extraction. Fortunately a few dedicated "endodontists" chose to rather improve their techniques in preserving pulpless teeth intact.

Other dates and events of importance to root canal obturation according to Cruse et al (1980) are as follows:

1911 - Callahan introduced the rosin-chloroform technique.

1920 - Herman began using calcium hydroxide (Calxyl) as a root filling material.

1925 - Rickerts advocated a cement sealer in conjunction with a gutta-percha cone.

1928 - Walkhoff propagated the resorbable iodoform paste that bears his name.

1929 - Grove advocated standardisation of root canal instruments and filling materials.

1933 - Jasper introduced silver cones as an obturating material.

This short historical review is concluded by referring to a reprint of an article by Gutman (1978), first published by McQuillen, which might be of some relevance even today. McQuillen in the Dental Cosmos (1860), describes root canal therapy as the "dentist's graveyard" where so many iatrogenic deficiencies are covered with the trust that it may never be detected or should symptoms arise, the tooth will be extracted. He writes that "humanity should thank God for a new light that will go into these dark places and show up what is often criminally careless or wilfully bad work in filling roots."

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CHAPTER 3
METHOD OF STUDY AND DATA OBTAINED

The questionnaire (addendum 1) was circulated to 320 members of the Cape (Western) Branch of the Dental Association of South Africa. Both Afrikaans and English copies were provided in each case. The question= naire was sent with the monthly newsletter to the members and a prepaid envelope addressed to the author was provided in each case. Two months were allowed for the questionnaires to be returned. Although a total of 18 questions was asked in the questionnaire only questions 11, 12, 13 and 16 were analysed for the purpose of this study.

Of the total of 320 questionnaires that were circulated, 176 were re= turned. A total of 4 was returned as not applicable due to the type of practice conducted by the respondent e.g. maxillo-facial and oral sur= geons, which left a viable total of 172 completed questionnaires. This figure represents 54,43% of 316 questionnaires.

Analysis of the relevant questions:

3.1. Question 16: When did you qualify as a dentist?

Four decades* were stipulated and the replies are tabulated in Table I.

Decade of Qualification of respondents	Total	Distribution (%)
Pre-1950	21	12,2
1950 - 1959	49	28,5
1960 - 1969	38	22,1
1970 - 1979	64	37,2
	172	100

Table I.

* The term decade as used in this thesis denotes a period of ten years.

As only 21 respondents, or 12,2% of the total sample qualified prior to 1950, it is assumed for the sake of convenience, that the median age of qualification will not vary significantly from the midpoint of the decade prior to 1950. Furthermore, the total of this group is so small that no significant influences on the graphs are foreseen.

3.2. Question 11: Which of the following root canal filling techniques do you use?

The different techniques stipulated as being used and the number of users in this particular survey can be seen in descending order of preference in Table II.

Filling Technique	Total
G.P. + lateral condensation	102
G.P. - single point	67
Silver point	58
Paste	40
G.P. + vertical condensation	32
Chloropercha	9
Pressure syringe	2
Other	2
	312

Table II.

The percentage distribution of the obturating techniques most commonly used, can be seen in the following bar chart (fig. 1).

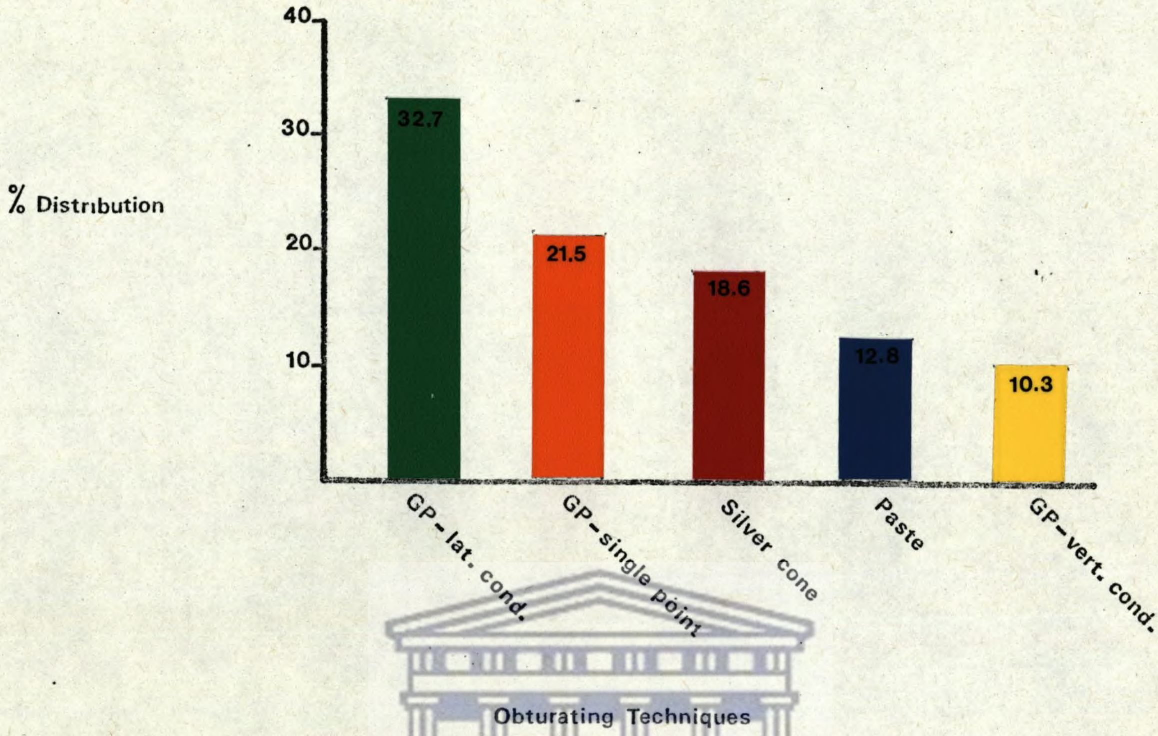

fig. 1. Relationship of obturating techniques most commonly used by the respondents.

According to this data gutta-percha with lateral condensation is the root canal obturation technique favoured by the majority (32,7%) of the respondents to the questionnaire. Furthermore, this technique also seems to be the favoured one by the practitioners who finished their formal training in the last three decades. In the group of practitioners who qualified in the pre-1950 era the single-point gutta-percha technique seems to be the favourite (refer Table IV, figures 2 and 3).

Should one group the different obturating techniques according to the basic material-type used, the following emerges. See Table III.

Type of material	Total	% Distribution
Semi-solid cone material (G.P.)	201	64,4
Solid cone material (silver)	58	18,6
Paste	49	15,7
Diverse	4	1,3
	312	100,0

Table III.

If this data is further analysed in conjunction with question 16 the following is realised. See Table IV. This might have some relevance to the type of endodontic training received by the respondents at the dental faculties at a specific time.

Filling technique	Decade of qualification of respondents			
	Pre-1950	1950-1959	1960-1969	1970 onwards
G.P. + lateral condensation	6	26	23	47
G.P. - single point	11	18	22	16
Silver point	5	12	11	30
Paste	8	15	11	6
G.P. + vertical condensation	5	7	9	11
Chloropercha	2	3	3	1
Pressure syringe	2	0	0	0
Other	0	1	0	1
Total	39	82	79	112

Table IV.

A graphic distribution of the obturating techniques most commonly used by the respondents in conjunction with the decade in which they qualified, revealed the following patterns (fig. 2 and 3).

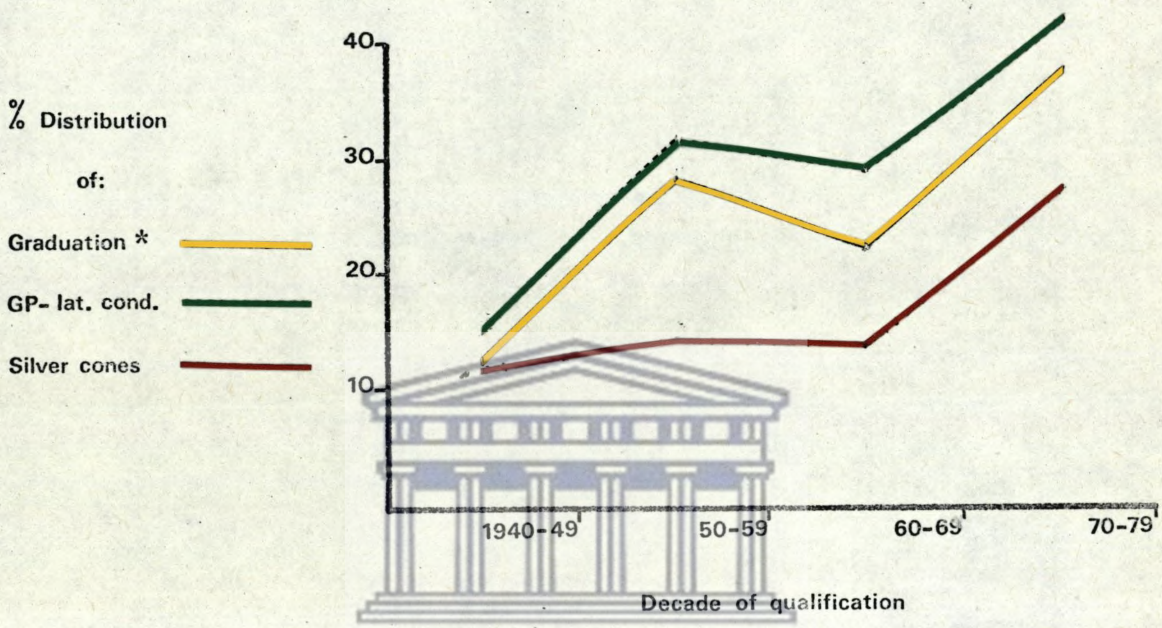

fig. 2. Relationship of the obturating techniques to the decade of qualification.

* The graduation age was determined by the sample figure for each decade as a percentage of the total sample. The distribution of this graph is repeated in figures 3, 4 and 5.

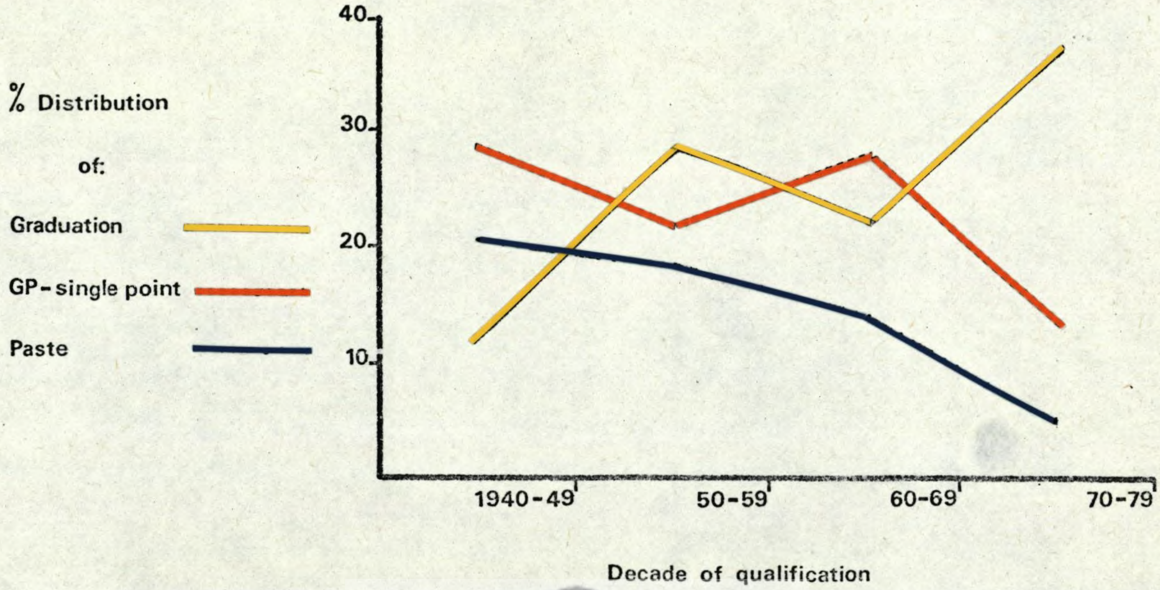

fig. 3. Relationship of the obturating techniques to the decade of qualification (continued).

The distribution for the lateral condensation gutta-percha and the silver cone obturating techniques show the same distribution as the graph depicting the time of graduation of the respondents (fig. 2). Since the inception of the Dental Faculty at the University of Stellenbosch, the lateral condensation gutta-percha technique has been taught and propagated. The silver cone technique has also been taught but to a lesser extent, especially during the last three years. The author postulates that should similar data be collected a decade further, the silver cone technique might show a drop in the number of users. Furthermore, if no new spectacular obturating materials or techniques materialise very soon, the same pattern or even an increase in the usage of the lateral condensation gutta-percha technique could prevail.

The graph showing the distribution of paste filling techniques and the single cone gutta-percha technique in relationship to the time of graduation of the respondents is depicted in figure 3. According to this information there has been a general decrease in the number of proponents of these two techniques (except for a slight increase in the 1960-69 graduates for the single cone G.P. technique). This tendency is generally in line with the techniques taught and advo= cated at the Dental Faculty, University of Stellenbosch.

3.3. Question 12: Which one or more of the following cements do you use in root canal therapy?

The choice of the different cements stipulated in the questionnaire were based on the availability of the proprietary or chemical brands, whichever is the more popular, from the dental supply firms in the Western Cape at the time of this study. The answers received are shown in Table V. in descending order of preference.

Cements	Total	%
Endométhasone	104	38,2
Rieblers	47	17,3
Zinc oxide-eugenol	34	12,5
AH26	18	6,6
Grossman's cement	15	5,5
Kerr's Pulp Canal Sealer / Tubliseal	12	4,4
Kri paste	12	4,4
Diaket	9	3,3
Biocalex	7	2,6
Sargenti / N2	5	1,8
Spad	4	1,5
Roth cement	2	0,7
No cement	2	0,7
Other cements	1	0,4
	272	99,9

Table V.

If the replies to question 12 are tabulated in conjunction with the decade of qualification of the responding dentist the following figures emerge. See Table VI.

Cement	Decade of qualification of respondents			
	Pre-1950	1950-59	1960-69	1970-79
Endométhasone	8	26	22	48
Rieblers	8	22	11	6
Zinc oxide-eugenol	3	7	7	17
AH26	3	5	6	4
Grossman's cement	2	4	3	6
Kerr's Pulp Canal Sealer / Tubliseal	1	2	3	6
Kri paste	2	3	5	2
Diaket	2	5	2	0
Biocalex	0	2	3	2
Sargenti / N2	2	2	1	0
Spad	1	0	1	2
Roth cement	0	2	0	0
No cement	2	0	0	0
Other cements	1	0	0	0
	35	80	64	93

Table VI.

From the total sample Endométhasone emerges as the cement of choice with 38,2% of the respondents using it, while among the pre-1950 graduates Endométhasone and Riebler's paste share the lead. Riebler's paste is also very popular among the 1950-59 graduates who responded. It is surprising that the material that causes so much controversy in the U.S.A., namely Sargenti's paste has so few supporters.

A graphic distribution of the obturating cements most commonly used by the respondents in conjunction with the decade in which they qualified, revealed the following patterns. (See fig. 4 and 5.)

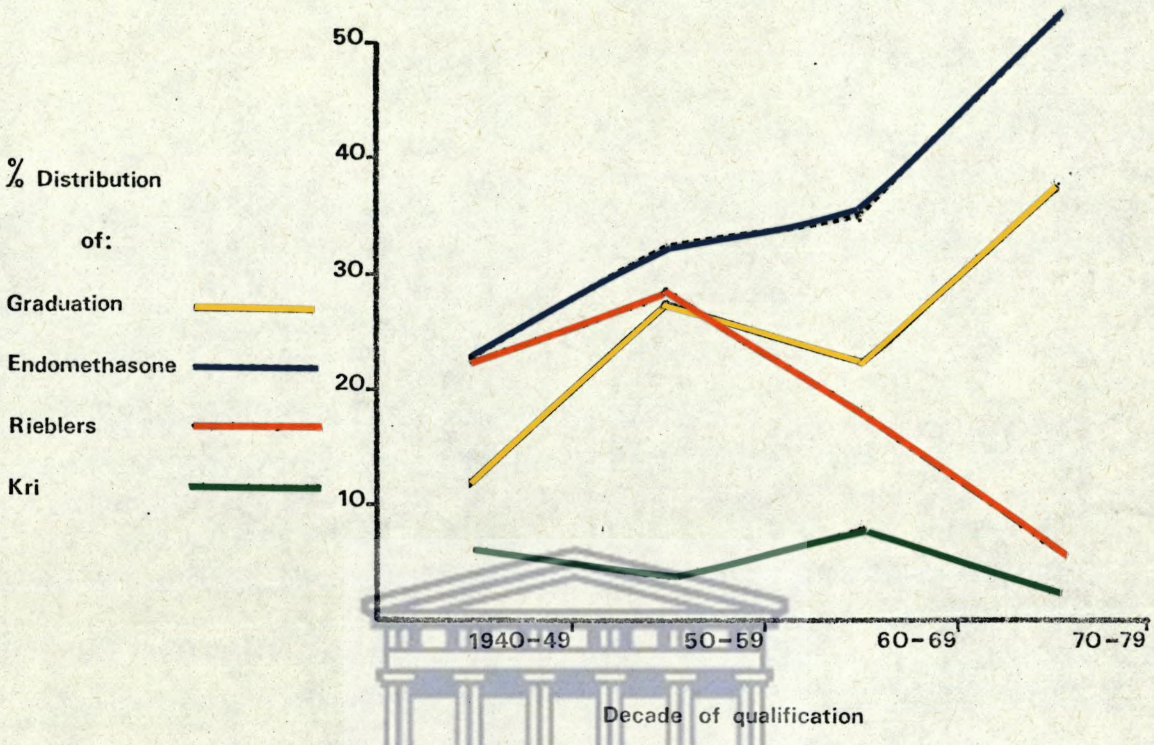

fig. 4. Relationship of the cement sealers to the decade of qualification.

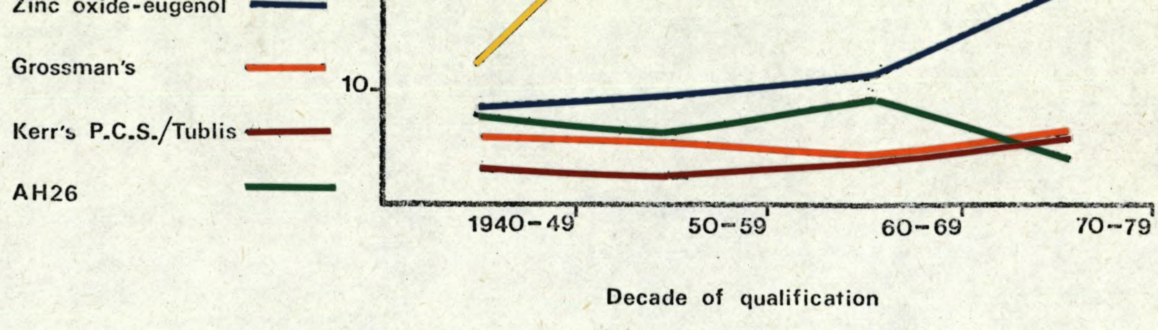

fig. 5, Relationship of the cement sealers to the decade of qualification (continued).

The distribution of Endomêthasone cement shows the same general distribution curve as the graph depicting the time of graduation of the respondents (fig. 4), but with a steeper percentage increase in usage relative to the year of qualification. This material as well as the other two shown in the same graph (fig. 4) are not used or their use advocated in the Dental Faculty of the University of Stellenbosch. The diminishing tendency of the use of Riebler's paste and Kri paste may be attributed to a similar policy adopted in the other dental faculties in which the respondents may have qualified. (The different faculties in which each respondent qua= lified were not identified.)

The graph depicting the distribution of zinc oxide-eugenol and relevant cements in relationship to the time of graduation of the respondents shows an increase in the past decade (fig. 5). AH26 (not a zinc oxide-eugenol cement) shows a decrease in the number of dentists using it. At the Dental Faculty, University of Stellenbosch the use of pure zinc oxide and eugenol as a root canal cement has been advocated since the faculty's inception. It is interesting to note that at present only Zinc oxide-eugenol and Endomêthasone cements show a relative increase in the number of users, whereas the other cements show a static or declining pattern of use. Lately the author has been propagating the use of some commercially available zinc oxide-eugenol preparations due to their better rheological properties. This could not have made any effect on the current data but may do so in the following decade.

In parts 2 and 3 a review of the available literature on various obturating materials and techniques used in current endodontic therapy will be presented.

CHAPTER 4

THE OBJECTIVES FOR OBTURATING THE PREPARED ROOT CANAL SPACE

The objective in obturating a prepared root canal space is to provide a hermetical seal at the apical foramen, as well as complete obturation of the prepared root canal space, according to Ingle and Beveridge (1976). The root canal filling should also be biologically acceptable to the periapical tissue, as is stated by Langeland et al (1971). Grossman (1978) answers the question as to why this is necessary as follows:

1. In order to prevent micro-organisms that might be present during a transient bacteremia lodging themselves in any unobliterated spaces and causing subsequent periapical pathology.

2. Should any micro-organisms be trapped in the root canal obturating material during obliteration and the canal is totally obliterated, these trapped micro-organisms would not be able to survive and re-establish themselves.

3. The problem of aerodontalgia whereby air or gas is trapped in the unobliterated space with resulting pain during conditions of lowered atmospheric pressure will be prevented in the completely obliterated root canal.

Furthermore, Ingle et al (1976) states that apical percolation was re= sponsible for 63,46% of failures noted in the famous University of Washington School of Dentistry's study on endodontic success and failure.

Dow and Ingle (1955) did in vivo experimental work on the subject of apical percolation as a cause of endodontic failures with the help of radioactive Iodine (I^{131}). They stated hypothetically that apical percolation does contribute to root canal failures and then assumed that noxious end-products of the apical percolation will act as an inflamma= tory irritant. They speculated that the fluid in this process of perco= lation will act as an inflammatory irritant. They postulated that the fluid in this process of percolation comes from blood serum and consists of a number of water-soluble proteins, enzymes and salts. These sub= stances then undergo degradation which in turn can act as physico-chemical irritants in the periapical area which leads to chronic apical periodontitis.

On the other hand Seltzer (1971) sees these foregoing purported reasons as unconvincing if they are scrutinised carefully. He reasons that healing of the wound that is caused at the apical foramen after pulp extirpation would take place as is the case with any other wound else= where in the human body. According to Seltzer (1971) the granulation tissue will disappear around the apex of the root canal. Fluid stagna= tion is unlikely as such and the accumulated fluid will be resorbed as healing progresses. He cites the example whereby root canals have been grossly underfilled and yet repair does take place. The answer to the success of endodontic therapy can be found in examination of the peri= apical tissues in the event of healing of a lesion. In such cases fibrous tissue and bone are formed in the periapical area and the apical foramen will be repaired by newly formed cementum. Further evidence is produced that repair of periapical tissues can occur in cases where the pulp was extirpated and the canal-space thoroughly debrided but no root canal obturation was performed. However, Seltzer (1971) does agree that although healing may occur without any obturation of the canal space, it is advisable to obturate the prepared canal space for the following reasons:

1. Exchange of metabolites.

   Through isotope studies by Bartelstone in 1954, Seltzer (1971) states that a constant exchange of metabolites does occur between the root canal and the saliva.

2. Permeability of occlusal restorations.

   After extensive experiments on dog premolars the suggestion was made that the permeability of a restoration does play a significant role in the eventual success of root canal therapy. Analogous with the fact that leakage of a restoration leads to recurrance of caries, leakage of a root canal filling may lead to reinfection of the root canal with consequent pathological changes. Should the situation develop whereby a restoration on a tooth develops marginal leakage and the root canal space in question is endodontically prepared, but not obliterated, the possibility of reinfection of the root canal is greatly enhanced with damaging pathological results.

3. Gingival recession and periodontal disease.

   Should gingival recession occur in an individual through ageing or periodontal disease the chance of exposing lateral or accessory canals on the root surface to the oral environment is possible. This situ= ation can lead to ingress of micro-organisms and oral fluids to the unobliterated root canal space with the result that periapical patho=

logy might be precipitated.

At this stage it might be interesting and useful to consider the proxi= mity of the apical end of the root canal filling to the apical foramen of the tooth.

Question 13 of the circulated questionnaire (addendum 1) reads as fol= lows:

How close to the apex* do you usually fill a root canal?

The resulting data of question 13 is tabulated in Table VII.

Grade of root filling	Total	Distribution %
To the apex	60	35,1
½ mm short	63	36,8
1 mm short	42	24,6
2 mm short	5	2,9
3 mm or more short	1	0,6
	171**	100

Table VII.

** This question was left unanswered by one respondent thus a total of 171.

According to this information the most favoured apical termination of a root canal filling is a ½ mm short of the apex, closely followed by fil= ling up to the apex. This position of terminating the apical end of the root canal filling is in accordance with the literature as quoted by Grossman (1978). He states that the ideal position is at the dentino-cemental junction, "within the root canal, a millimeter or so from the root apex."

If the information obtained from question 13 is further tabulated accor= ding to the year of qualification the following emerges. See Table VIII.

* The term apex denotes the radiographic apex of a particular tooth in this case.

Grade of R.C. Filling	Decade of qualification of respondents			
	Pre-1950	1950-59	1960-69	1970 onwards
To the apex	10	23	14	13
½ mm short	5	17	16	25
1 mm short	3	7	7	25
2 mm short	2	1	1	1
3 mm or more short **	0	1	0	0
Total	20	49	38	64

Table VIII.

** This data is not depicted on the graph (fig. 6) as only one respondent indicated that point of apical termination of root canal fillings.

An interesting fact emerges from this data in that among the pre-1950 and 1950-59 groups of graduates the tendency to obturate the canal up to the apex prevails. From 1960 onwards the tendency to obturate the canal a ½ mm short of the apex prevails, while among the post-1970 graduates the tendency is divided evenly between obturating a ½ mm short and 1 mm short of the apex.

If this distribution is shown graphically the following emerges. See fig. 6.

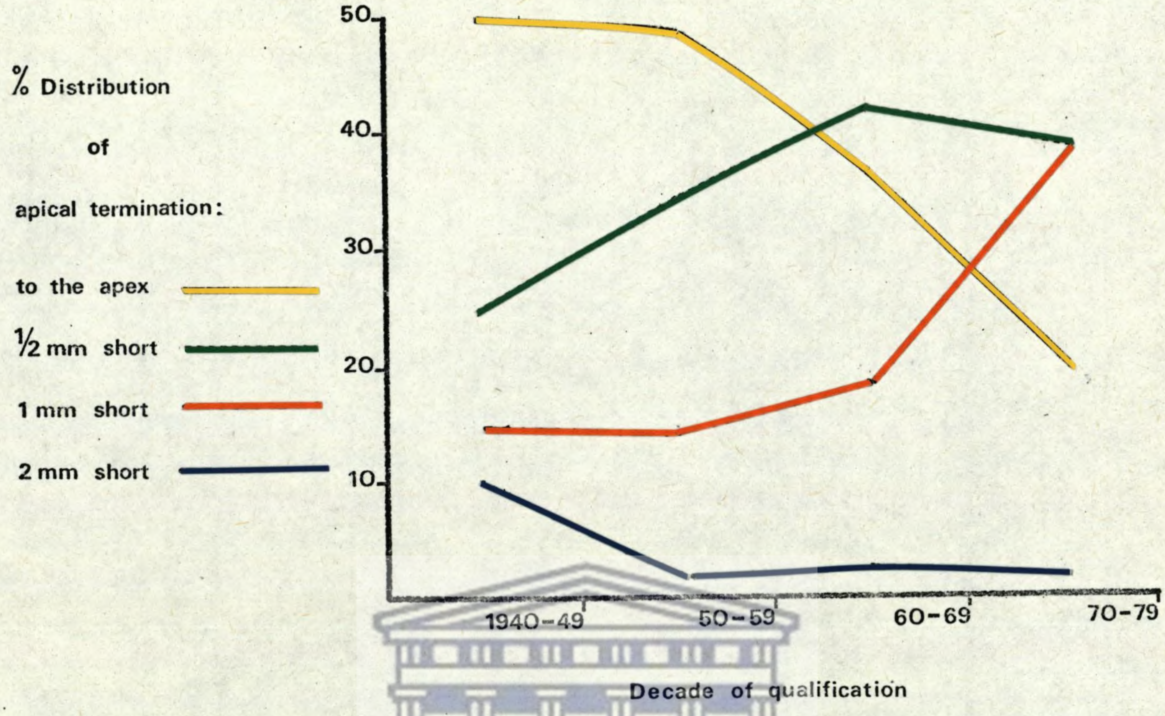

fig. 6. Relationship of the preferred apical termination to the decade of qualification.

A marked decrease in the tendency to obturate the canal to the apex can be seen according to this data. The number of respondents who obturate the canal a ½ mm short of the apex rose steadily in the first three de= cades in question, after which a slight decrease is depicted. A steep increase in the number of respondents obturating teeth 1 mm short of the tooth apex is seen amongst those who qualified in the latter half of the decades in question.

In a study done by Helig and Kischinovsky (1979) on the factors af= fecting successful endodontic therapy it was found that the highest rate of success was achieved when root canal fillings were underfilled but the filling terminated less than 2 mm short of the apex (89,0%); this was followed by underfilled cases where the filling terminated more than 2 mm from the apex (87,5%); then followed fillings that terminated flush with the apex (83%); while the fillings that exten= ded beyond the apex showed the poorest success rate (64,7%).

Burch and Hulen (1972) determined that the position of the apical foramen on average differs in 92,4% of teeth from the anatomical apex and the average deviation was 0,59 mm in a coronal direction.

Seltzer (1971) cites various authors to support the same basic conclu= sion i.e. the main apical foramen seldom coincides with the anatomical apex of the tooth. Should a root canal filling terminate at the apex according to a radiographic picture, that root canal will probably be overfilled. This impingement on vital tissue may be detrimental to the expected repair around such a tooth.

Kuttler (1955) after extensive observations on the topographic and micro= scopic anatomy of the apices of teeth, concluded that the position of the apical foramen deviates progressively further from the anatomical apex with increased age.

The rationale of the current teaching at the Dental Faculty of the University of Stellenbosch regarding the ideal apical termination is based on the abovementioned findings, i.e. to obturate the prepared canal space 1 mm short of the radiographic apex of the tooth, both in teeth with vital and non-vital pulps.

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PART 2

OBTURATING MATERIALS

The history of root canal obturating materials according to Grossman (1978) and Cohen and Burns (1980), is the history of many and diversi= fied materials that may be placed in a root canal with varying degrees of safety according to the expertise of the operator and the qualities of the material.

The following classification of modern obturating materials in endodontic practice is suggested as a base from which individual materials may be discussed.

1. Solid core materials
2. Semi-solid core materials
3. Pastes
4. Plastics
5. Cements

In the following five chapters attention will be given to various aspects of each of these groups of materials.

CHAPTER 5

SOLID CORE OBTURATING MATERIALS

5.1. Silver cones

5.2. Stainless steel instruments

5.3. Chrome-cobalt and Vitallium implant cones

5.4. Titanium cones

5.5. Silver amalgam

5.1. Silver cones

Silver cones are used by 18,6% of the respondents in the survey as an endodontic obturating material. (This figure does not in= dicate sole users of silver cones, as several respondents indicated more than one material and not necessarily in order of preference.)

Cohen and Burns (1980) give the "oligodynamic" property of silver as one of the main reasons why silver was selected as a filling material as early as 1890. They state that oligodynamic refers to the toxic effect on living cells of very small quantities of a substance in solution. The surface soluble salts on a silver cone had a bactericidal effect in that protein denaturation of the bac= teria resulted.

Amongst the first modern proponents of silver cones, Elmer Jasper and Louis Grossman are the most notable. Jasper (1930) felt that if instruments and silver cones could be manufactured to standard sizes, silver cones would be a very good obturating material.

Grossman (1978) states that he is aware of the negative aspects of silver cones, and nowadays prefers to use gutta-percha as an endodontic obturating material wherever possible.

Silver is the forty seventh element in the Periodic Table of Elements and can be classified as a semi-precious metal. The first silver cones were made by hand and standardisation of sizes was therefore a problem. With modern machines and manufacturing techniques one of the main advantages of silver cones is that they can be manufactured to correspond to the ISO* specifications. The result is that when silver cones are used in conjunction with standardised instruments, cone selection is much less time consu= ming for the operator. Kerekes (1979) found that Kerr silver cones** conformed to the ISO specifications but that Beutelrock*** silver cones were larger than the limits of the specifications. The author found no evidence of other comparative studies.

A further advantage of silver cones is that although they are flexible and can be precurved to conform to canal configurations, they are also relatively rigid enough to be placed in narrow tortuous canals according to Cohen et al (1980).

Weine (1976) attributes a further advantage to silver cones in that they are readily visible on dental radiographs. Because of this reason Naudé (1980) prefers to use smaller sized silver cones when

* International Standards Organization.

** Kerr Mfg. Co., Detroit, Mich., U.S.A.

*** Beutelrock & Sohn, Munich, West Germany.

determining the length of a root canal by radiographic means instead of files, reamers or smooth broaches.

The use of silver cones to explore a draining fistula and record the course thereof on a dental radiograph as a diagnostic aid should not be overlooked according to Ingle et al (1976). The author prefers a more flexible gutta-percha point for this purpose although they are admittedly less radiopaque.

The main disadvantage of silver cones as an obturating material according to the author, is preparing the root canal to conform to the standardised shape of an endodontic file or reamer. Luks (1972) describes the problem of achieving engineering precision in an anatomical situation as virtually impossible.

One of the criteria for success in endodontic therapy according to Grossman (1978) is that the canal should be hermetically sealed. This condition could not be met by two incompressible materials viz. silver and dentine. The hermetic seal of the root canal filling then relies on the cement sealer. Weine (1976) feels that as the Knoop hardness number of silver (± 112) is higher than that of den= tine and should sufficient pressure be exerted, the dentine may expand slightly and grip the forced silver cone to achieve a good apical seal. Seltzer et al (1972) maintains that if a silver cone is forced under pressure, deformation of the cone may cause a defect which in turn may enhance corrosion.

In a scanning electron microscope study Wollard et al (1976) found that the cement adaptation was better in cases where the silver cone fitted rather loosely in the canal. This finding is rather contrary to the generally accepted norm as to how a silver cone should fit a prepared root canal.

During a comparative evaluation of polycarboxylate cement as a root canal sealer utilising roughened and nonroughened silver points, Sanders and Dooley (1974) found a statistically significant difference between the two types of silver cones when their adhesive properties were compared. True chemical bonding between the silver cone and cement does not take place and the mechanical interlocking that does take place is enhanced by the roughened surface. They urged manufacturers to produce standardised silver cones with a roughened surface.

In the clinical experience of the author and this view is sustained by Seltzer et al (1972), it is a common observation than when silver cones are removed from teeth of which the endodontic treatment has failed, these cones are black in colour and a foul smell is usually detected.

In an intensive study by Seltzer et al (1972) of 25 endodontic failure cases that were filled with silver cones they examined the following:

1. by scanning electron microscope, the morphological changes that have occurred in the silver cones;

2. the various types of corrosion patterns that were observed;

3. the elements present on these silver cones by means of electron probe analysis;
4. the nature of the corrosion products by means of x-ray diffraction;
5. the cytotoxicity of these elements in tissue cultures.

It is interesting to note that none of the silver cones that were removed from either successful or unsuccessful cases in this study could be described as unchanged. Corrosion defects ranging from pitting to deep crater formation were observed. Sulphur peaks were distinguished on the corroded points. With the x-ray diffrac= tions studies it was determined that various silver salts were formed during the corrosion process and these were found to be highly cytotoxic in tissue culture studies.

According to Cohen et al (1980) the corrosion of the silver cone can be limited to a large extent when it is cemented within the canal space and is completely covered with a non-corrosive cement sealer.

In a study Brady and del Rio (1975) came to very much the same conclusion as Seltzer et al (1972) regarding the corrosion products. They determined that the sulphur and chlorine concentrations dimi= nished very rapidly the further coronally from the apex the analysis was carried out. From this data they supported the contention that the corrosion of silver cones is due to the exposure too, and per= colation of tissue fluids in the apical area of the obliterated canal.

During a preliminary study by West et al (1979) it was determined that if silver cones were covered by negatively charged Teflon, two beneficial effects in endodontic treatment may materialise, viz:

1. it may enhance the formation of osteodentin which in turn will promote apical closure;
2. due to the reduction in the inflammatory response it is postulated that the undesirable end-products of corrosion may be eliminated.

5.2. Stainless Steel Instruments

None of the respondents to the questionnaire volunteered infor= mation on the usage of stainless steel instruments as a root canal obturating material. However, the author is of the opinion that stainless steel instruments are being used, but not on an elective basis. This opinion is based on personal experience in endodontic techniques and during observation of student-operators in dental school.

Ingle et al (1976) is of the opinion that "broken instrument obtu= ration" is to be emphatically discouraged, but that a situation may arise where this material is the last resort before resorting to extraction, viz. inaccessibility to surgical endodontics or conven= tional spreaders for a gutta-percha technique. The author is how= ever, of the opinion that if an instrument can be introduced to a certain point in the canal a silver cone could be introduced to the same level. According to them the success of stainless steel instruments as a root canal filling is much better if the instru= ment (preferably an unused file) is forcibly turned into the den= tinal wall to form a good seal. Should a stainless steel instru= ment be used intentionally, a cement sealer as in the case of a silver cone must be used. If the instrument is loosely fitting in the canal space, i.e. having no seal even if it is stainless steel, it will rust away within a year and will no longer be apparant on a dental radiograph, as was reported by Ingle et al (1976).

Crump and Natkin (1970) did a controlled clinical investigation as to the endodontic prognosis of teeth in which broken root canal instruments were left in the root canal. This study was prompted by the difference in opinion as to whether broken instruments should be left in the canal space or should be removed, bypassed or surgical endodontics performed. Clinical and radiographic examination of 53 cases revealed no statistical significant dif= ference in the failure rates of the broken instrument and control groups. They therefore advise a conservative "wait and see" approach to broken instruments with a definite routine recall observation program. The author is of the opinion that irrever= sible damage may occur if the "wait and see" approach is practised injudiciously.

5.3. Chrome-cobalt or Vitallium Implant Cones

Although it is not an object of this thesis to elaborate on the rationale of endodontic implants, the material used in this tech= nique does constitute an obturating material and will therefore be briefly discussed.

The technique, according to Grossman (1978) was first described by Souza, popularised by Orlay and placed on a scientific basis by Frank (1967).

Vitallium is a chrome-cobalt base alloy and it is not a completely different entity from chrome-cobalt as is frequently understood, but is a registered trademark*.

Ingle et al (1976) cites Venable, Stuck and Beach in that an implant should be inert and non-electrolytic. It is known that chrome-cobalt alloys have been used in orthopaedic surgery and maxillo-facial and oral surgery as replacement or reinforcement parts for a considerable period.

Cohen et al (1980) states that the usage of a cast Vitallium cone as a solid core root canal obturating material in the case of a traumatically avulsed tooth, does hold an advantage. When this avulsed tooth is replanted endodontic therapy should be performed and a specially cast Vitallium cone is then cemented in the pre=pared canal.

In the event of root resorption this rigid vitallium cone can act as an endodontic stabiliser or implant and thus enhance the prog=nosis of the particular tooth. The tooth will then once again have

*Howmedica Inc., Rutherford, N.J., U.S.A.

a favourable crown-root ratio. The author is of the opinion that the prognosis is still limited in these cases because resorption can still continue and the loss of the tooth in question is still inevitable. Only if the resorption is stopped can the endodontic implant be classified as a success. The impression for the cast Vitallium cone is made by fabricating a custom made cone of gutta-percha with chloroform. This cone is then invested and cast but special attention to the elimination should be given by dissolving it with chloroform.

A marked difference in opinion as to the tissue reactions to chrome-cobalt type alloys exists in the literature. Frank and Abrams (1969) is of the opinion that the metal is well tolerated by the periapical tissues. The implants they examined were sur= rounded by a fibrous capsule or possibly a pseudo periodontal ligament. The chronic inflammatory response that was present in the examined cases was due to the cement sealer used in each case. The author agrees with the conclusion of Frank et al (1969) that as only two cases were investigated no firm scientific evidence could be drawn from this paper. Frank (1978) was of the opinion that the alloy was well tolerated in the periapical tissues and the principal factor in achieving success was the ensurance of a perfect hermetic seal at the apex of the involved tooth.

On the other hand Seltzer et al (1973) is of the opinion that the Vitallium implants showed signs of corrosion and that the corro= sion products were responsible for the inflammatory response. Furthermore, they established that corrosion products could be detected in the surrounding bone; several of the roots were ankylosed; blood and nerve supplies to the region were impaired and an ingrowth of inflamed tissue was detected between the im= plants and root canal walls. This study was done by scanning electron microscope, electron probe and histologic examination of eight Vitallium implants in a male mongrel dog. In the opinion of the author this was a much more scientific study than that of Frank et al (1969).

Simon and Frank (1980) in a report on an endodontic implant after three years found the implant surrounded by a dense fibrous cap= sule which in turn was covered by bone. This picture was attri= buted to the absence of any corrosion products after examination by scanning electron microscopy. The root resorption present in this case was probably due to an incompletely sealed apex.

Following the publication of Seltzer et al (1973), Weisman (1974) in a letter to the editor stated that the Vitallium used in the aforementioned experiment was not of the Vitallium alloy composition that is normally used in either cast medical or dental Vitallium alloy. Seltzer (1974) replied to this letter and explained that the implants used, were purchased on the open market as Vitallium endodontic implants.

Hodosh, Shklar and Povar (1974) covered Vitallium implants with a polymer material and found that a physiologic attachment takes place between the implant and the host's tissues. They do main= tain that a perfect apical seal is necessary for a successful implant.

5.4. Titanium cones

Corrosion of silver cones in root canals has prompted several workers to do research in an attempt to find a viable alterna= tive for replacing silver cones without losing the advantages of silver cones. Harris (1971) states a case were 2 mm of the apical end of a silver cone was completely dissolved in a period of 7 to 35 months. The question does arise if this was the fault of the particular silver cone or of the technique employed by the operator.

Messing (1980) states that titanium has been used for numerous years as implantation material in bone and he cites different authors to exemplify the suitability of the metal. Weissman and Aragon (1976) did a comparative in vitro study on the corrosion of silver and titanium endodontic cones. In this preliminary re= port they came to the conclusion that titanium is less likely to corrode than silver when used as a root canal obturating material.

Palmer et al (1979) did an in vivo study on teeth of rhesus monkeys on the tissue reaction to silver cones compared with Ti - 6Al - 4V*. They concluded that Ti - 6Al - 4V (plus suitable sealer) initiated a smaller inflammatory response than corresponding silver cones (plus suitable sealer).

* Star Dental Mfg. Co., Conshohocken, Pa 19428, U.S.A.

Messing (1980) in a clinical study over a period of three years on 43 teeth found titanium cones and tips very satisfactory as an obturating material. He concedes that acceptable results can be achieved by a well fitting silver cone but recommends that titanium cones should replace silver cones as an obturating material, espe= cially if a chance of extrusion into the periapical surroundings may be a possibility.

5.5. Silver Amalgam

Silver amalgam is the current material of choice when placing a retrograde filling at the tooth apex in cases where endodontic surgery is indicated, but does not seem to be very popular in non-surgical endodontics. Two of the respondents to the questionnaire (addendum 1) indicated the use of silver amalgam as a conventional root canal obturating material.

Walker (1977) states that the silver amalgam technique offers a definite alternative obturation material and the technique can be mastered and executed by any dentist. He cites advantages of the material such as tissue tolerance, non-resorbability, compressi= bility and expansion of amalgam as particularly important. The major disadvantages are the difficulty in introducing and conden= sing the amalgam in the confined space of a prepared root canal as well as the problem of removing the amalgam from the canal should this prove necessary.

Field and Browne (1968) found that silver amalgam produced a severe inflammatory response in the two to four day post-operative period, but no inflammatory response was discernible at three months or longer periods which made it exceptionally well suited as a root canal obturating material.

Nicholls (1979) states that the possibility of corrosion products forming in time may enhance the apical seal of silver amalgam. The problem of introducing the amalgam into the apical portion of the root canal has been overcome by different special amalgam car= riers advocated by Messing (1958), Dimashkieh (1975) and Thomas (1978).

Pitt Ford (1980) did extensive research on the leakage of different types amalgam used in root canal obturating procedures. He con= cluded that amalgam root canal fillings showed leakage of a similar order compared to other root canal fillings using a root canal cement as sealer. He advises that if a conventional alloy is used as a filling material it should be placed for at least the apical 5 mm of the root canal and with high copper amalgam alloys at least the apical 7 mm should be filled. The importance of obturating the whole canal space was however, firmly stressed. Harty (1976) main= tains that silver amalgam gives the best possible seal in root canal therapy, but the results of the Pitt Ford (1980) study seems to contradict this statement.

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CHAPTER 6

SEMI-SOLID CORE OBTURATING MATERIALS

Included in the semi-solid core category of obturating materials are gutta-percha and gutta-percha composition cones. Gutta-percha cones were used by 64,4% of the respondents in some or other technique. The use of gutta-percha in the lateral condensation technique proved the most popular method of root canal obturation (32,7%), followed by the gutta-percha single point technique (21,5%) and the vertical condensa= tion technique (10,3%).

Natural gutta-percha is a purified coagulated exudate made from the latex of trees of the genus Payena, popularly named, Mazer trees ac= cording to Cohen and Burns (1980). These trees are indigenous in the Malayan Peninsula, Brazil and Indonesia.

Gutta-percha is one of the earliest known moulding materials in general usage, but was introduced into dentistry by chance, through the work of A.S.A. Hill in the eighteen forties, hence the name "Hills Stopping". Cohen et al (1980) reports that G.A. Bowman was the first exponent of gutta-percha as a root canal obturating material in 1867 and the S.S. White dental manufacturing company began manufacturing gutta-percha cones for endodontic use as early as 1887.

Ingle and Beveridge (1976) states that natural gutta-percha is a polymer of isoprene and closely resembles natural rubber. The natural form appears in an "alpha" cristalline form whereas commercial gutta-percha is of the "beta" cristalline form, but there is no difference in the physical properties of the two forms. Friedman, Sandrik and Heuer (1975) states that gutta-percha is the natural occurring polymer of polyisoprene (trans isomer) which differs widely from natural rubber (cis isomer). Wolfson and Seltzer (1975) gives information where both materials have the same empirical formula, (C_5H_8), and the difference between gutta-percha and natural rubber lies mainly in the orientation of the (C_5H_8)-units in the molecular chain.

Friedman et al (1975) analysed five commercially available brands of gutta-percha cones for their composition and mechanical properties. They found these cones to consist of the following ingredients:

gutta-percha	18 - 21,8%
zinc oxide (filler)	59,1 - 75,3%
heavy metal salts (radiopacifier)	1,5 - 17,3%
waxes and/or resins (plasticiser)	1,0 - 4,1%

The concentration of gutta-percha in each case was found to correlate to the yield strength of each specimen examined. The gutta-percha cones displayed a high elastic modulus, tensile strength and yield point. From their findings they postulated that the zinc oxide is not only an inert filler, as is usually assumed, but acts as a vulcanising agent and there= fore will increase the elasticity and strength of the gutta-percha cones.

Marlin and Schilder (1973) examined the physical properties of gutta-percha when subjected to heat and vertical condensation. In a simulated model of a tooth, they found that the temperature increases by $4^{o}C$ at the apex of a root and concluded that the thermal changes are not signi= ficant in their influence on body tissues. Hand, Huget and Tsaknis (1976) studied the effect of heated gutta-percha as used in the vertical con= densation method advocated by Schilder (1967) on the periodontal tissues. They found that although the temperature rises by 3 - 4^{o}C on the outer surface of the root, it returned to 37^{o}C within two minutes. The heat was probably dissipated very rapidly by the vascular supply of the perio= dontal ligament. They do however, warn clinicians against abuse or drastic modification of the warm gutta-percha technique.

Gurney, Best and Gervasio (1971) did a study of various physical changes related to temperature variations on gutta-percha. They found that the specific proprietary brand of gutta-percha tested, did expand slightly with an increase in temperature. At a low temperature (frozen with ethyl chloride spray) the gutta-percha has a superior thrust resistance which would prevent bending of the tip of the gutta-percha cone. This quality is however, lost at room temperature and does not hold any clinical significance. Water caused almost no dimensional changes to the test sample in this experiment.

Marlin et al (1973) further examined the compressibility of gutta-percha and found that it was compressed during condensation and thus provided an obturating material that will adapt to the prepared canal wall and will remain so in view of the internal pressure created by the compres= sion forces. In a later study Schilder, Goodman and Aldrich (1974) also examined the compressibility of gutta-percha and found that the material undergoes compaction of existing voids and not true compression. Water is considered incompressible and they found gutta-percha less compressible than water. This fact is of clinical importance in that no molecular "spring back" will take place to enhance the seal of a gutta-percha root canal filling. Wollard et al (1976) examined the interface between root canal obturating materials and the prepared dentinal wall with a scan= ning electron microscope. In the case of gutta-percha they found no adaptation to the dentinal walls and advocated the use of a sealer to complete the obturating process.

Friedman et al (1977) did a study to determine whether there is a corre= lation between the chemical composition and the mechanical characteris= tics of five different proprietary brand names of gutta-percha cones. They found the amounts of organic and inorganic substances to be the same in all specimens. High levels of gutta-percha produced stronger and thus more rigid filling materials, whereas a high level of zinc oxide (filler) would increase the brittleness and decrease the elastic flow of the gutta-percha.

Oliet and Sorin (1977) did a study to examine the effect of storage for up to twenty four weeks in differing temperatures on the mechanical properties of gutta-percha cones. The results indicated that the com= pression, torsion, tension and bending properties all changed during this time. The greatest changes occurred at the highest temperatures.

The condition of a gutta-percha cone determines the decision to use or discard it and this differs according to each individual clinician's requirements. Oliet et al (1977) found that when they submitted their test sample to their own subjective testing, they thought all the speci= mens to be suitable for clinical usage. Since ideal standards for mechanical properties do not exist, their assessment is only speculative and arbitrary.

Goldberg, Gurfinkel and Spielberg (1979) assessed the standardisation achieved with fabricated gutta-percha cones which were available under different proprietary brand names. An optical microscope was used in this study and they found deformations in the apical third of all eleven examined specimens. They came to the conclusion that the deformations would not permit correct adaptation of the master gutta-percha cone in a prepared root canal. The necessity of a precision technique to manu= facture gutta-percha cones was stressed by them.

Langeland and Dowden (1971) state that any root canal obturating mate= rial should meet two major requirements, i.e. it should be biologically acceptable to the periapical tissue and it should hermetically seal the canal. The tissue toxicity of any root canal obturating material is therefore of the utmost importance.

Spangberg and Langeland (1973) tested the toxicity of twelve different root canal obturating materials on Hela cells in vitro. This experiment included two different proprietary brand names of gutta-percha cones. In the discussion of the findings of the experiment they conclude that gutta-percha appears to be the least toxic or tissue-irritating root canal obturating material available at that time. One fact that also emerged is that gutta-percha does not adhere to the dentinal wall, thus necessitating the use of a cement as sealer, which in turn may cause adverse reactions in the human tissues.

Wolfson et al (1975) investigated the reaction of connective tissue of rats to different gutta-percha formulations available as endodontic cones.

The results indicated that gutta-percha is a non-toxic and harmless obturating material. The chemical substances which are added to im= prove the physical and chemical characteristics do not play any major role in the tissue irritating potential of the gutta-percha cones. Barker and Lockett (1972) did experimental work on the reaction of dog tissue to immediate root filling with zinc oxide cement and gutta-percha. Although the emphasis was more on the immediate filling after pulpectomy, it was shown that gutta-percha is well tolerated by the apical tissues.

Nicholson et al (1975) did a comparative study on the tissue response elicited by a synthetic gutta-percha cone and a natural gutta-percha cone. Their investigation was prompted by a report that natural gutta-percha can be mildly irritating. In the consequent experiments carried out on white rats, the histologic appearance elicited by each type of gutta-percha cone was found to be essentially identical.

Feldman, Solomon and Notaro (1965) published a case report where a root canal was overfilled with gutta-percha. During consequent follow-up visits it was noted that the overfilled portion was undergoing resorption. Complete resorption occurred in thirteen years and no evidence of any further pathological changes in the periapical region was evident. The author is of the opinion, after examining the published radiographs of this particular case, that the overfilled portion might have been extruded sealer i.e. chloropercha, into an existing sinus-tract and not the gutta-percha cone.

Figure 7 illustrates the resorption of a gutta-percha cone cemented with chloropercha after a period of twenty five years. Approximately 3 mm of the apical section has resorbed - the original filling having been at the apex of the palatal root of the left maxillary second molar. (As confirmed by D.A. Naude.)

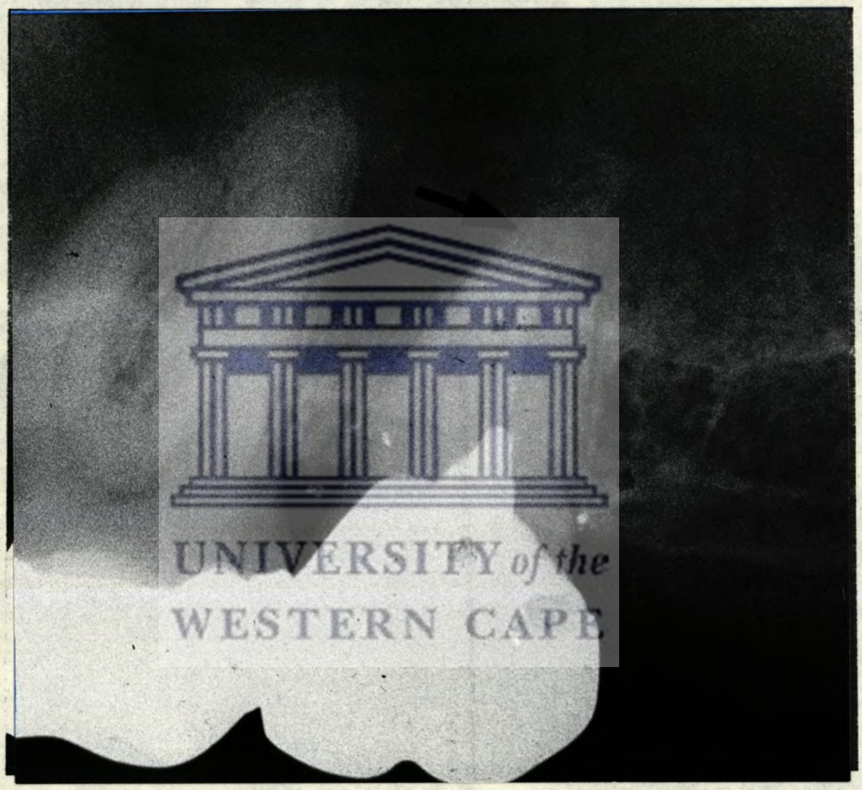

fig. 7. Resorbed gutta-percha and chloroform root canal filling. (Courtesy Prof. D.A. Naudé.)

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CHAPTER 7

PASTES AS OBTURATING MATERIAL

7.1. Formaldehyde and paraformaldehyde pastes

7.2. Iodoform pastes

7.3. Calcium hydroxide pastes

7.4. Chloropercha, Kloroperka-NØ and Eucapercha pastes

This classification is not empirical as some of these pastes are utilised as the sole obturating material by some clinicians, whilst the same paste can be used as a cement sealer with a solid or semi-solid core obturating material and can then be classified as a cement sealer. Ingle and Beveridge (1976) classifies only chloropercha, eucapercha and the iodo= form pastes in this category.

7.1. Formaldehyde and paraformaldehyde pastes

Friedman, Pitts and Natkin (1979) gives a brief historical review of the paraformaldehyde pastes. Gysi in 1898 made a paraformalde= hyde paste available known as Gysi's Triopaste which was the first known paste in this category and is still used world-wide by some practitioners. This was followed by the marketing to the dental profession of Robin's paste, Easlick's paste, Triozine paste, Neo-paraform, Endométhasone, Riebler's paste and N2-paste.

Endométhasone*, Riebler's paste** and Sargenti / N2 / RC2B paste*** are the best known examples and the most universally used of these paste materials.

Among the respondents to the questionnaire (addendum 1) Endométha= sone proved to be the most popular material being used in the Western Cape at that particular time. A total of 104 respondents which represents 38,2% of the sample, indicated that they use this material, especially among respondents who qualified in the last two decades covered by the study, this material proved very popular.

Riebler's paste proved to be the second most popular material among the respondents to the questionnaire. Forty seven dentists, which represents 17,3% of the sample, indicated their use of this material in endodontic practice. It was particularly in the 1950-1959 period of qualification that Riebler's paste had a high level of proponents.

Sargenti's paste (N2 or RC2B) did not prove to be very popular among the respondents in the Western Cape. Only 5 dentists which represents 1,8% of the sample indicated the use of this material.

* - Specialités Septodont - Septodont, France.

** - Riebler - Bisingen, West Germany.

*** - AGSA - Switzerland.

In the review of the available English language literature on this subject the author came to the conclusion that Sargenti's paste is the most commonly used of this category in the United States accor= ding to Wasilkoff and Maurice (1976) as well as Hovland and Gutman (1977).

Cohen and Burns (1980) state that Endométhasone and Sargenti's paste, as reformulated in 1970, are very similar materials as far as their basic ingredients are concerned, i.e. zinc oxide, eugenol, paraformaldehyde and steroid preparations.

7.1.1. Composition

Endométhasone is mainly a zinc oxide powder with the following therapeutic ingredients:

Dexaméthasone	0,01 g
Hydrocortisone acetate	1,00 g
Di Iodothymol	25,00 g
Paraformaldehyde	2,20 g
Excipient radiopaque q.s.p.	100,00 g

The powder is mixed with eugenol liquid and according to the manufacturer's instructions a ratio of 7 parts powder to 1 part of liquid will ensure optimum results.

Riebler's paste is a powder and liquid package combination with the following ingredients:

Powder: Zinc oxide
Formaldehyde
Barium sulphate
Phenol

Liquid: Formaldehyde
Sulphuric acid
Ammonia
Glycerine

Cohen et al (1980) describes Riebler's paste as the "most extreme" example of a sealer cement of which therapeutic properties are claimed.

N2 was popularised by Sargenti and Richter in Switzerland in 1959 according to Friedman et al (1979). The major substance of N2 is zinc oxide and it is mixed with eugenol. Sargenti (1973) maintains that the percentage of the various ingredients could be varied without influencing the effectiveness of the material, with the exception of paraformaldehyde. Should para= formaldehyde be omitted according to him, the clinician is bound to have failure in the endodontic therapy performed.

The composition of N2 according to Cohen et al (1980) is as follows:

Powder:	Zinc oxide	69,0 - 62,0%
	Lead tetroxide	12,0 - 11,0%
	Paraformaldehyde	6,5%

	Bismuth subcarbonate	5,0 - 9,0%
	Bismuth subnitrate	2,0 - 4,0%
	Titanium dioxide	2,0 - 3,0%
	Barium sulphate	2,0 - 3,0%
	Phenylmercuric borate	0,1%
	Hydrocortisone	1,2%
	Prednisolone	0,2%
Liquid:	Eugenol	92,0 - 100%
	Geraniol	8,0%

Brown, Kafrawy and Patterson (1978) describes a variation of RC2B which contains an antibiotic-steroid opthalmic preparation and this combination is described as a "polyvalent canal medi= cation" by Sargenti. According to Cohen et al (1980) some available formulations do not contain corticosteroids or lead tetroxide. Shapiro et al (1975) determined in a preliminary study that lead containing root canal cements could raise the blood lead levels of experimental animals after filling canals with such a cement. West et al (1980) did a study on the lead blood levels of 39 healthy dogs after root canal treatment with RC2B. They determined that a statistically significant increase in the lead concentration in the blood of the various animals could be found both after one and after twenty four hours.

7.1.2. Physical, chemical and sealing properties

According to Friedman et al (1979) the formaldehyde which is used in the obturating pastes is the polymeric hydrate of for= maldehyde. The chemical properties of formaldehyde (Riebler's paste) is essentially the same as paraformaldehyde except that it gradually loses its formaldehyde content to the atmosphere or into solution.

Grossman (1976) did a detailed study on the physical properties of various root canal cements which included N2, N2 no-lead and RC2B. In comparing the particle size, flow, setting time, adhe= sion and peripheral leakage he found that the paraformaldehyde pastes were of average particle size; that it had no flow characteristics; the setting time was relatively fast (6 - 8 hours); showed no adhesive characteristics and the average leakage of a freshly mixed specimen when compared to the other cements tested, showed a similarity.

Younis and Hembree (1976) did an experiment with ten commercial= ly available sealers either as the sole filling material or in conjunction with a master gutta-percha cone. The materials were all handled according to the manufacturer's instructions and the leakage was tested by radio-isotopic means. In the case of N2 as a paste filling, leakage was observed after one day and right up to the conclusion of the experiment after three weeks. In conjunction with a gutta-percha cone leakage could be observed after two days and up to two weeks.

The leakage pattern of Riebler's paste showed the same pattern when used as a paste filling alone and diminished after one week when used with a gutta-percha cone. Younis et al (1976) does conclude that their sample size might be too small to draw definite conclusions.

Yates and Hembree (1980) evaluated the sealing ability after one year and concluded that N2 with a gutta-percha cone showed a very poor seal with a leakage pattern varying from moderate to gross.

Erausquin and Muruzábal (1968) in a research programme on four root canal cements which included N2, came to the conclusion that all the cements will be resorbed if the canal is overfilled, but that this resorption takes place very slowly.

Langeland (1971) states that sealers and pastes are generally resorbable and that it may lead to a situation whereby materials can be transported away from the pulp canal to other areas or inner organs. A sealer or paste should therefore be as inert as possible and not contain any harmful or toxic elements. Accor= ding to Cohen et al (1980) formaldehyde causes necrosis of vital tissue which forms the basis for fixing materials for histologic examination. Should this material be accidently extruded beyond the apical foramen severe consequences may follow. Another harm= ful substance in N2 is heavy metal ions, e.g. lead, which may be spread throughout the body.

Kaufman and Rosenberg (1980) describes a case where a long-lasting paresthesia of the lower lip of a patient occurred after root canal obturation with Endométhasone (as a paste-filling), was performed. The second mandibular molar in question was re=treated with a lateral condensation gutta-percha technique and AH26 sealer with no real improvement. The cause of the pares=thesia is attributed to the penetration of Endométhasone paste into the inferior alveolar canal and a recommendation is made that paraformaldehyde containing pastes or sealers should not be used in endodontic therapy.

Langeland (1971) concluded that pastes which are intended to fill the entire prepared canal space are not acceptable and the canal space should be obliterated by a solid or semi-solid material for the greatest part and the sealers are only intended to fill the voids left by these materials.

Grossman (1980) describes the controversy in the dental profes=sion regarding the usage of an antimicrobial agent in the cement sealer that would sterilise and maintain a sterile root canal. He examined the relative antimicrobial effect of eleven root canal cements under aerobic conditions. The conclusion of this experiment is that all types of cement tested did have an anti=microbial effect and those that contained paraformaldehyde had a more effective antimicrobial effect. This effect diminished after 7 - 10 days to the same level as the other cements. The author is of the opinion that this last finding may be a con=tributing factor to the fact that success can be achieved with most modern obturating materials as the "therapeutic effect" of the materials peter out after a certain period of time.

7.1.3. Tissue reactions to pastes

A fair amount of experimental investigation has been conducted on the tissue toxicity of these materials. Sargenti (1973) maintains that the most significant research should be in vivo with the material in contact with a vital pulp or while being released from the apical foramen. The criterium is not easily met and therefore a lot of experimental work is done in vitro on laboratory animals.

Rappaport, Lilly and Kapsimalis (1964) studied the tissue reac= tion, cellular toxicity and bactericidal properties of ten com= mercially available root canal sealers. In the discussion of their findings they stated that N2 and N2-medical elicited a severe inflammatory response with diffuse oedema and necrosis as seen in the histologic examination. Tissue culture studies showed these materials to be most toxic and the bactericidal properties were in the lower range of the tested materials.

Friedman et al (1979) states that formaldehyde could be used as an antimicrobial agent against bacteria, fungi and viruses, but the action of the drug is considered slow. Once bound to blood or tissue debris the effect diminishes further and the disinfec= ting quality becomes unreliable.

Munaco, Miller and Everett (1978) investigated the relative variation in cytotoxicity of a few endodontic materials and determined the duration of such a toxicity. They found that N2 and RC2B showed the same pattern of cell death with N2 re= sulting in 96% of cells dying in the first 5 days but this level diminishes to 1% after 4 months.

Antrim (1976) determined the period of time that four different cements will remain cytotoxic over a seven month period. With radioactive tissue culture cells he determined that all four materials studied, which included N2 (permanent), possess a lasting tissue toxicity. Langeland (1971) on the other hand states that the irritating effect of sealers may diminish after curing or setting of the material has occurred. Spangberg (1969) in examining the toxic effect of root canal filling materials on Hela cells and human skin fibroblasts found that very low concen= trations of N2 and Riebler's paste completely inhibited growth of the cells.

Brown et al (1978) studied the effect of RC2B on connective tissue and found it to produce coagulation necrosis of the con= nective tissue in contact with the material. The necrosis is ascribed to the paraformaldehyde in RC2B. The lack of a severe inflammatory response as was usually associated with earlier formulations of N2 was ascribed to the inclusion of corticos= teroids.

Cohler et al (1980) studied the effect of RC2B on inflamed and necrotic pulps of monkeys. During histological examination of the specimens with pulpitis, lesions such as apical periodon= tis and granulomas were detected. The necrotic specimens in contact with RC2B showed apical periodontitis, root resorption or apical granulomas in all but one of the treated teeth. Newton, Patterson and Kafrawy (1980) did a similar histologic investigation on the effect of RC2B treatment on teeth with in= duced pulpitis and necrosis. The results were compiled after 6 months and one year and they showed periapical pathology ranging from apical periodontitis to osteomyelitis in all the teeth treated. It is important to note according to Newton et al (1980) that little or no correlation could be determined between the histologic and radiographic findings.

Campbell et al (1978) citing Morse, Lasater and White states that immunoglobulin producing cells have been seen in periapical lesions when examined. They felt that a specific immune response might be induced by materials used in endodontic treatment. After their investigation of the immune response to four root canal cements they concluded that these materials, which inclu= ded RC2B, were not capable of producing a delayed hypersensiti= vity reaction in the sensitised animals. Stuart et al (1979) is of the same opinion that endodontic cements may act as antigens or haptens and therefore constitute a factor in the failure of root canal fillings. In their experiment RC2B was included. They concluded that animal experiments are not always represen= tative of the situation in humans, but that immediate hypersen= sitivity reactions to the tested cements will not occur. No humoral response could be elicited and these authors feel that this factor could be disregarded as a cause of root canal failures.

Hoover, Thoma and Madden (1980) did an in vivo experiment on dogs to determine the changes produced by zinc oxide-eugenol plus 6% paraformaldehyde. After 4 weeks a zone of bone damage was evident surrounding the implantation site with the greatest damage apparent after one week. It is interesting to note that the area of damage was smaller than the control with zinc oxide-eugenol only. Barker and Lockett (1972) concluded that should N2 be used every effort should be made to confine it to the canal space as the extruded part becomes encapsulated in fibrous tissue.

Friedman et al (1979) concludes that the issue of extruded formaldehyde pastes is somewhat vague. Long-term in vivo observation seems to indicate that the pastes are reasonably well tolerated. However, in view of tissue culture and implan= tation studies the chance of an acute inflammatory response with extrusion of the material is significantly higher than with other root canal cements.

7.2. Iodoform pastes

The Iodoform pastes are not dealt with in great depth in the available English literature. Two types of Iodoform paste are described by Ingle et al (1976) viz. the rapid absorbable and slowly absorbable types.

The first advocate of such a paste was Walkhoff (circa 1940) ac= cording to Castagnola and Orlay (1952), although Cohen et al (1980) gives 1928 as the year of the first manufactured product.

In response to the questionnaire (addendum 1), a total of twelve respondents (4,4%) indicated the use of such an obturating material.

7.2.1. Composition

Examples of Iodoform pastes available according to Castagnola et al (1952) are as follows:
Cibazol paste; W1 Walkhoff original; Kri 1; Pharmachemie; W1 Pharmaton; W1 Wild; Asphalin and Argocyt Wild.

Cohen et al (1980) describes the following formula for Walkhoff's paste:

Powder:	iodoform	
Liquid:	parachlorophenol	45,0%
	camphor	49,0%
	menthol	6,0%

Mynol* cement is also listed as a somewhat similar paste with the same indicated usage.

* Mynol Chem. Co., U.S.A.

7,2,2. Physical, chemical and sealing properties

Ingle et al (1976) states that iodoform is radiopaque and re=sorbable and proponents of this technique advocate gross over=filling with the understanding that rapid resorption of the overfilled portion will take place. According to Ingle et al (1976) it is just this resorption that leads to so many failures with these materials.

Castagnola et al (1952) describes iodoform as a very suitable medium for the drugs that Walkhoff's paste contains. It is non-irritant, radiopaque, non-shrinking and not soluble. The paste is also understood to adhere very well to dry canal walls. Iodoform is apparently not a disinfectant but the bactericidal properties of the parachlorophenol is close to optimal according to Castagnola et al (1952). These authors describe resorption of the material from the canal as a sign of successful treatment and not of incomplete canal obliteration.

7.2.3. Tissue reactions to iodoform pastes

Castagnola et al (1952) describes a study of 1 000 cases treated with an iodoform paste in Switzerland. After a two year follow-up period they found "perfect" results in 68% of cases and an improvement in almost 78% of the cases.

Friend and Browne (1969) did an extensive study on tissue reac=tions to seven obturating materials implanted in the tibias of rabbits. They felt that these implanted materials in polythene tubes resembled the clinical situation found in teeth due to the approximation of bone and soft tissue (subcutaneous) on the two ends of the tube. Regarding Kri 1 paste they found evidence of necrotic inflammatory cells after 2 days. Because of the resorb= able nature of the paste phagocytosis of the material took place with the result that the lumen of the polythene tube was full of necrotic polymorphonuclear leucocytes and macrophages after two weeks. A fibrous capsule with new bone trabeculae was found after four weeks with the consequence that bone formed into the lumen of the tube and eventually right through it.

In another article Friend and Browne (1968) came to the conclu= sion that although Kri 1 paste seems to be well tolerated by the periodontal environment, it is just this resorbable nature with consequent ingrowth of fibrous tissue that makes it unacceptable as a root canal obturating material. The fact that a permanent seal will not form may hamper subsequent restorative procedures where the pulp canal must be utilised e.g. post crown preparation.

7.3. Calcium hydroxide pastes

Calcium hydroxide is currently in vogue as a medicament to stimu= late apexification and apexogenesis in traumatised immature per= manent teeth. Goldman (1974) describes the rationale and treat= ment of such teeth with their vital pulps intact as well as for pulpless teeth. Numerous other publications to the same effect can be found in the literature.

Frank (1979) in an article on the uses of calcium hydroxide con= cludes that there is indeed a place for a temporary paste filling material to improve the environment in the canal to allow repair to take place. This medicament is however, not the principal fac= tor for achievement of successful endodontics. Through a question= naire to the chairmen of graduate endodontic programmes in the U.S.A., Frank (1979) tried to determine the extent to which cal= cium hydroxide was being used. Only one respondent to his ques= tionnaire indicated the use of calcium hydroxide as a sole perma= nent obturating material, while not one respondent used it in conjunction with gutta-percha. Frank (1980) states that the results of the survey was statistically insignificant but that it clearly emphasised the existing confusion regarding the usage of calcium hydroxide.

Biocalex* is a calcium hydroxide material that grasped the imagi= nation of the dental profession some years ago. It consists of a powder (60 g. calcium oxide and 30 g. zinc oxide) and a liquid (ethylene glycol 80 g.). According to the manufacturers a consi= derable expansion of six to nine times the initial volume of the paste will take place. The expansion in the root canal is how= ever, limited by the available endodontic space and a reservoir of a "reserve paste" remains.

In reply to the circulated questionnaire (addendum 1) to the members of the Western Cape branch of the D A S A, seven dentists

* La Physiotechnie S.A., France.

which represents 2,6% of the total, indicated the use of Biocalex as an obturating material.

7.3.1. Biological effects

Seltzer (1971) states that calcium hydroxide causes degeneration of a cell immediately upon contact by disturbing the cell mem= brane. After a period of time however, it will induce minerali= sation in the tissues.

Laws (1962) maintains that when a vital pulp has been extirpated and endodontic therapy performed, the apical foramen will be closed by cementum. He found that calcium was well tolerated by the periapical tissues through histologic study. The calcium hydroxide was gradually resorbed and then replaced by granulation tissue which in turn changed to a cementum-type tissue.

Rowe (1967) found that calcium hydroxide powder as well as a powder-distilled water mixture produced a severe inflammatory response with abscess formation in the periapical tissue of cats.

Abramovich and Goldberg (1976) in a study on the relationship between the dentinal tubules and Biocalex as well as calcium hydroxide, found with both materials empty tubules interspersed with obliterated tubules. No evidence of any remineralisation could be seen with either of the materials.

Seltzer (1971) concluded that calcium hydroxide does not induce cementum or dentin formation as a routine and that the formation of such tissues may occur without calcium hydroxide being used.

7.4. Chloropercha, Kloroperka-NØ and Eucapercha

A total of nine respondents to the questionnaire (addendum 1) indicated the use of chloropercha as a filling material repre= senting 2,9% of the total sample.

According to Ingle et al (1976) chloropercha and eucapercha are among the prevailing pastes currently in world-wide use. Cohen et al (1980) however, reports that the Food and Drug Administra= tion of the U.S.A. has shown that chloroform may act as a carci= nogen. Therefore many clinicians have recommended that eucalyptol* be used as a solvent for gutta-percha. The disadvantage of euca= lyptol as an organic solvent is that it takes a little longer than chloroform to dissolve the gutta-percha.

Cohen et al (1980) states that Chloropercha has been used relative= ly unaltered for well over a century. Nygaard-Østby introduced Kloroperka in 1939 but it is very similar to chloropercha.

7.4.1. Composition

The paste is essentially made by dissolving gutta-percha in chloroform or eucalyptol.

* an extract of Myrtaceae : Eucalyptus rostrata trees

Cohen et al (1980) gives the following formulas:

Chloropercha*

Gutta-percha composition	9,0%
Chloroform	91,0%

Kloroperka-NØ**

Powder:

Canada balsam	19,6%
Rosin	11,8%
Gutta-percha	19,6%
Zinc oxide	49,0%

Liquid:

Chloroform	100,0%

Eucapercha

Eucalyptus oil / Eucalyptol is used instead of chloroform as dissolving medium.

7.4.2. Physical, chemical and sealing properties

Schnell (1978) determined that chloropercha showed evidence of a substantial leakage pattern and even when additional gutta-percha cones were used a 7,5% volume loss could be detected due to shrinkage.

Ingle et al (1976) does however, maintain that chloropercha as

* J. Bird Moyer Co., U.S.A.

** Union Broach Co., U.S.A.

a sealer in conjunction with gutta-percha cones is being used for severely curved and dilacerated canals. In assessing the future of endodontics Cohen et al (1980) feels that chloropercha will be used to a lesser extent as an obturating material or molding material for gutta-percha, especially if reports on the carcinogenic potential of chloroform can be substantiated.

Langeland (1971) found all the sealers in his experiments were resorbable and chloropercha proved no exception.

Spangberg and Langeland (1971) states that although chloropercha is less toxic than Kloroperka - NØ, it is not such a good clini= cal proposition because it lacks stickiness and volumetric sta= bility.

7.4.3. Tissue reactions

Spangberg et al (1971) evaluated the tissue toxicity of several root canal obturating materials in vitro and found chloropercha and Kloroperka - NØ (after evaporation of the chloroform) to have the lowest toxic effect on Hela cells in his experiment. In the freshly mixed state the materials were found to be highly toxic with complete cell lysis within one hour. One must remember that the evaporation of chloroform in the closed canal space will be relatively slow and the tissue fluids will be responsible for removing it.

Spangberg (1969) showed that a very low concentration of chloropercha was capable of inhibiting the growth of Hela cells.

Langeland (1971) in evaluating the toxicity of root canal pastes, found that after evaporation of the chloroform, the chloropercha cements were among the most tissue tolerant found in his work.

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CHAPTER 8

PLASTIC MATERIALS AS AN OBTURATING MEDIUM

Ingle and Beveridge (1976) feels that plastic materials as an obturating medium is still in an experimental stage but that they hold promise for the future as a biocompatible and hermetically sealing root canal obtura= ting material.

In this category the author includes the following materials with the re= servation that the classification is not empirical.

- Silicone rubber (Silastic*)
- Hydrophilic gels (Hydron*)

Grossman (1978) lists a number of substances as plastic obturating mate= rials e.g. acrylic monomers, amalgam, synthetic and epoxy resins, gutta-percha paste and a number of materials seldom used.

Rising, Goldman and Brayton (1975) maintain that modifications of current sealers and filling materials to diminish their tissue irritating proper= ties is not the ideal solution but a new substance should rather be de= veloped that will be more biocompatible. The use of silicone rubber to demonstrate the complex anatomy of a prepared root canal gave rise to the study of soft plastic materials as a possible alternative to solid or semi-solid obturating materials.

* Dow Corning Corporation, Michigan, U.S.A.

* N.P.D. Dental Systems Inc., New York, U.S.A.

8.1. Composition, physical and chemical properties.

Silastic 382 medical grade elastomer and Silastic Medical Adhesive type A are linear silicone rubber polymers with long side chains according to Rising et al (1975). Silastic 382 is a viscous fluid that requires a catalyst to polymerise, while Silastic Adhesive autopolymerises once in contact with atmospheric moisture.

Hydron or poly-hydroxyethyl-methacrylate (poly-Hema) is a gel that forms when the alcoholic re-esterification of methyl methacrylate and glycol takes place. The polymerisation of the monomer metha= crylate to the poly-Hema state is dependent on an aqueous environ= ment. According to Kessler (1980) the material will polymerise to a hard brittle substance in the absence of water. If the Hydron is now exposed to water it will swell to a rubber mass that is dimen= sionally stable. It is therefore imperative that Hydron should be mixed on a dry slab and then introduced into a dry root canal. The material will now absorb moisture through the foramina and dentinal tubules and swell to a stable mass.

Rising et al (1975) concluded that Hydron was a much better obtura= ting material than Silastic 382 or Silastic Adhesive, in view of it being biocompatible and non-toxic.

8.2. Sealing properties and Tissue reactions

Jones (1980) states that if injectable materials with good flow characteristics are used for obturating the prepared canal space it will be possible to achieve complete obturation of all the ir= regularities in the canal. In this experiment Silastic 382 was injected into prepared root canals and compared with gutta-percha and Procosol as control. Both materials showed apical leakage and no statistically significant difference could be detected. He con= cluded that Silastic was not superior to gutta-percha in conjunction with a cement sealer as an obturating medium.

Kasman and Goldman (1977) found in a preliminary study that Silas= tic is extremely well tolerated by the periapical tissue with only a minimal inflammatory response and a tendency to encapsulate the material.

Goldman et al (1980) did an in vitro study on the adaptation and porosity of poly-Hema and found that the Hydron in this particular model system did not allow bacterial penetration to take place. The fact that the bacteria used in this experiment is actively motile and relatively small in size, might be indicative of a good sealing quality that may be expected of Hydron. Kronman et al (1979) determined that Hydron does not support bacterial growth.

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CHAPTER 9

CEMENT SEALERS IN OBTURATION OF ROOT CANALS

The cement sealers can be divided in two main groups viz. sealers that are based on zinc oxide-eugenol formulations and the non zinc oxide-eugenol types.

Cohen and Burns (1980) mentions another category described as therapeutic cements. The author is of opinion however, that this category should classify as a paste type obturating material (refer chapter 7), because they are often used as the sole obturating medium by their proponents.

All but two of the 172 respondents to the questionnaire (addendum 1) indicated the use of one or more of the root canal cements listed in question 12. The two dentists who indicated that they used no cement were both pre-1950 graduates and proponents of the chloropercha technique according to question 11. (Refer chapter 3.)

If the cement sealers available to the respondents were listed in alpha= betical order in the two proposed categories the following emerges. (Refer Table IX.) Those not listed here but included in the question= naire, have been dealt with in chapters 8 and 9.

The manufacturers of the cement sealers in Table IX are as follows:

1. Claudius Ash, Inc. Niagra Falls, U.S.A.

2.)
) Kerr Mfg. Co., Romulus, Michigan, U.S.A.
3.)

4. Roth Drug Co., Chicago, U.S.A.

5. Powder: May & Baker Ltd., Dagenham, England.

   Eugenol: De Trey, Amalgamated Dental, England.

6. Wach, 1925 - 1955.

7. De Trey, A.G., Zürich, Switzerland

8. Espe, G.M.B.H., West Germany

Grossman (1978) describes the function of a cement as a compensatory medium for the slight space left between the solid or semi-solid core obturating material and the prepared canal wall. He further lists the requirements of a good root canal cement which is generally used in the literature as a standard when comparing different cements. Cohen et al (1980) further describes the function of a cement in root canal obturation as a binding agent of the cone to the canal wall, a lubricant to aid in the "seating of a cone", as well as a medium to fill patent lateral and accessory canals.

9.1. Composition of Cement Sealers

9.1.1. Composition of Zinc oxide-eugenol cement sealers

The substances in the most frequently used cements in this category are listed in the following table. (Table X.)

Zinc oxide-eugenol cement sealers	
1. Grossman's cement	*
2. Kerr Pulp Canal Sealer	*
3. Kerr Tubliseal	*
4. Roth Root Canal Cement	
5. Zinc oxide-eugenol	
6. Wach's cement	
Non Zinc oxide-eugenol cement sealers	
7. AH26	
8. Diaket	

Table IX.

* Cohen et al (1980) gives the formulations of three different cements by Grossman viz.

- Procosol radiopaque silver cement (Grossman, 1936)
- Procosol non-staining cement (Grossman, 1958)
- Grossman's sealer (Grossman, 1974)

The same authors also describes Rickert's sealer (1931) as the currently known Kerr sealer. Kerr Tubliseal is essentially the same with the precipitated silver omitted. They further describe Kerr sealer and Procosol to be the most widespread zinc oxide-eugenol type sealer in usage.

Cement Sealer	Contents	Percentage
Grossman's Sealer	Powder: Zinc oxide	42,0
	Staybelite resin	27,0
	Bismuth subcarbonate	15,0
	Barium sulphate	15,0
	Sodium borate (anhydrous)	1,0
	Liquid: Eugenol	100,0
Kerr Pulp Canal Sealer	Approximate composition of mixed sealer	
	Silver (molecular) C.P.	25,0
	Zinc oxide (arsenic free)	34,0
	Dithymol Diiodide	11,0
	Oleo resins	30,0
Kerr Tubliseal	Approximate composition of mixed sealer	
	Zinc oxide	57,4
	Bismuth trioxide	21,5
	Thymol iodide	3,75
	Oils	7,5
	Modifiers	2,6
Zinc oxide-eugenol	Powder: ZnO	
	Assay material - Not less than 99% on ignited material	
	Loss on ignition - Not more than 1%	
	Iron - Not more than 0,01%	
	Liquid: Eugenol B.P.C.	

Table X.

According to Cohen et al (1980) zinc oxide-eugenol hardens due to a combination of physical and chemical processes. The set mate= rial is a hardened mass of zinc oxide embedded in a matrix of zinc eugenolate crystals. The excess eugenol can be absorbed by the zinc oxide as well as the eugenolate, but the trapped eugenol may cause a weakening of the material. Crane et al (1980) maintains that the free eugenol that remains in the hardened cement consti= tutes a tissue irritant.

9.1.2. Composition of Non zinc oxide-eugenol cement sealers

The most popular cements in this category are AH26 and Diaket. The substances of each are listed in the following table.(Table XI.)

Cement Sealer	Contents		Percentage
AH26	Powder:	Silver powder	10,0
		Bismuth oxide	60,0
		Hexamethylene tetramine	25,0
		Titanium oxide	5,0
	Liquid:	Bisphenol diglycidyl ether	100,0
Diaket*	Powder:	Zinc oxide	98,2
		Bismuth phosphate	2,0
	Liquid:	2,2 - Dihydroxy - 5,5 - dichloro= phenyl methane	
		Proprionylacethophenone	
		Triethanolamine	
		Caproic acid	
		Copolymers of vinyl acetate, vi= nyl chloride, vinyl isobutyl ether	

Table XI.

* Although this material contains a substantial amount of zinc oxide, no eugenol is used and it is therefore classified in this category.

Grossman (1978) describes AH26 as an epoxy resin which is hardened by a non-toxic substance. He also describes Diaket as a polyvinyl resin.

Cohen et al (1980) describes Diaket as essentially a keto-complex in which neutral organic agents react with basic salts and metal oxides to form a polyketone. This polyketone then reacts with the metal salts in the material to form water-insoluble cyclic complexes.

Cohen et al (1980) states that AH26 was introduced in Europe by Schroeder in 1957 and Diaket by Schmitt in 1951, while Grossman (1978) states that Scheufele introduced Diaket in 1952 in Europe.

9.2. Physical, chemical and sealing properties of cement sealers

Grossman (1976) did an extensive study on the physical proper= ties of a number of root canal cements regarding the influence of particle size, flow, setting time, adhesion and dimensional change of each material. He found AH26 had the finest particle size while zinc oxide-eugenol and Diaket had the largest particles. Fragola et al (1979) investigated the difference made by varying particle sizes to the physical properties of Grossman's cement. They found that smaller particles led to a smoother mix which also set at a faster rate. This in turn led to a more homogeneous and crystalline matrix of the hardened material. Although other workers may have found a relationship between particle size and setting time, Grossman (1976) could not substantiate this claim.

The flow characteristics showed the materials to be divided into three groups with AH26 as a rapid flowing cement, Kerr sealer, Tubliseal and Procosol in a medium flowing category, while Diaket showed no flow according to Grossman (1976). A cement sealer with poor flow characteristics will hardly obturate the irregularities in the root canal, while too rapid a flow rate may lead to over=filling the canal according to Weisman (1970). Uhrich, Moser and Heuer (1978) in examining the rheologic properties of five root canal sealers, found that these materials behaved in a pseudo=plastic manner. To the clinician this means that a cement should generally be inserted as rapidly as possible to fill as many ir=regularities and lateral canals as possible. The rapid insertion would decrease the viscosity of the cement. This information is contrary to the belief that a slow insertion rate is preferable.

Vermilyea, de Simon and Huget (1978) also investigated the rheolo=gic properties of seven endodontic cements and concluded that the viscosity can be affected by many factors. The initial viscosity is determined by the particle size and powder, liquid or base and catalyst ratio. Because of these factors each clinician can select a material that is ideal to the experience of the specific operator.

The setting time is an important factor to consider in root canal cements. It must however, be noted that the setting times recorded under experimental conditions differ appreciably from those in the root canal. In the root canal the temperature and relative humidity is much higher. This factor will lead to acceleration of the set=ting time according to Grossman (1976). It is therefore imperative that a root canal should be as dry as possible when obturating it, in order not to interfere with the flow and setting time. The setting times achieved in Grossman's (1976) experiments varied from one hour (Kerr sealer and Tubliseal) to almost forty hours (Procosol). It is interesting to note that AH26 which has the smallest particles, had a relatively long setting time (36 hours).

Wiener and Schilder (1971) studied the setting times of eight root canal sealers at conditions of varying temperature and humidity. They emphasise the factor that the temperature at the root apex is normally 37°C and the relative humidity is 100%. This situation will lead to faster setting times within the canal and may compli= cate or prevent complete obturation.

Grossman (1976) states that regardless of the type of root canal cement no bonding to the dentinal wall will take place. Abramovich and Goldberg (1976) studied the relationship between dentinal tu= bules and different root canal cements. They found that AH26 and Diaket appeared as a conglomerate of granules adhering to the den= tinal wall while some loose granules were sometimes found within the tubules. Tubliseal was seen as fibrous granules adhering to the canal wall while Grossman's cement was seen as irregular spheres with different sized conglomerates. The apparent adhesion of Grossman's cement was found to be worse than the other materials tested. These workers concluded that none of the materials showed total obliteration of the dentinal tubules and that sealers do not adhere but are only compressed against the dentinal wall. Because of this characteristic no true hermetic seal can be accomplished by these cement sealers.

Grossman (1976) found dimensional change or peripheral leakage very difficult to determine experimentally. He concluded that all the cements tested showed some contraction at room temperature.

Several other workers also tested the leakage of different root canal cements but because of the difference in protocols different results were obtained which may make comparisons difficult.

Wiener and Schilder (Nov. 1971) investigated the dimensional changes that may occur after a zinc oxide-eugenol type cement has set. They determined that shrinkage occurred in all samples and that this shrinkage was not uniform. Visually, Tubliseal appeared to show the most overall retraction while AH26 (not a ZOE cement) showed slight initial expansion under experimental conditions.

Wiener and Schilder (Dec. 1971) concluded that since solid or semi-solid core materials cannot produce complete obturation, the herme= tic seal is dependent on a "less-than-perfect sealer". Therefore clinicians are advised to use a maximum volume of solid or semi-solid core material when obturating a canal and limit the amount of sealer to an essential minimum.

Younis and Hembree (1976) in a pilot study on the sealing ability of commercially available sealers, found the least leakage with the resin-formulated materials in general. The combination of sealer and a gutta-percha cone produced a more successful seal.

Grieve (1972) studied the sealing properties of five sealers with eosin dye and colour photographs. Kerr's sealer showed very good sealing properties whilst the other four cements showed moderate to severe leakage.

Yates and Hembree (1980) after evaluating the sealing ability of three materials found after one year that Tubliseal with gutta-percha showed the best sealing ability and there was no indication that time would have any effect on the obturating ability of the material. Diaket showed a less favourable sealing pattern but better than N2, the third material tested.

In the search for an ideal cement sealer McComb and Smith (1976) compared polycarboxylate-based cements with nine commercially available sealers. They concluded that polycarboxylate cements showed advantages regarding strength, adhesion and solubility over the other materials. Their investigation was however, only of a preliminary nature.

Barry and Fried (1975) in examining the sealing quality of two polycarboxylate cements in root canals found them to be unsatis= factory both from the sealing point of view, as well as from a handling point of view.

9.3. Tissue reactions to Cement Sealers

After investigating the toxicity of fourteen root canal obturating materials Langeland (1971) concluded that in their freshly mixed state all sealers are irritating to the periapical tissues but this effect may diminish after the material has set.

Many different substances are included in the composition of root canal sealers as was illustrated in section 9.1. and these may all have some effect on the human tissues.

Seltzer (1971), in animal studies found severe inflammation around particles of a root canal cement containing silver. Furthermore he states that the severe staining of dentine that can be caused by the silver in such a cement should lead to the abandonment of such cements.

Jonck, Eriksson and Comins (1979) examined the loss of zinc to the dentine of a tooth of which the prepared canal space was obturated with a zinc oxide and eugenol cement. They found that zinc was given off to the dentine and this may alter the physical properties of the dentine.

Erausquin and Muruzábal (1967) examined the histological response of the periapical tissue of 141 Wistar rats to zinc oxide-eugenol cement and found it to be very irritating with a polymorphonuclear leucocyte infiltration which lasted for two weeks. Necrosis of the periodontal ligament was observed initially but it subsided after four days. It was further determined that a fibrous capsule fre= quently encapsulated the overfilled portions of cement.

Hoover, Thoma and Madden (1980) in experimental work on dogs deter= mined that a zone of bone damage could be distinguished after four weeks around an implanted zinc oxide-eugenol cement. Erausquin and Muruzábal (Sept. 1968) also observed bone necrosis and resorption in response to three zinc oxide-eugenol preparations.

In order to diminish the tissue toxicity of cements, Erausquin and Muruzábal (Oct. 1968) added acrylic polymer spherules (inert filler) to the cements and found more favourable tissue reactions to all four cements tested.

Rappaport, Lilly and Kapsimalis (1964) studied the tissue reaction, cellular toxicity and bactericidal properties of ten commercially available root canal sealers.

With zinc oxide-eugenol they found a "median minimal" inflammatory response with an average tissue toxicity response. Procosol non-staining cement also showed a moderate inflammatory response with a low grade of tissue toxicity. Kerr sealer showed an initial marked inflammatory response with a gradual decrease. In tissue culture studies it was found to be rather toxic. Munaco, Miller and Everet (1978) found that Kerr sealer had a substantial toxic effect on bovine pulp tissue in the first week after placement and this effect diminished until no cell death could be detected after five months.

Rappaport et al (1964) found AH26 initiated a marked inflammatory response with necrosis, which changed rapidly to mild inflammation and later the inflammation disappeared completely. In tissue cul= ture studies AH26 revealed a low grade of toxicity. This finding is in accordance with those of Keresztesi and Kellner (1966) in their experimental studies. According to Seltzer (1971) there are not many studies available on the use of AH26 in the root canals of humans but he concludes that the material is well tolerated and any excess material tends to become encapsulated.

Rappaport et al (1964) found Diaket initiated a marked inflammatory response which diminished to a moderate reaction. The toxicity study of Diaket showed it to be the most toxic of the ten materials tested. Seltzer (1971) came to the same conclusion regarding Diaket as with AH26, in that it is well tolerated and overfilled portions were well encapsulated.

Antrim (1976) determined the period of time that four cements would remain cytotoxic. He stated that although a material may prove to be toxic during in vitro experiments, the situation in the human might be different due to ageing of the material and the effective= ness of the physiologic defence mechanism of the human body. If a material does prove to be toxic in vitro, it should however, not be used as the sole obturating material but rather in conjunction with a solid or semi-solid core material.

Campbell et al (1978) felt that because a specific immune response might be triggered by endodontic materials it should be investigated.

None of the four materials that were tested, which included Procosol and zinc oxide-eugenol, were capable of producing a delayed hyper= sensitivity reaction. Stuart (1979) in a similar experiment came to the same conclusion, but with the reservation that the situation in humans may differ from experimental animals. They do however, feel that the immunologic response can be discarded as a possible cause of endodontic failures.

On the other hand Block et al (1978) determined that dog pulp tissue could be antigenically sensitised by Procosol and a specific humoral response could be elicited.

Torabinejad, Kettering and Bakland (1979) felt that protocols of investigators differed from the clinical situation in that no pre-immunisation was performed. They simulated the clinical situation in dogs with AH26 as possible antigen or hapten and found that AH26 will not cause detectable immunologic reactions.

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PART 3

OBTURATING TECHNIQUES

This part of the thesis will cover various aspects of some obturating techniques but the basic principles of endodontic technique will not be discussed as they are not relevant to this study. If an obturating technique requires a special root canal preparation form it will be discussed as well as interesting technicalities concerning the filling technique. This review is concerned with obturation techniques cur= rently employed by the dentists in the Western Cape area who responded to the questionnaire (addendum 1) and is not intended as a manual on the subject.

Although many variations exist in obturating techniques, a broad clas= sification can be made into three categories which cover virtually all techniques reported in the sample.

<u>Techniques</u>:

- where gutta-percha is involved
- where solid core obturation is performed
- where obturation is by means of a paste

CHAPTER 10

GUTTA-PERCHA OBTURATING TECHNIQUES

Gutta-percha was used by 64,4% of the responding dentists in obturating prepared root canal spaces. The lateral condensation technique was the one favoured by the majority of the respondents and especially among graduates of the last three decades. In the pre-1950 group of graduates the gutta-percha single point technique proved to be the most popular technique employed. (Refer to chapter 3.)

10.1. Gutta-percha lateral condensation technique

The lateral condensation technique was employed by 102 (32,7%) of the respondents to the questionnaire (addendum 1). This is the obturating technique currently taught and employed in most cases at the Dental Faculty of the University of Stellenbosch.

The lateral condensation technique is described in detail in various endodontic textbooks, notably; Cohen and Burns (1980), Ingle and Beveridge (1978), Grossman (1976), Bence (1976) and Nicholls (1977).

The objective of this technique, as with any other technique ac= cording to Schilder (1974), is to achieve total root canal obtu= ration. An advantage of the technique is that a dimensionally stable root canal filling can be anticipated and there is less likelihood of forcing the obturating material through the apex, although this may still happen as is shown in fig. 8.

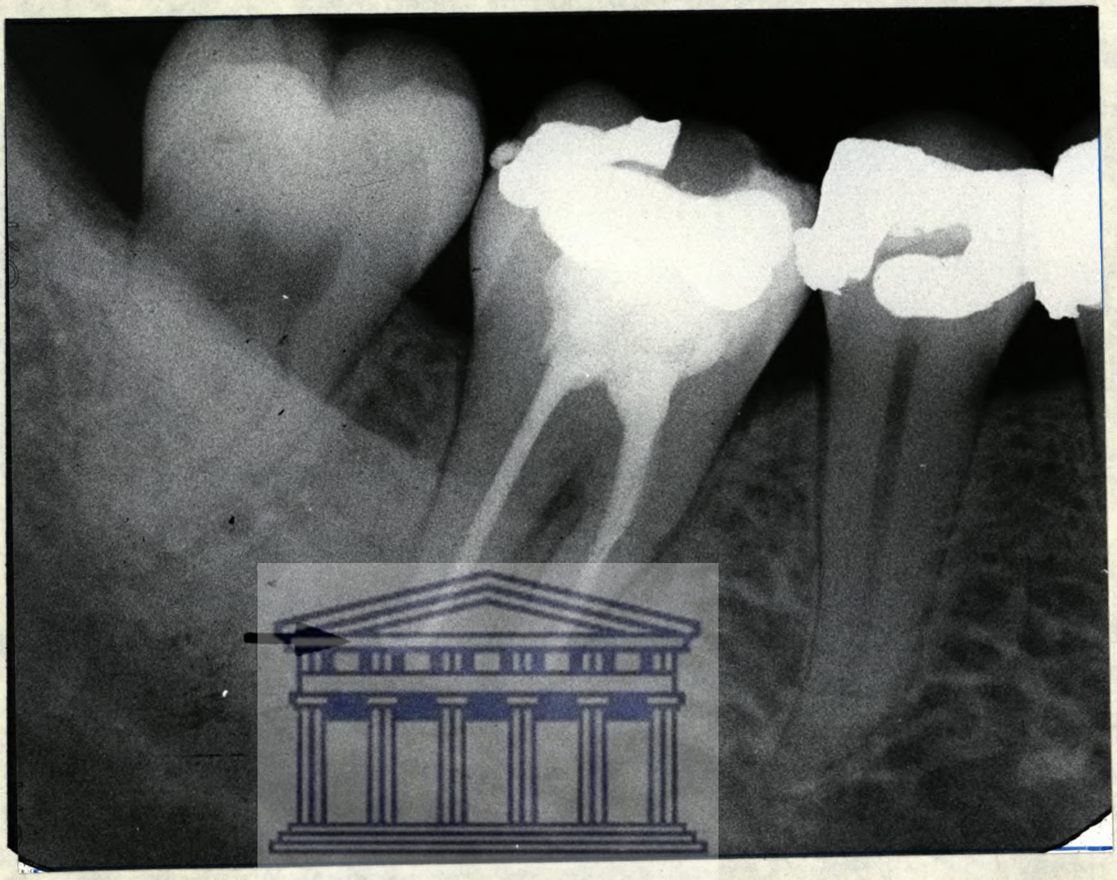

fig. 8. Gutta-percha in the distal root of mandibular molar was forced through the apical foramen.

According to Cohen et al (1980) the canal should be specially prepared for the lateral condensation technique with a continuous tapering or funnel shaped preparation with the narrowest diameter at the dentino cemental junction. This will act as a matrix against which the gutta-percha can be forcibly condensed. Harty (1976) states that with a dimensionally stable and well condensed root canal filling there will be little chance of the apical seal being disturbed should the need arise for a post retained resto=ration on that particular tooth.

Brayton, Davis and Goldman (1973) maintains that many techniques have been put forward for obturating root canals with subsequent controversies arising. A lot of this support for any particular technique was based mainly on clinical impressions and not on scientifically controlled experiments. In a preliminary inves= tigation of the gutta-percha lateral condensation technique on decalcified teeth, they found many irregularities in the root canal fillings with inadequate spreading of the sealer. According to their findings no variations of the canal space were produced and the actual filling showed little correlation to radiographs taken before decalcification.

A disadvantage of this technique is that no true homogeneous mass develops and the filling is comprised of a large number of sepa= rate gutta-percha cones tightly pressed together and joined only by frictional gripping or the cement sealer according to Schilder (1967). In examining the thermomechanical properties of gutta-percha Schilder, Goodman and Aldrich (1974) maintained that no true compression of gutta-percha is possible and only collapse of internal voids can be expected.

Nicholls (1977) stresses the fact that no amount of additional cones employed in the lateral condensation technique can improve the apical seal of the root canal filling. It is therefore imperative that the master cone fits snugly in the apical portion of the canal. He recommends that the gutta-percha lateral conden= sation technique should be used for ovoid canals (cross-section) or root canals that taper to a large extent.

Grossman (1976) believes that because of the pressure exerted by the lateral condensation there is a chance of lateral and acces= sary canals being filled in the apical and middle thirds of a prepared root canal. This fact is clearly demonstrated in figures 9 and 10. However, Harty (1976) maintains that the sealer in the lateral canal may be resorbed in due course.

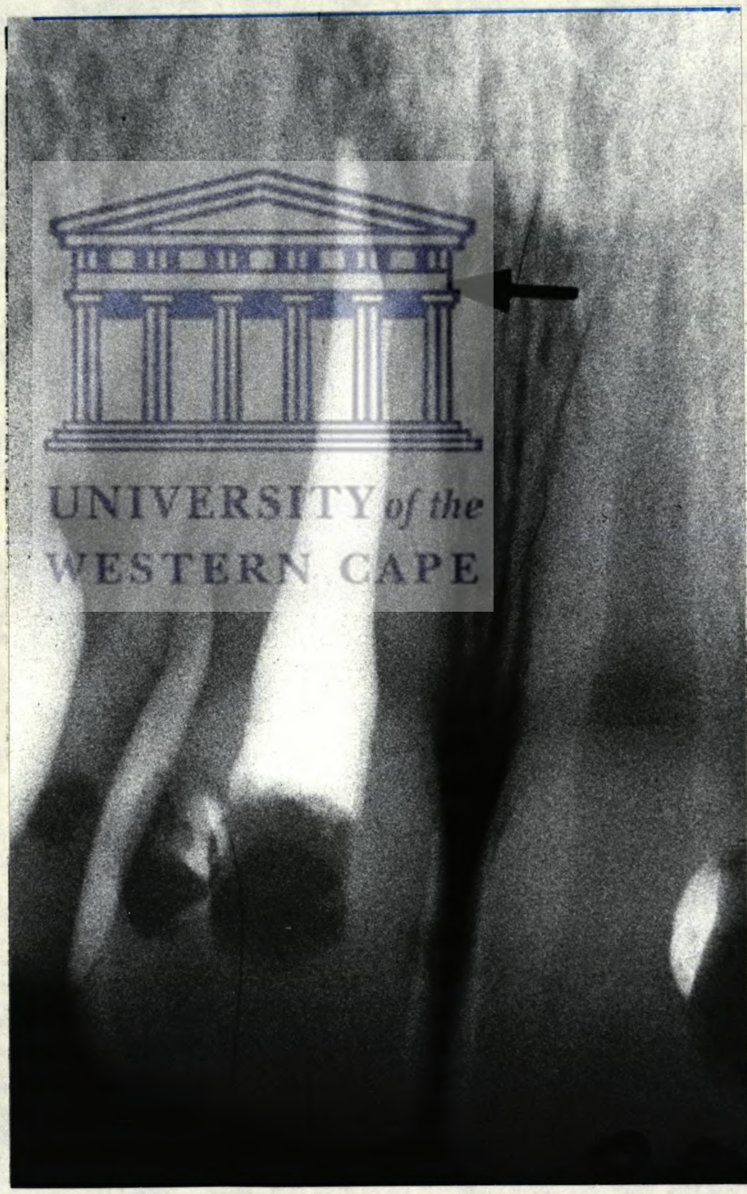

fig. 9. Lateral condensation gutta-percha technique with a filled lateral canal in the apical third.

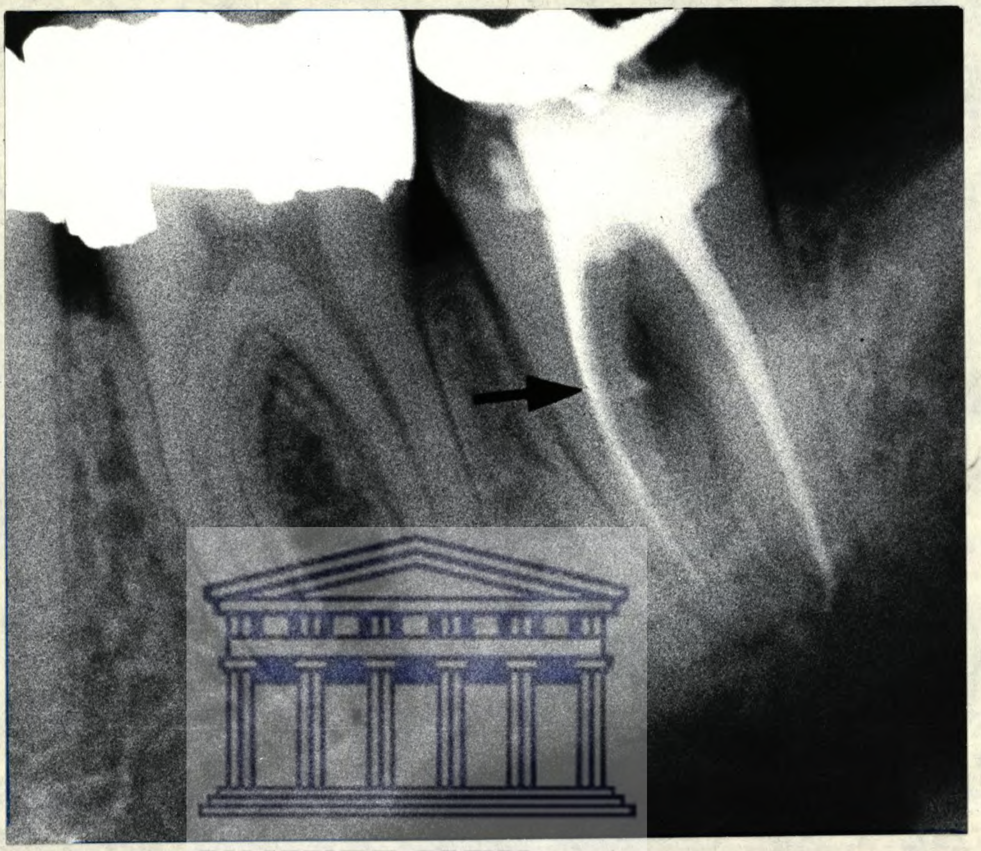

fig. 10. Lateral condensation gutta-percha technique with a filled lateral canal in the furcation lesion.

Ingle et al (1976) states that there is essentially no difference in the lateral condensation technique as used in straight or curved canals, but the main difference lies in the preparation form. A telescoping or step-back technique as described by Ingle et al (1976) as well as Weine (1976), should be employed for curved canals.

Allison, Weber and Walton (1979) in a study on the effect of canal preparation on the quality of the seal achieved, concluded that the step-back technique which allows for maximum spreader penetration showed minimal microleakage. They found a direct relationship between the depth to which the spreader could penetrate and the seal achieved in each case.

Seltzer, Bender and Turkenkopf (1963) did a study on almost 3 000 teeth concerning the factors that might influence successful repair after endodontic therapy. Among their findings the fact emerged that the lateral condensation technique yielded slightly better results than the single cone technique, however, the difference was not statistically significant.

Russen et al (1980) cites a survey among graduate endodontic prac= titioners and found that the majority preferred the gutta-percha lateral condensation technique for obturating root canals.

10.2. Gutta-percha vertical condensation technique

The vertical condensation technique was employed by 32 (10,3%) of the respondents to the questionnaire (addendum 1).

The rationale for using this technique with gutta-percha according to Schilder (1967), is that it provides a root canal filling that is inert, dimensionally stable, homogeneous and physiologically acceptable. While in the plasticised phase the material can be manipulated to form a permanent cast of the internal configuration of the prepared root canal. The technique also provides a very dense apical filling and yields the highest number of accessary or lateral canals being obturated by any method employed at that time.

Nicholls (1977) maintains that the vertical condensation technique is very useful in obturating a canal in which a ledge has been formed during enlargement.

Vertical condensation techniques are described by various authors with small practical modifications viz. Schilder (1967), Bence (1976), Ingle et al (1976), Weine (1976), Grossman (1978) and Cohen et al (1980).

The preparation form required for this technique is very critical for optimum success. A continuous tapering preparation that flows with the shape of the original canal and especially a definitive apical matrix to offer resistance to the condensed gutta-percha and prevent overfilling is essential, according to Grossman (1978).

Ingle et al (1976) maintains that the access preparation and flaring of the canal should be sufficient to accommodate the rigid pluggers used for vertical condensation. From a prosthodontic viewpoint Strating (1979) is of the opinion that such teeth are sometimes unnecessarily structurally weakened and complicate the eventual restorative phase.

A criticism often directed at this technique is that the heated gutta-percha will shrink upon cooling. Schilder (1967) maintains that although molten gutta-percha does contract upon cooling, at no stage in the vertical condensation technique will the apical end of the gutta-percha be in contact with the heated instrument. The gutta-percha is not liquefied and is softened only by the proximity of the heat source.

10.3. The single-cone gutta-percha technique

The single-cone gutta-percha technique was employed by 67 (21,5%) of the respondents to the questionnaire (addendum 1).

The actual technique is described by Nicholls (1976) and Grossman (1978). According to Nicholls (1976) this technique is intended for use in narrow canals in both mesio-distal and bucco-lingual dimensions. The canal should be prepared entirely with reamers to a standardised size into which a standardised gutta-percha cone should fit fairly closely for most of the prepared length.

An interesting variation of the single-cone gutta-percha technique is sometimes necessary to obturate a tooth of which the prepared canal is too wide to be completely obturated by the available standardised sizes. Cohen et al (1980) describes a method whereby a customised gutta-percha cone can be fabricated to fit such a canal. Several gutta-percha cones are warmed over a flame and rolled into one large cone. This cone is now customised with chloroform solution to the shape of the prepared canal. The "tailor-made" cone is then cemented into the canal as a single cone or lateral condensation with additional cones may be performed. Naudé (1979) found this technique especially useful when endodontic therapy is necessary on the teeth of animals e.g. a canine of a dog of which the pulp has been traumatically exposed.

A further variation of the single-cone gutta-percha obturating technique is the sectional method (not to be confused with the sectional vertical condensation technique), where an apically fitting section of gutta-percha is customised to fit that por= tion of the canal. The apical section is then cemented and condensed, with the rest of the canal space available for a post retained restoration. Thé (1979) describes a sectional gutta-percha obturating technique to overcome the problem of too little sealer reaching the apex, or on the other hand, sealer being extruded periapically by the master cone. With this technique a well fitting section of gutta-percha is con= densed against an apical matrix without any cement being uti= lised. A second apical seal is then created just coronally of the gutta-percha with a cement sealer, which is in turn conden= sed. The third part of the canal is only coated with sealer to facilitate a post-retained restoration.

Combinations of various obturating techniques may also be neces= sary in selected cases. In fig. 11 a mandibular second premolar with branching of the canal in the apical part of the root can be seen. This tooth was in need of endodontic treatment and one canal was prepared and obturated utilising a sectional single-cone gutta-percha technique, following which the other canal and coronal part was prepared and filled utilising the gutta-percha lateral condensation technique.

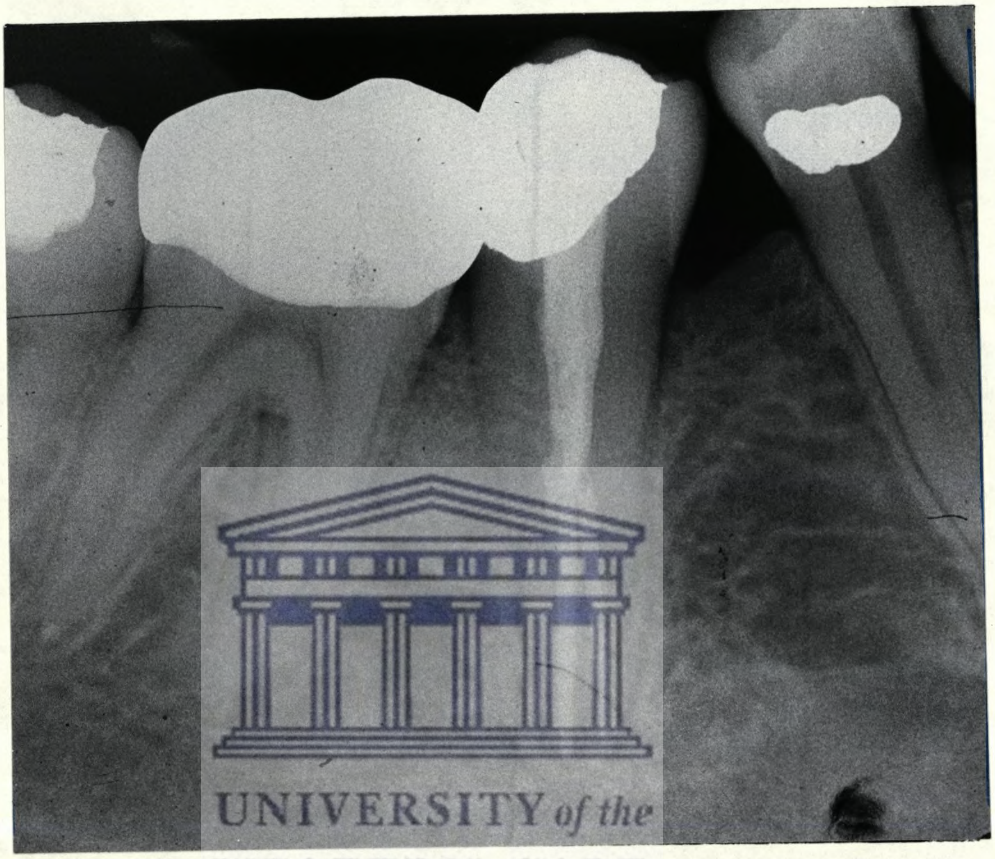

fig. 11. Obturation with a sectional gutta-percha cone and the lateral condensation technique.

10.4. Gutta-percha with solvents

Harty (1976) mentions that various solvents can be used to make gutta-percha more pliable in order to adapt it to the irregular shape of a prepared root canal space. Chloroform, eucalyptus oil and xylol can be used as solvents of the gutta-percha.

Harty (1976) further mentions that the technique employing gutta-percha was first advocated by Callahan in 1914 and modified by Johnston in 1927. A later modification of the technique by Nygaard-Østby is mentioned by Schilder (1967).

The obturating technique for these solvent materials is de= scribed by various authors, viz. Grossman (1978) and Cohen et al (1980).

The advantages of this technique according to Grossman (1978) are that a better adaptation of the gutta-percha to the canal wall is obtained and lateral canals are often filled during this technique. Special indications for the solvent technique accor= ding to Weine (1976) are found when ledge formation or perfora= tion occurs during root canal preparation. Cohen et al (1980) further advises the use of this obturating technique for severely curved canals that cannot be negotiated easily with root canal instruments. They advise that enlargement to a size 25 or 30 file is usually sufficient for this technique.

The disadvantages of this technique are essentially those of the solvent material which was discussed in chapter 7 (7.4.). Cohen et al (1980) advises that great care must be exercised during condensation because the freshly mixed paste is very toxic before evaporation.

Coviello, Brilliant and Wright (1977) did a preliminary study with a scanning electron microscope of three variations of the lateral condensation technique. They employed a conventional technique with gutta-percha and sealer as well as gutta-percha and chloro= sin in conjunction with and without a sealer. Although some specimens were damaged the authors concluded that with all three techniques the voids in the canal were partially filled and the techniques would provide a fairly complete obturation of the prepared root canal space.

Luks (1974) describes a combination gutta-percha technique where the initial cone is customised with chloroform, followed by lateral condensation and eventually vertical condensation of the obturating mass. He does not advise heating of the gutta-percha in the third phase and maintains that should one feel compelled to heat a root canal instrument it should be done in a glass-bead steriliser.

Russen et al (1980) did a study to compare the seal of laterally condensed gutta-percha and chloroform to lateral condensation of the same material with a cement sealer. They found a statis= tically significant better seal with the latter technique. In conclusion they postulated that the solution to better obturation of a root canal might be in a combination technique whereby the master cone is customised with chloroform, removed to dry and then used in conjunction with a sealer and a lateral condensation technique.

10.5. Thermoplasticised gutta-percha techniques

The vertical condensation method of obturating a root canal as advocated by Schilder (1967) is the most well-known and used thermoplasticised technique. (See 10.2.)

Three new and interesting techniques based on thermoplasticised gutta-percha have been put forward.

Yee et al (1977) did a preliminary study on the feasibility of using thermoplasticised gutta-percha in a pressure syringe to obtain three-dimensional obturation of the prepared root canal. The experiment was conducted in vitro with gutta-percha in the pressure syringe being plasticised by placing it in a glycerine bath at 160^{o}C. The temperature of the molten gutta-percha was however, much lower and should be tolerable to the oral mucosa or periodontal ligament. Their results indicate that an effec= tive root canal filling can be achieved by this method with the advantage of using a pressure syringe providing an easy method of introducing a material into the canal and thus saving time for the endodontic practitioner.

Johnson (1978) describes a technique whereby the fitting of a master cone, which is a skilful operation, is greatly eliminated. An adequate canal preparation is essential to allow unobstructed access of instruments and a step-back preparation technique is advised. A stainless steel file of which the flutes have been removed is used as a carrier for the thermoplasticised gutta-percha. The smoothened file is notched at the desired length, covered with gutta-percha and heated in a flame until it glistens. The file with the soft gutta-percha is then placed in the cement-coated canal and severed at the notch. Vertical pressure is now applied with a lubricated rubber stop and pluggers. Johnson (1978) states that this technique ensures a three-dimensional obturation of the root canal without the need of fitting a master cone or any other special skills. The author is of the opinion that fitting a master cone with the help of standardised instruments and gutta-percha points might be quicker than the abovementioned technique.

Cohen et al (1980) describes the technique recently introduced by McSpadden. The principle of the technique is one of thermo=mechanical condensation whereby heat is delivered to a condensing instrument by means of a controlled heat collar around the con=denser. The mechanical phase is accomplished by the condensing instrument which resembles a Hedström file with inverted blades. With the up and down movement of the mechanical compactor, the gutta-percha in contact with the heated shaft is softened and condensed in a vertical and lateral fashion. In large canals no heat is needed and the mechanical phase is sufficient to accom=plish complete obturation. Overfilling is controlled by control=ling the depth of penetration of the compacting instrument.

Cohen et al (1980) concludes that although no independent studies had been done at that time the technique appears to be effective and several advantages to the practitioner and patient will be gained by this technique.

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CHAPTER 11

SOLID CORE OBTURATING TECHNIQUES

The most popular of the solid core obturating techniques is the silver cone technique, either as a single cone or as a sectional (split cone) technique. Other techniques or materials that may be included in this category are vitallium cones in the endodontic implant technique; stain= less steel files in extremely narrow canals; titanium cones as an alter= native to silver cones and cast metal dowels to obturate the entire canal space. Apical silver or titanium tips are commercially available* and are designed to improve the placement of the apical portion in a sec= tional obturating technique.

In reply to the questionnaire (addendum 1) (18,6%) of the respondents indicated that they use the silver cone obturating technique.

This technique is described by various authors notably Schilder (1967), Bence (1976), Ingle and Beveridge (1976), Nicholls (1977), Grossman (1978), and Cohen and Burns (1980). Ingle et al (1976) further gives a detailed description of the endodontic implant technique.

The principal indication for the use of the silver cone obturating technique is when a root canal is very narrow in a mesio-distal and bucco-lingual dimension or the canal is very tortuous as is shown in fig. 12.

* P.D. Apical Silver tips, Vevey, Switzerland.

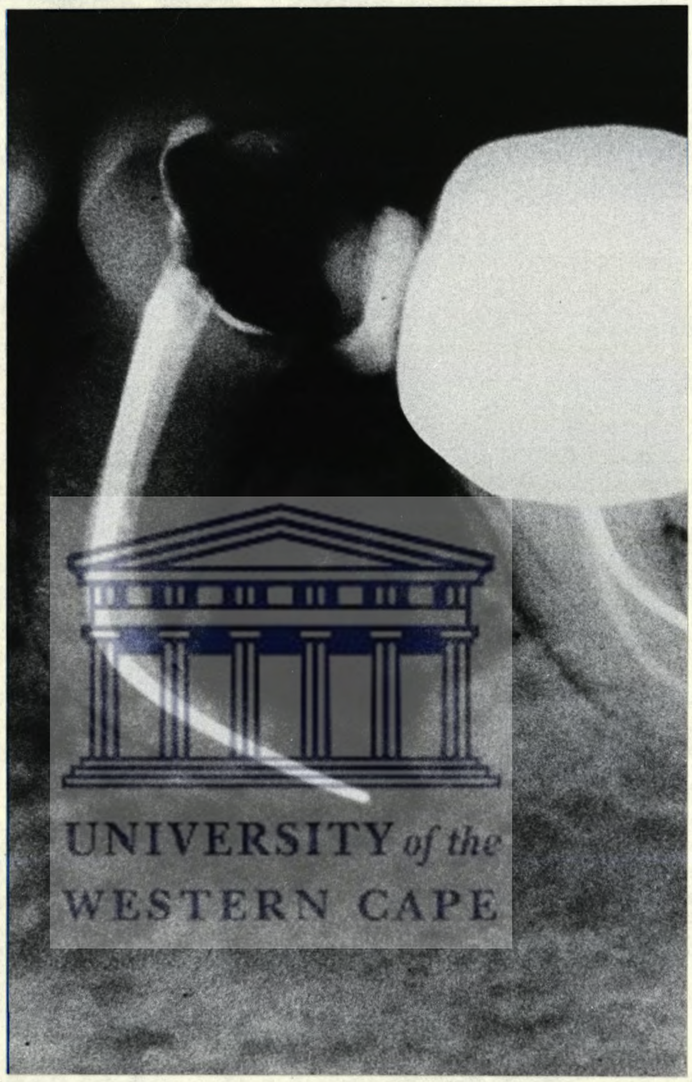

fig. 12. Silver cone technique in a severely curved canal. (Courtesy Dr. G. Strijdom.)

Harty (1976) states that the technique can be used in conjunction with a gutta-percha lateral condensation technique where the silver cone is used as an incompressible master point. He further mentions that the silver cone is not a true obturating material but only acts as a "spreader" for the cementing medium.

Schilder (1967) states that although the technique is advocated for narrow and curved canals, the canals have to be shaped and enlarged. The preparation required for the silver cone should correspond to the diameter and taper of the silver cone and according to him this is a difficult task even in experienced hands. The apical portion of such a canal may become round but with an elliptical or "tear-drop" shaped foramen. Cohen et al (1980) emphasises the fact that a round apical preparation should be developed for this obturating technique and the apical seal should not be dependent on the use of a root canal cement or the "compressibility" of silver and dentine. Luks (1974) describes this technique whereby engineering precision must be obtained by means of a dentist operating a root canal instrument in any sort of canal, as a "folly". He vehemently discusses the negative aspects of both the material and technique with the conclusion that "patients are entitled to receive a dependable service and not a compromise based solely on the operator's capabilities."

In an effort to improve the sealing ability of silver cones, Cassidy and Gregory (1969) undertook an interesting study whereby a chilled silver cone was employed as an obturation material. The rationale of this technique is that during chilling (-60^{o}C) the silver cone contracts and with subsequent warming to body temperature it should expand against the root canal walls and provide an adequate apical seal. They do not fore= see any chance of this technique causing a root fracture due to the expansion.

Ingle et al (1976) mentions the special cases where this technique could be indicated. In teeth with "mature" canals and an associated loss of constriction at the apex the silver cone technique could be used in the same fashion as a cork is used to close a bottle.

Nicholls (1977) indicated that the sectional filling technique could be used when a post retained restoration is planned for a particular tooth. An example of such a filling can be seen in fig. 13.

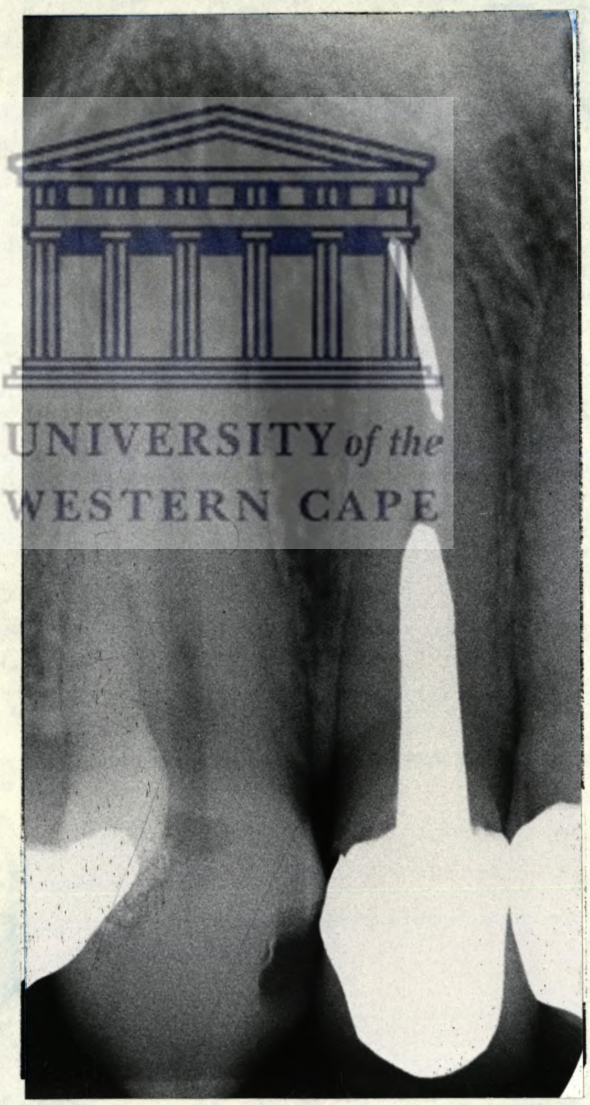

fig. 13. Post-core restoration on sectional silver cone obturation.

Nicholls (1977) does however, mention two potential drawbacks of this technique. Although unlikely, it may happen that during preparation of the post crown, salivary contamination via a lateral canal in the unfilled root may reach the periodontium and cause a lesion. A second and more valid complication may happen during the dowel preparation where the apical seal may be disturbed by the rotary instruments.

Another disadvantage of the sectional technique according to Nicholls (1977) is that should the root canal treatment fail, removal of the apical portion to re-treat the canal non-surgically is not possible. This renders the tooth liable to either an extraction or periapical surgery. In fig. 14 an example of such a case can be observed.

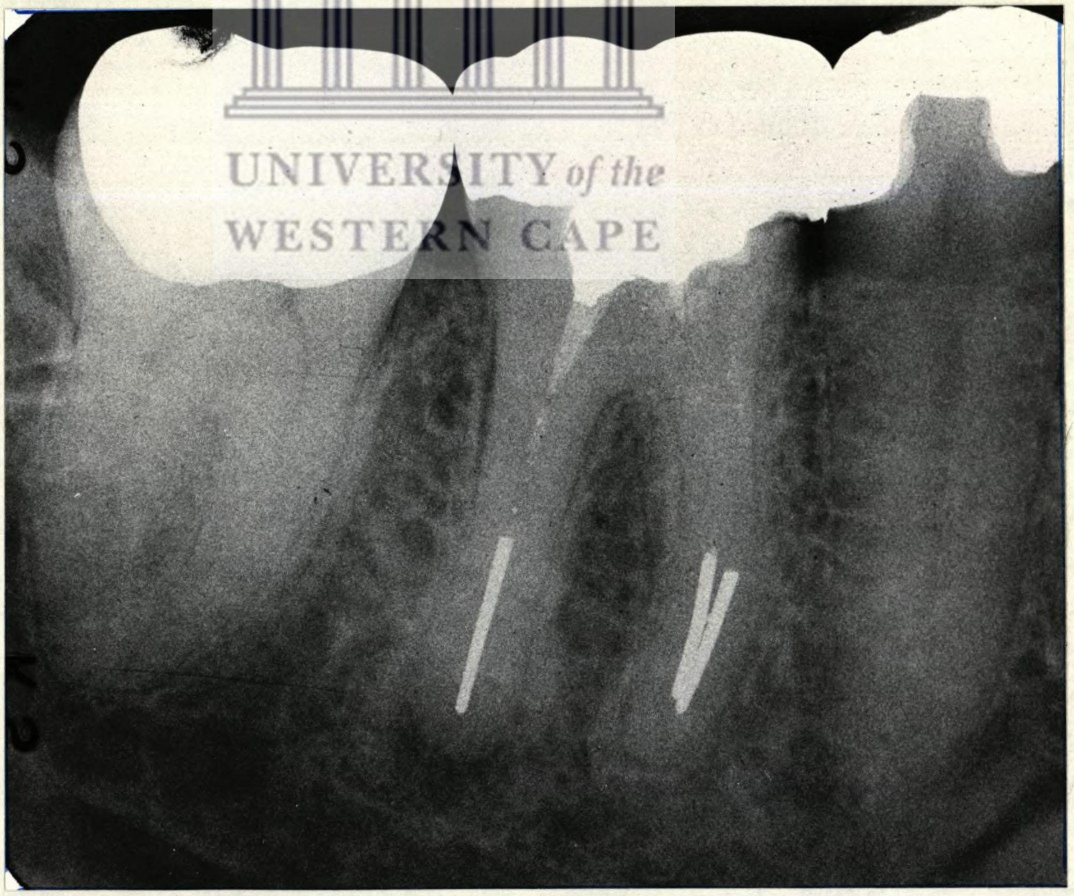

fig. 14. Sectional silver cones with a periapical lesion 10 years post-operatively.

Ehrmann and Feiglin (1980) advocates an obturating technique to overcome the problem of a short root that has to retain a post crown. They describe a method whereby the whole canal is obturated with a cast dowel and a cementing medium. A surgical flap procedure is also done at the cementing phase to remove any excess cement and curette the periapical area if necessary.

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CHAPTER 12

OBTURATING TECHNIQUES EMPLOYING PASTE MATERIALS

Two discernible obturating techniques could be found in this category, viz. a technique in which the paste material is placed into the canal by means of a Lentulo spiral filler and secondly, in techniques where a specialised device such as a pressure syringe is used to introduce the obturating material.

In reply to the questionnaire (addendum 1) 40 respondents (12,8%) indi= cated the use of the paste obturating technique with an additional 2 dentists (0,6%) indicating the use of a pressure syringe.

The conventional paste obturating technique is described by Weine (1976), Ingle and Beveridge (1976), and Cohen and Burns (1980). The injection technique is described by various authors, notably Greenberg (1963), Krakow and Berk (1965), Goerig and Seymour (1974), Kessler (1980), and Cohen and Burns (1980).

Greenberg (1963) wrote a very enthusiastic report on the pressure syringe and advocated its use in all endodontic obturation procedures. He main= tained that the technique would be especially useful in "blunderbuss" canals and extremely fine and curbed canals. No mention is made on how any possible overfilling should be controlled.

Krakow and Berk (1965) gives a detailed description of the different uses of the pressure syringe. The main advantage of this technique lies in the fact that the obturating material can be easily and rapidly intro= duced into the prepared canal. A disadvantage seen by them is that the material may be difficult to remove should this prove necessary and should be kept in mind when a post retained restoration is anticipated, as is shown in fig. 15. The author is of the opinion that this technique should prove very valuable in pedodontic endodontics where a resorbable material is indicated and limited overfilling is not such a serious complication.

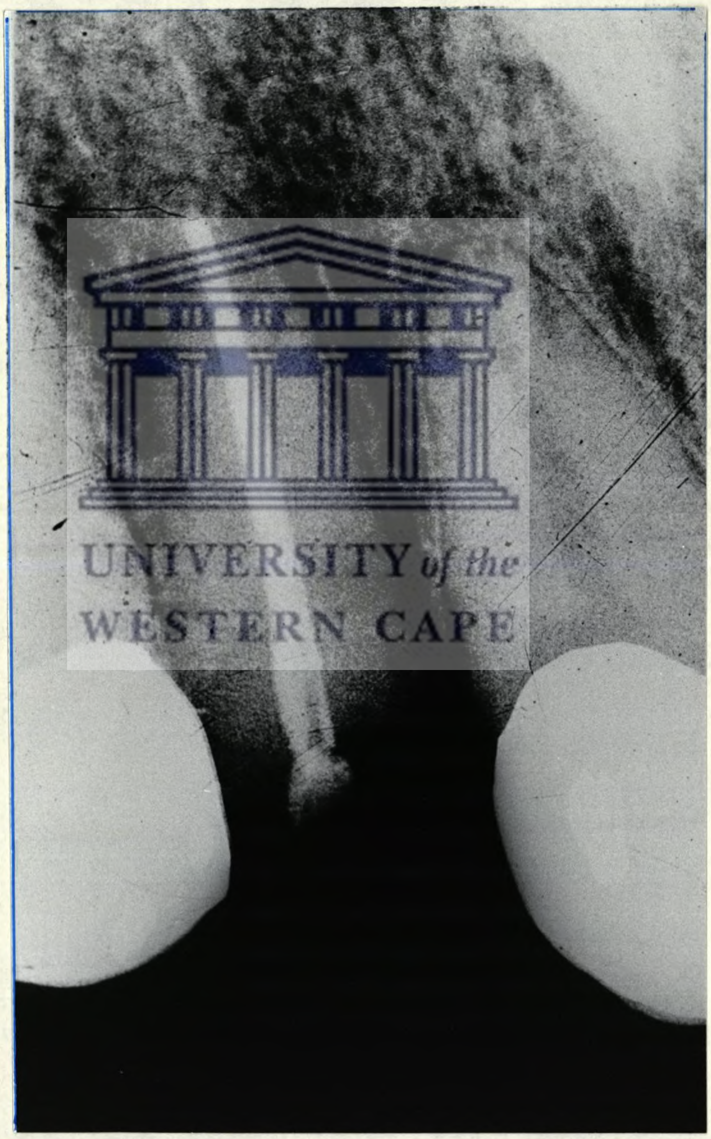

fig. 15. Pulpless tooth obturated with a pressure syringe technique*. (Courtesy Dr. W. Schwartz.)

* Pulpdent Corp., Boston, U.S.A.

Weine (1976) indicates that a paste filling technique is sometimes in= dicated when apexification is induced and the filling should be seen as an intermediate one. Furthermore, he finds it a difficult concept to grasp that a creamy paste material can possibly obliterate a canal to the same extent as a solid (or semi-solid) core material in conjunction with a sealer. Pastes tend to look impressive on radiographs but it should be remembered that the picture is only two-dimensional and the actual obturation in three dimensions cannot be evaluated.

Overfilling is generally advocated when using a resorbable paste e.g. Kri paste, with the objective of inducing periapical repair to any damaged tissues according to Grossman (1978).

Cohen et al (1980) sees the control of excessive overfilling as a diffi= cult task when exploying a pressure syringe technique. As is the case with any overfilling of a root canal, according to Ingle et al (1976) the patient is bound to experience discomfort and the pain may even be excruciating.

Pyner (1980) cites a case report where paresthesia of the area supplied by the inferior alveolar nerve was caused by overfilling with a pressure syringe technique using Hydron as obturating material. The difficulty in controlling the apical termination with this technique in conjunction with the fact that the area was anaesthetised at that visit is given as possible causes for the overfilling.

Friedman, Pitts and Natkin (1979) in an article on formaldehyde pastes concludes that evidence of success on numerous cases of poorly debrided, prepared and filled canals are available with the use of any obturating material or technique. Furthermore, it is not probable that any obtu= rating material used in a careless and inadequate technique will give rise to such a high success rate that can be expected with meticulous debridement and obturation of the canal with the same material. Should a paste filling be implemented with an exacting technique it may "yield a fair number of success." However, the disadvantage of a paste obtu= rating technique in the sense of controllability and compactness of the material cannot be disguised.

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PART 4

CHAPTER 13

CONCLUSION

In the author's opinion successful endodontic therapy depends to a large extent on creating a favourable environment in a pulpless tooth, to allow the body to repair the damage done. Previously, equal em= phasis was placed on biomechanical preparation, sterilisation and total obturation of the root canal in order to achieve success in root canal therapy according to Schilder (1967) and Grossman (1978). Although this viewpoint is not incorrect, the author is of the opinion that thorough canal debridement or biomechanical preparation is the princi= pal factor to ensure success in any endodontic technique. It is not the material with which the canal is filled, but rather the contents which are removed from it that is of utmost importance. Schnell (1978) maintains that even if the canal is not totally obturated by the mate= rial or technique employed, it is still likely that repair and healing can occur. There is probably a critical leakage limit beyond which healing cannot take place.

The correctness of the assumption made by the author, that a wide variety of obturating materials and techniques are being used in current endo= dontic therapy is clearly evident, as can be seen in the data obtained in the survey. (Refer to chapter 3.)

The question as to why such a variety exists can only be answered hypo= thetically at this stage. The ideal obturating material or technique is as yet not available to the dental profession. All available obtura= ting materials and techniques have certain deficiencies according to the literature reviewed. Some of these materials and techniques are undoubtedly more successful than others. Ingle and Beveridge (1976) is still hoping for a "dream" material that will become a reality. Should this event materialise, all the potentially harmful obturating materials will be abandoned and tedious obturating techniques that have "plagued" the dental profession for so long will be eliminated.

The use of solid core obturating materials and techniques remained constant among the respondents during the whole period covered by this survey. In the opinion of the author the use of silver cones in obturating techniques will decline as more practitioners become aware of the biologic principles involved in endodontic therapy. A material that produces an acceptable radiographic picture does not imply that the root canal is three-dimensionally obturated. There will however, be certain selected cases where these materials and techniques will be indicated. Grossman (1978) states that he is aware of the shortcomings of silver cones and prefers to use gutta-percha wherever possible.

The semi-solid core obturating materials and techniques proved to be the most popular among the respondents. From the evidence gathered in the literature this material was well tolerated and proven as a root canal filling. Most of the gutta-percha techniques seem to have yielded acceptable results. In the author's opinion it is to a large extent the familiarity and proficiency of each clinician with a particular techni= que that is important. This expertise of the clinician cannot be bet= tered by an indifferent attempt with a "better" technique. In the author's opinion the combination technique of chloropercha customising of the master cone, lateral condensation of the prepared space in con= junction with an acceptable sealer, followed by vertical condensation with a blunt plugger might become the technique of choice in future.

The use of paste materials as the sole obturating medium should be discouraged in view of the negative comments drawn by a large number of authors as was noted in chapter 7. Cohen and Burns (1980) state that paraformaldehyde containing pastes (N2) "has essentially been banned in a number of countries, in California, and in several branches of the U.S. Armed Forces."

The author is in agreement with the majority of authors that the use of the paste materials cannot be recommended in view of the inconclu= sive and pseudo-scientific explanations offered by their proponents.

The plastic materials that are currently being developed (especially Hydron) does hold a promise for the future but the author still has some reservations in propagating their usage in all endodontic cases.

The implications of this study on the Endodontic curriculum (concerning root canal obturation) of the Dental Faculty of the University of Stellenbosch are as follows:

1. The gutta-percha lateral condensation technique will be taught and advocated for utilisation in most of the teeth in need of root canal therapy. Any improvements on the technique will be brought to the attention of the students.

2. The silver cone technique will be demonstrated and used to a limited extent when a definite indication prevails. Students will be versed in the factors that make this technique and material a risk in routine root canal therapy.

3. The use of a suitable cement sealer will be propagated in the obturation of a prepared root canal. Zinc oxide-eugenol or proprietary brand names with the same basic ingredients will be advocated as an acceptable cementing medium. Attention will be given to the expected properties of each cement available and will be included in didactic instructions.

4. Because of the large number of proponents of paraformaldehyde containing cements (Endométhasone) in use, students will be well versed in all aspects concerning these materials. This has been neglected in the present curriculum. However, the technique for using the material will be described to the students in order to ensure that should such a student upon graduation, feel compelled to use these materials, they will not be ignorant of the material or technique.

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ADDENDUM 1

(Sien keersy vir Afrikaans)

DEPARTMENT OF RESTORATIVE DENTISTRY : UNIVERSITY OF STELLENBOSCH

ENDODONTIC QUESTIONNAIRE

THE QUESTIONNAIRE IS STRICTLY CONFIDENTIAL. THERE ARE NO CORRECT OR INCORRECT ANSWERS.

Dear Colleague,

This questionnaire will take about 5 minutes of your time. It's purpose is to establish a correlation between pregraduate endodontic training and the situation in practice. Would you kindly complete this questionnaire and return it in the pre-paid envelope.
Thank you very much for your cooperation.

JOHAN VENTER.

1. Do you like doing root canal therapy? Yes ☐ No ☐
2. Do you treat only SINGLE-ROOTED teeth ☐ or MULTI-ROOTED teeth as well ☐
3. On average, how many visits do you spend on a root canal treatment?
   one ☐ two ☐ three ☐ more than three ☐
4. Do you use RUBBER-DAM during root canal therapy?
   never ☐ occasionally ☐ routinely ☐
5. Which one or more of the following INSTRUMENTS do you use for root canal preparation?
   Giromatic ☐ H-files (Hedstrom/Rat Tail) ☐ K-files ☐ Reamers ☐
6. How many RADIOGRAPHS do you usually take during root canal therapy?
   one ☐ two ☐ three or more ☐ none ☐
7. Do you employ any CHELATING AGENTS during root canal therapy?
   none ☐ Calcinase ☐ Largal-Ultra ☐ RC/Endoprep ☐ other ....
8. Which one or more of the following liquids do you use for IRRIGATION during root canal therapy?
   Saline ☐ Distilled water ☐ Sodium Hypochlorite ☐ Hydrogen Peroxide ☐ other ....
9. Do you employ any INTRACANAL MEDICATION between visits? none ☐ Cresatin (metacresyl acetate) ☐
   Cresophene ☐ CMCP ☐ Formocresol (T.C.F.) ☐ Ledermix ☐ other ....
10. Do you take a BACTERIOLOGICAL SPECIMEN (culture) of the root canal under treatment?
    routinely ☐ occasionally ☐ never ☐
11. Which of the following root canal FILLING TECHNIQUES do you use? Chloropercha ☐ Pressure Syringe (Hydron) ☐
    Gutta Percha (G.P.) single point ☐ G.P. + lateral condensation ☐ G.P. + vertical condensation (heat) ☐
    Paste (Biocalex, $Ca(OH)_2$, Kri, Sargenti/N_2) ☐ Silver Point ☐ other ....
12. Which one or more of the following CEMENTS do you use in root canal therapy? AH26 ☐ Biocalex ☐
    Diaket ☐ Endomethazone ☐ Grossman ☐ Kerr's Pulp Canal Sealer/Tubliseal ☐ Kri ☐
    Rieblers ☐ Roth ☐ Sargenti/N_2 ☐ Zinc Oxide + Eugenol ☐ Spad ☐ other ....
13. How close to the APEX do you usually fill a root canal?
    to the apex ☐ ½ mm short ☐ 1 mm short ☐ 2 mm short ☐ 3 mm or more short ☐
14. Do you do any ENDODONTIC SURGERY (e.g. apicectomy) when indicated?
    never ☐ occasionally ☐ routinely ☐ refer patient ☐
15. Do you FOLLOW UP root treatment cases?
    never ☐ for 6 months ☐ for 1 year ☐ 2 years plus ☐
16. When did you qualify as a dentist?
    Pre 1950 ☐ 1950-1959 ☐ 1960-1969 ☐ 1970 onwards ☐
17. Do you do any BLEACHING of discoloured teeth?
    never ☐ occasionally ☐ often ☐
18. How do you keep abreast of the latest developments in Endodontics?
    Refresher courses ☐ Lectures ☐
    Literature - please quote journals.

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SUMMARY

A review of current root canal obturating materials and obturation techniques was undertaken. This was prompted by the wide variety of the materials and techniques currently being used in the Western Cape. A questionnaire was circulated to 320 members of the Cape (Western) Branch of the D.A.S.A. A viable return of 54,43% was received and this data was studied to determine the pattern of usage of the different materials and techniques in the sample area.

Gutta-percha proved to be the most popular obturating material (64,4%) and the gutta-percha lateral condensation technique was indicated by 32,7% of the respondents as being used by them.

The cement sealer employed by most respondents was Endométhasone (38,2%), followed by Riebler's paste (17,3%) and zinc oxide-eugenol (12,5%). This is contrary to the current teaching at the Dental Faculty of the University of Stellenbosch.

An extensive review of the literature on obturating materials and techniques was undertaken with consideration to the composition and the physical, chemical and sealing properties of the materials being given. Adverse tissue reactions caused by the different materials were reviewed as were any peculiarities of the root canal obturation technique. The expected success or failure rates of relevant techniques were considered as well as their advantages and disadvantages.

In conclusion certain recommendations as to viable changes to the present endodontic curriculum of the Dental Faculty, University of Stellenbosch are made, based on information revealed by this study.

OPSOMMING

'n Oorsig oor hedendaagse wortelkanaalvullingsmateriale en vullings=tegnieke is onderneem. Die omstandigheid dat so 'n groot verskeiden=heid vullingsmateriale en -tegnieke tans in gebruik is in die Wes-Kaaplandse streek het tot die studie aanleiding gegee. 'n Vraelys is aan 320 lede van die Tak-Weskaapland van die T.V.S.A. gestuur, waarvan 54,43% positief gereageer het. Hierdie data is bestudeer om die ten=dens van die gebruik van die verskillende vullingsmateriale en -tegnieke vir die betrokke gebied vas te stel.

Gutta-percha is blykbaar die gewildste vullingsmateriaal (64,4%), terwyl 32,7% van die respondente aangetoon het dat hulle die gutta-percha met laterale kondensasietegniek gebruik.

Die wortelkanaalsement wat deur die meeste respondente gebruik is, is Endométhasone (38,2%). Riebler se pasta (17,3%) en sinkoksied-eugenol=sement (12,5%) is onderskeidelik tweede en derde mees algemeen in ge=bruik. Hierdie gegewens is nie in ooreenstemming met die huidige on=derrig aan die Fakulteit Tandheelkunde van die Universiteit van Stellenbosch nie.

'n Omvattende literatuuroorsig wat beide wortelkanaalvullingsmateriale en -tegnieke dek, is onderneem. Spesiale aandag is aan fisiese, chemiese en verseëlingseienskappe van die betrokke materiale gegee. Daar is gewys op skadelike weefselreaksies wat moontlik deur die

materiale veroorsaak kan word. Sommige afwykings in die wortelkanaal=vullingstegnieke sowel as die verwagte suksesse en mislukkings, voor- en nadele is ook behandel.

As slotsom is sekere veranderinge in die huidige Endodonsie kurrikulum van die Fakulteit Tandheelkunde, Universiteit van Stellenbosch voor=gestel.