Chapter 1

Introduction

The manipulations necessary for endodontic treatment are delicate and meticulous yet however skilfully and conscientiously these are carried out they are always accompanied by the risk of causing minor or even major health damage due to so-called "iatrogenic errors". The sequence of interdependent steps characteristic of an endodontic treatment may be interrupted, or even fail, at any time or stage of the process due to iatrogenic error. These procedural errors, may in mild cases, merely complicate conservative root canal treatment or simply affect its prognosis, imposing the necessity for periodic clinical and radiographic follow-up examinations (Fig 1.1, 1.2 and 1.3). In more serious cases, however, such damage may eventually lead to surgical endodontics (Fig 1.4) or even to tooth extraction.

Iatrogenic errors during endodontic treatment usually affect dental and / or periodontal tissues. In some cases, however, they may implicate organs quite remote from the oral cavity such as in accidents involving swallowing or inhaling an instrument or in cases of emphysema. Some of these errors occur relatively frequently and they will be described in the

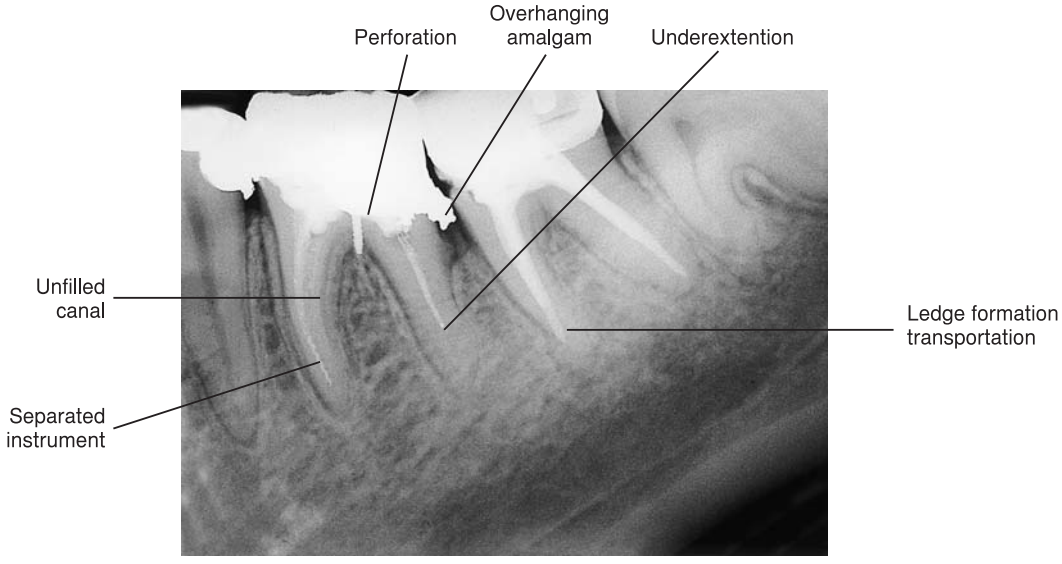

Fig. 1.1. Several iatrogenic errors.

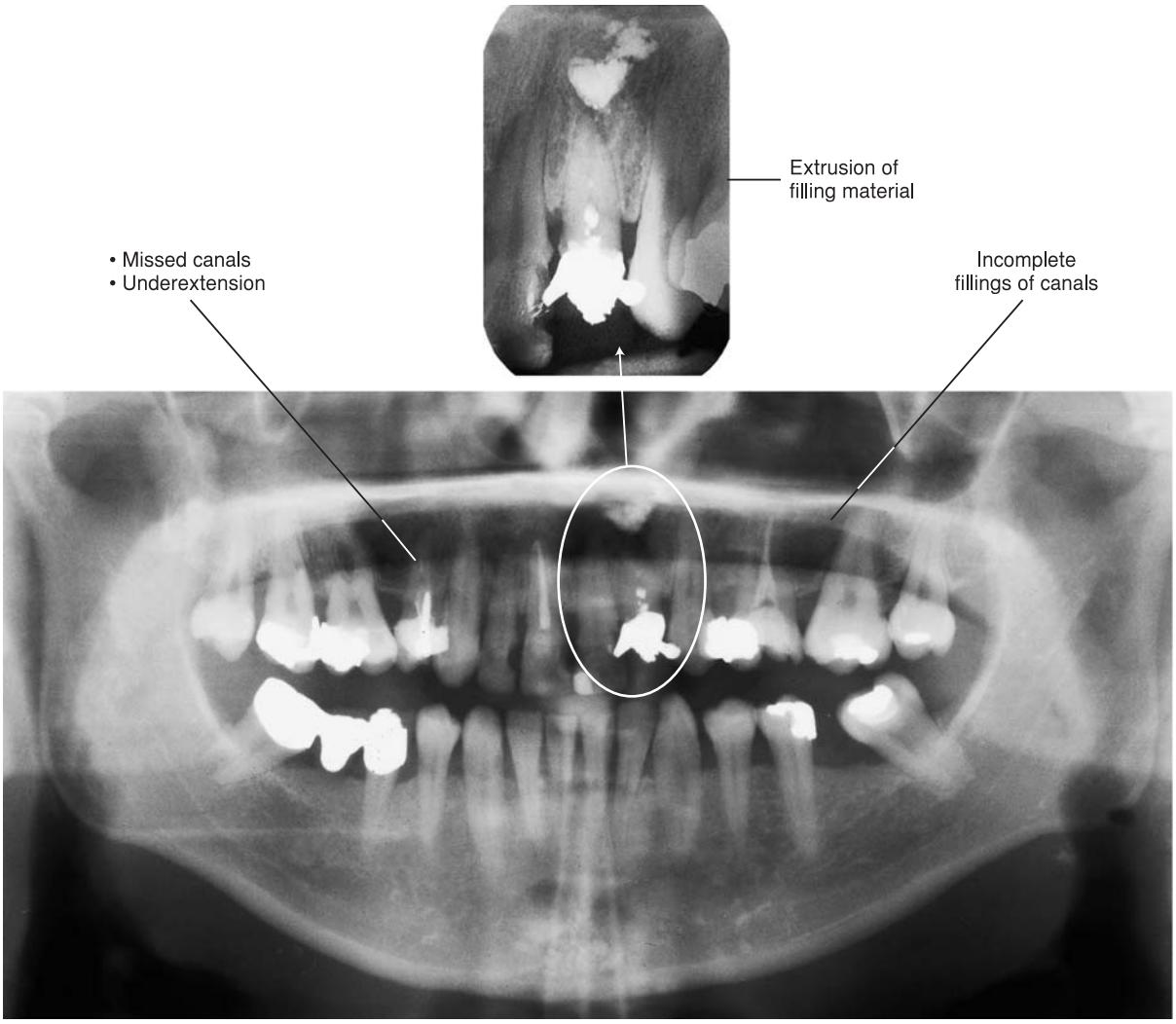

Fig. 1.2. Unfilled-incompletely filled canals and extrusion of filling material into the periapical region.

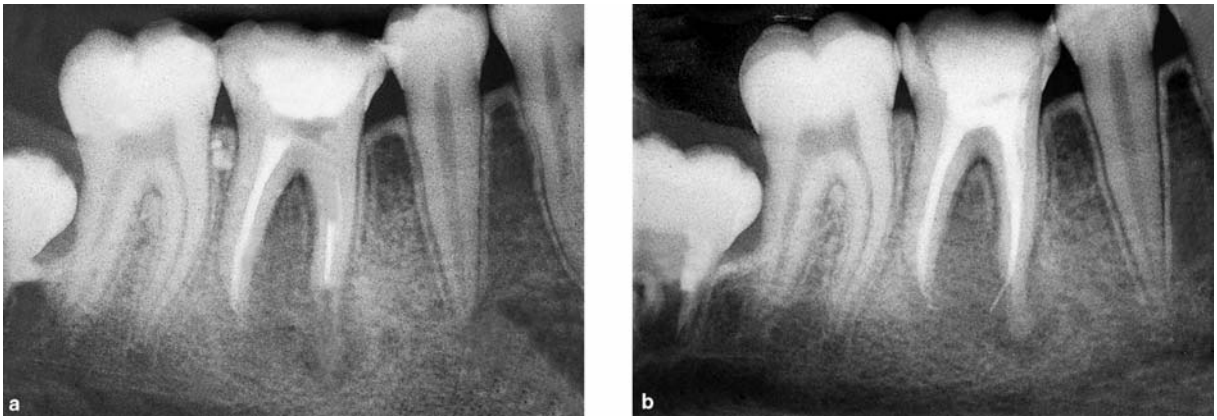

Fig. 1.3. Mettalic foreign object into root canal. *Separated spreader (a). Immediate post-obturation radiograph (b). Fragment was bypassed. Note extrusion of guttapercha cone into the periapical area.*

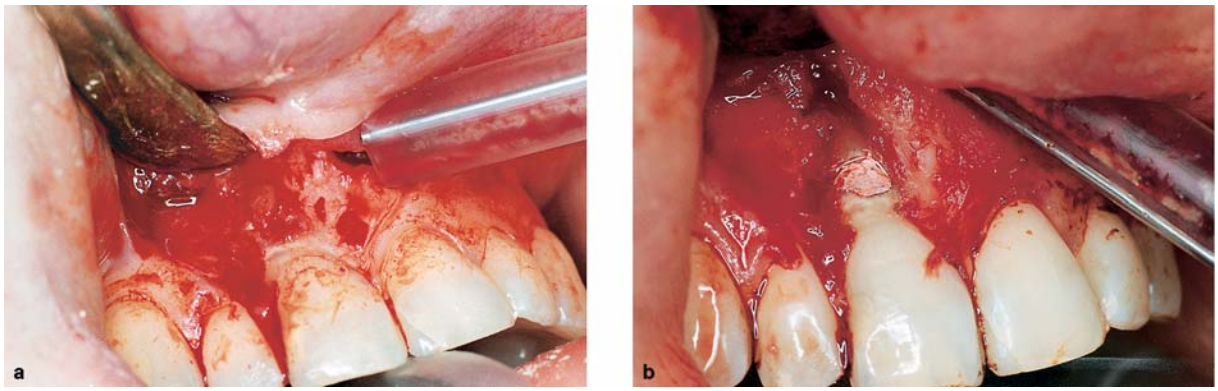

Fig. 1.4. Surgical treatment of iatrogenic error. *Perforated area (a) was sealed with injection of thermoplasticized gutta-percha (b).*

text with special emphasis on their commonest causes, diagnosis, treatment, influence on prognosis, and finally their prevention. The structure of this book, as in most clinically oriented endodontic literature, follows the principle that endodontic therapy is a standardised and predetermined step-by-step procedure. It is necessary, however, prior to the main description, to outline the basic steps of endodontic treatment in relation to the most frequent risk factors that may be present at each stage. For this purpose, the standard endodontic process is presented in an outline which associates each stage of treatment with the commonest risk factors. The main concept is to promote the idea that "each step of the endodontic procedure is equally vulnerable and susceptible to iatrogenic error". Uncommon errors are also occasionally presented (Fig 1.5) In order to emphasise the truth of the statement, each endodontic stage is treated as a distinct "dental act" and the potential or commonest risk factors in each of them are described (Tables 1.1 and 1.2).

For the purposes of this presentation, the principal steps of endodontic treatment are defined as follows:

- Tooth isolation
- Access cavity preparation
- Working length determination
- Root canal instrumentation
- Root canal disinfection
- Temporary sealing of the access cavity
- Root canal obturation

A safe aseptic technique, apart from using sterilised instruments, also requires **tooth isolation** from the oral environment. The only safe method to this end is the use of a rubber dam. The placement of a rubber dam, however, entails the risk of causing iatrogenic damage (Tables 1.1 and 1.2), a risk that increases when the tooth under therapy is covered by a crown or it is part of a cantilever bridge. However, this potential risk certainly does not imply limited use of the rubber dam since its many

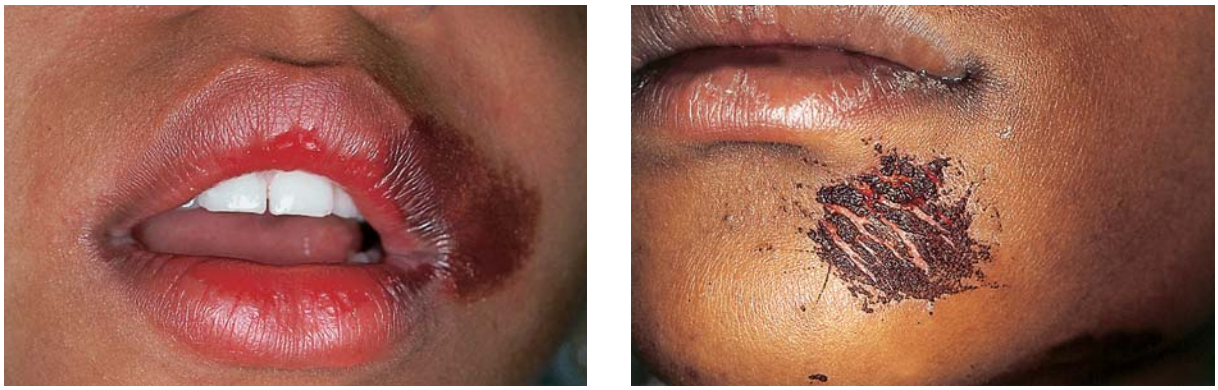

Fig. 1.5. Chemical injury. *On completing the treatment, after the removal of the rubber dam, the dentist aligned the patient's face with fingers that had previously squeezed the cotton pellet soaked in antiseptic (courtesy of Arapostathis K).*

advantages are well established and its application should be considered practically mandatory.

Access cavity preparation aims at giving direct access to the pulp chamber and root canals. The shape of the access cavity should be specifically designed for each tooth, since it has to be adjusted accordingly to each particular case. The shape of the pulp chamber, the number and location of canal orifices, the number and direction of root canals, as well as, individualities, including anomalies of the internal anatomy of the tooth should all be carefully considered in order to achieve the optimum configuration. On the other hand, aesthetic considerations, as well as the principle of limiting dental tissue loss only to what is absolutely necessary, should not be neglected. Modifications and adjustments of the so-called typical access cavity may be considered necessary since the objectives of access preparation are:

- Easy identification of the orifices of the root canals.
- Direct and unrestricted access of instruments to the apex.
- Creation of an appropriate shape and space for the temporary seal.
- Easy insertion of the filling materials and of the instruments utilised for the root canal obturation.

The crucial role of access cavity preparation is evident since, following diagnosis, it is the first stage of root canal treatment. An iatrogenic error at this stage regarding the position, shape, depth or extent of the cavity may determine the entire outcome of the treatment since it may lead on to additional iatrogenic errors, a kind of domino effect.

Upon completion of the access cavity preparation and before proceeding to root canal instrumentation, it is important to determine the **working length**. The accurate and precise determination of the root canal length is a key factor in the success of endodontic treatment. It is of paramount importance since it forms the basis of safe and successful instrumentation and obturation. Several methods have been proposed and used[3,4,15]. Some are either very time consuming or require the use of mathematical equations[6,38]. Others depend on the experience of the practitioner and on his tactile ability to feel the apical constriction through the endodontic instruments. This ability is enhanced when the coronal and middle third of the canal have been already instrumented. Finally, other length determination methods require the use of electronic devices. In order to characterise a method of length determination as satisfactory, it has to be accurate, easy-to-use, fast, and repeatable (see: Length determination methods. In: Chapter 8. Erroneous length instrumentation). A false length determination may lead to instrumentation short of or beyond the apical foramen, which will inevitably lead to iatrogenic damage (Tables 1.1 and 1.2).

The objectives of **root canal instrumentation** have been summarised in the expression “cleaning and shaping”, introduced by Schilder[47]. In this context, cleaning refers to the removal of all the contents of the root canal system before and during shaping. Shaping refers to the specific cavity form of the root canal that facilitates a complete obturation.

To ensure appropriate biomechanical preparation and to limit the risk of iatrogenic errors, some basic principles have to be respected:

- Root canal instrumentation must always be performed under conditions of tooth isolation.
- All instruments used in the canals must be sterilised.
- Endodontic instruments should come from the same manufacturing company and be of the same design. Despite all standardisation efforts, even instruments with the same ISO number may differ in diameter and shape, depending on the manufacturer[13,36].
- The access cavity must allow free and uninhibited penetration of the instruments into the root canals all the way to the apical foramen.
- Root canals must always be instrumented in a wet environment.
- Curved root canals should be instrumented using pre-curved instruments. This does not apply to Ni-Ti instruments.
- The narrowest cross-sectional diameter of the prepared root canal should be at its terminus (the only exceptions being cases with internal resorption or with unusual bulges in their shape).
- The apical foramen should remain intact.

The established sequence and, hence, interdependence of the stages in root canal treatment underline the importance of canal instrumentation. The latter has been repeatedly characterised in the literature as the most important step in endodontic therapy since, in simple words, there is no way to achieve a sterile, hermetic obturation if the root canal has not been appropriately prepared. Similarly, root canal instrumentation cannot be consi-

dered separately from endodontic access cavity preparation and may lead to minor corrections in cavity design. Nevertheless, access cavity preparation may be regarded as an easier-to-perform task since there is usually direct and immediate vision of the working field. It is rather easy, therefore, to modify and adjust the entry cavity shape during the process to fit the particular situation. This is not the case with canal instrumentation where important parameters, such as, the direction and shape of the canal, can only be assessed radiographically or by sensing after initiation of the instrumentation, and even then with limited accuracy. Indeed, root canal instrumentation is the "first among equals" of the important stages and definitely the most time-consuming stage of root canal treatment. Imperfections in obturation of perfectly prepared canals are biologically acceptable, while insufficient instrumentation of a contaminated root canal facilitates the development of periapical lesions. In the process of instrumentation a number of risk factors are involved that subsequently could lead to serious damage (Tables 1.1. and 1.2.).

It is generally accepted that meticulous istrumentation under heavy **irrigation** with NaOCl drastically reduces bacteria in the root canals. Despite restrictions on its use, mainly due to its toxic effects on soft tissues and its failure to penetrate root canal abnormalities[43,49], NaOCl remains the most widely advocated irrigant[44]. It can eliminate all micro-organisms in the root canal system including spore-forming bacteria and viruses, maintaining its microbicidal effect even in diluted concentrations[7,20,21,25,52]. In this respect, the role of antiseptics is quite limited. There is no antiseptic in any quantity that can possibly substitute for instrumentation or "correct" its inadequacies and shortcomings. Irrigation related risks are mostly due to irrigant's: inadvertent extrusion into periapical tissues, to leakage to adjacent or even distant tissues, to allergic reactions or finally due to their increased concentration in the environment.

The main cause of persistent root canal infection is incomplete removal of the bacterial substrate. The use of potent antiseptics, therefore, would have very limited results as long as pulp tissue residuals remain as a substrate for micro-organisms. For this reason, it is recommended that antiseptics be used **with caution** during root canal treatment[39]. Actually, potent caustic solutions are not indicated because they are more harmful than useful, frequently causing periapical inflammation. The preferred solutions must create aseptic conditions in the root canal system and exercise the least possible inflammatory action. The irritative action depends on the type and quantity of the antiseptic, the way it has been used, the size of the apical foramen and the type of the temporary sealing material.

Antiseptics are also commonly used in endodontics in order to relieve interappointment pain in the course of endodontic therapy. It has been shown, however, that no antiseptic, eugenol and cresatin included, gives better results in alleviating pain than a dry cotton pellet placed in the pulp chamber[21,32].

Despite the controversy and although the prevailing view suggests a limited role for antibacterial agents, their use in modern endodontics is still widespread, dictated by clinical conditions in everyday practice.

- There is always some degree of clinical uncertainty as to whether all debris and bacteria have been removed from the root canal system.
- After instrumentation, there may be bacteria still remaining deep inside dentinal tubules constituting an important reservoir from which root canal infection or reinfection may occur [40]. These bacteria can grow in the empty root canal if no intracanal medicament is used between appointments[9,10].
- Antibacterial agents act as a barrier against external re-infection due to incorrect placement of the temporary sealing material[17].
- They may have some microbicidal effect on the bacteria of the lateral root canals. The ability of contaminated material in lateral canals to recontaminate a thoroughly instrumented root canal has not been experimentally proven. Similarly, the ability of antiseptics to eliminate bacteria in lateral canals can only be speculated on. The use of antibacterial agents in canals with vital pulp is mostly dictated by their known action against external re-infection.

Finally, it is important to remember that, when antiseptics are used[39]:

- They may act as antigens.
- They may act as inflammatory agents on the apical tissues.
- They may penetrate into the blood circulation.

In conclusion, antimicrobial agents may contribu-

TABLE 1.1.
Dental procedure and related risk factor

Dental procedure	Risk factor involved
Isolation	Allergic reactions to the rubber dam Trauma of dental and periodontal tissues
Access cavity preparation	Malpositioned, inadequate or overextended access cavity Incomplete instrumentation Inadequate obturation Crown perforation Root perforation Tooth discoloration Fractured instruments Ledge formation
Working length determination	Incomplete instrumentation Foramen perforation Aspiration or swallowing of instruments Extrusion of filling material Acute apical periodontitis Ledge formation Canal blockage Underfilling of root canal
Root canal instrumentation	Incomplete instrumentation Root perforation Foramen perforation Aspiration or swallowing of instruments Emphysema Vertical root fracture Fractured instrument Acute apical periodontitis Clepsydra-like preparation Ledge formation Canal blockage
Root canal disinfection	Tooth discoloration Emphysema Acute apical periodontitis Irritation of mucosa due to antiseptic leakage
Temporary seal	Acute apical periodontitis Irritation of mucosa due to antiseptic leakage
Root canal obturation	Incomplete obturation Tooth discoloration Emphysema Vertical fracture Acute apical periodontitis Underfilling Overfilling

TABLE 1.2.
Risk factor and the dental procedure where it may arise

Risk factor	Dental procedure
Acute apical periodontitis	Working length determination Root canal instrumentation Root canal disinfection Temporary seal Root canal obturation
Allergy to rubber dam	Isolation
Aspiration or swallowing of instruments	Working length determination Root canal instrumentation
Canal blockage	Root canal instrumentation working length determination
Clepsydra like preparation	Working length determination Root canal instrumentation
Crown perforation	Access cavity preparation
Discoloration of the tooth	Access cavity preparation Root canal disinfection Root canal obturation
Emphysema	Root canal irrigation Root canal instrumentation Root canal obturation
Erroneous assessment of the extent of the instrumentation	Root canal instrumentation
Fractured instrument	Access cavity preparation Root canal instrumentation
Incomplete obturation	Access cavity preparation Root canal instrumentation Root canal obturation
Incomplete instrumentation	Access cavity preparation Working length determination Root canal instrumentation
Instrumentation short of the apex	Working length determination Root canal instrumentation Access cavity preparation
Irritation of mucosa by antiseptic leakage	Root canal disinfection Temporary seal
Malpositioned, inadequate or overextended cavity access	Access cavity preparation
Overfilling	Working length determination Root canal obturation
Root perforation	Access cavity preparation Root canal instrumentation
Trauma of dental and periodontal tissues	Isolation
Underfilling	Working length determination Root canal obturation
Vertical root fracture	Root canal instrumentation Root canal obturation

te to eradicating residual root canal micro-organisms after completion of the instrumentation and to limiting or reducing the risk of re-infection due to improper temporary sealing. Their careful and frugal use, therefore, is recommended with the caveat that irritation or any other form of adverse effect should be avoided in order to minimise the risk of iatrogenic damage during root canal disinfection (Tables 1.1. and 1.2.).

Calcium hydroxide is the recommended and most widely used antibacterial agent in modern endodontics. Although the mechanisms of its antimicrobial ac-

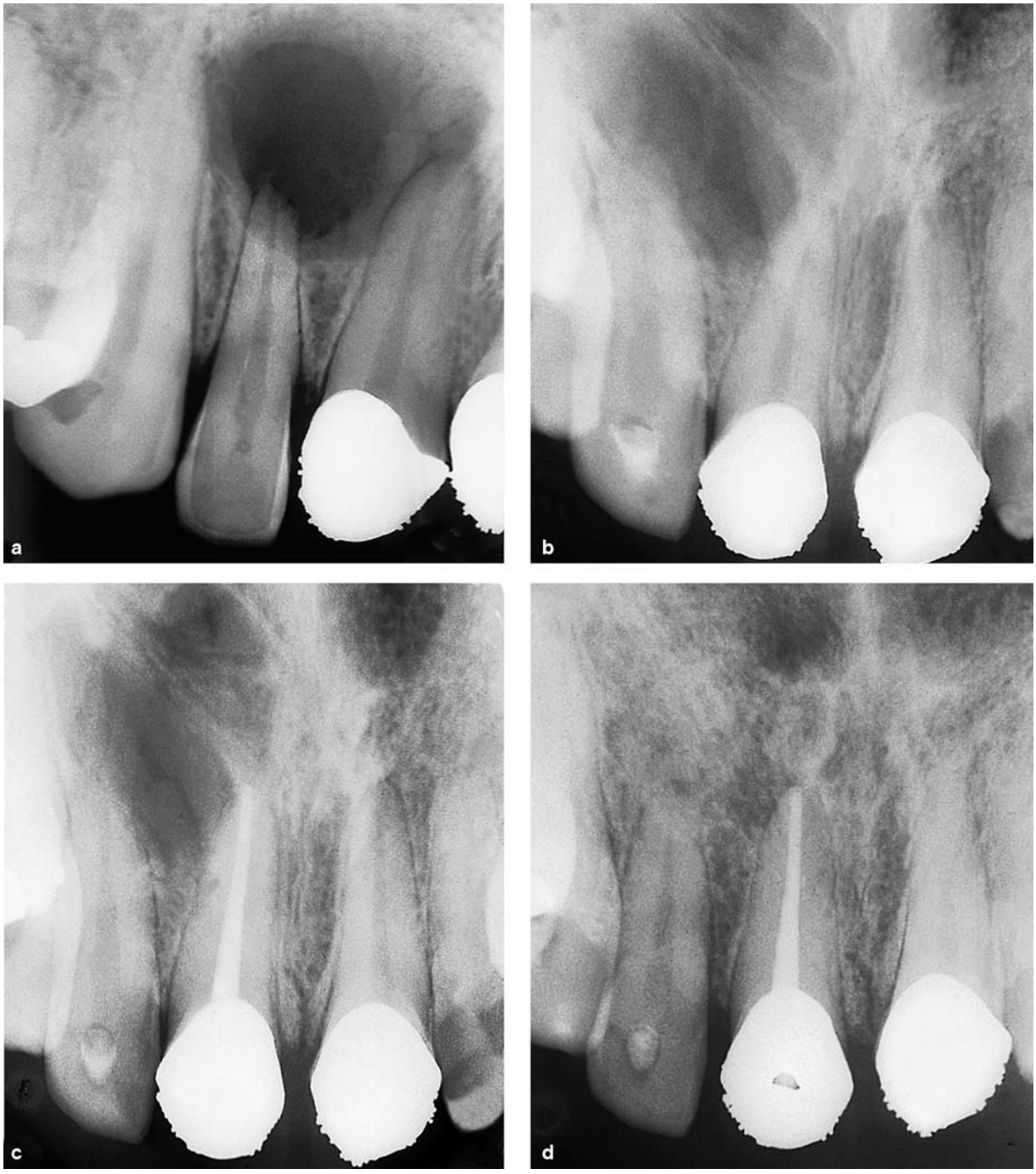

Fig. 1.6. Diagnostic error. *The dentist based on the periapical radiograph(a) and skipping vitality tests started access cavity preraration of the maxillary right lateral incisor. When the patient reacted he referred him for apicoectomy!!! On a second oblique view of the area (b) the causative tooth was identified and the central incisor was treated (c). Six year recall examination revealed complete osseous healing and preservation of vitality of the lateral incisor (d).*

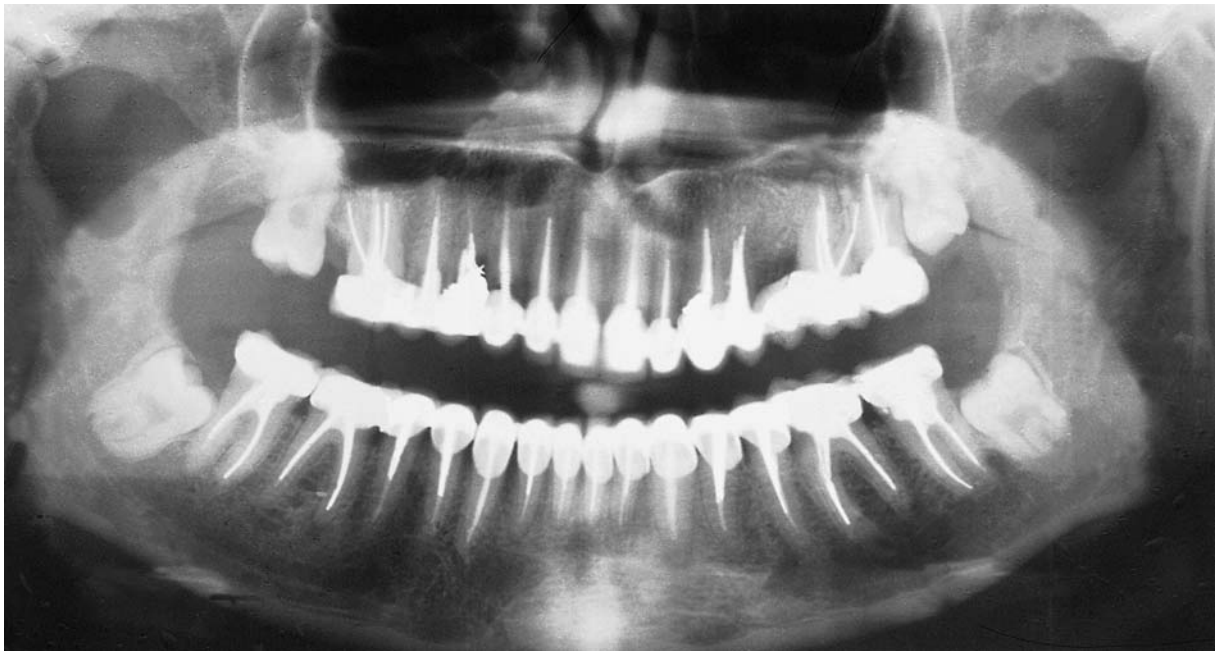

Fig. 1.7. Treatment planning errors. *It is nearly impossible to rationalize all these root canal treatments performed in a period of two months on this 28 year old lady, who according to her dental history visited her dentist for prosthetic restoration of a missing maxillary premolar. It is also interesting to note that in the year 1999 silver cones were used as a filling material.*

tivity are not well understood[50], as a disinfectant it rates higher than most chemical antimicrobial agents because:

- It has been shown that calcium hydroxide in the root canal for 7 days results in eradication of all bacteria remaining after instumentation[51].
- It has been found to be particularly effective against some bacteria related to intense cinical symptoms, such as B. melaningenicus, and P. pigmentalis[16]. However in some infections calcium hydroxide may not be the optimal root canal medicament, enterococci and yeasts have both been shown to tolerate an alkaline environment[56,57].
- Its antimicrobial action can last for weeks[9].
- It disolves necrotic residual tissues[23]
- Its action is so effective that infected root canals properly instrumented under copious NaOCI irrigation and dressed with calcium hydroxide, can be obturated in the second session [8,9,11].

Calcium hydroxide removal prior to final obturation is routinely accomplished by mechanical and chemical cleansing. In an in vitro study on the efficiency of removal of calcium hydroxide dressing from the root canal by mechanical and chemical means (endodontic files, NaOCl, chelating agent, normal saline) no method was found efficient in removing the entire dressing, leaving a considerable amount covering the canal walls[31]. Residual calcium hydroxide left intracanally has been shown to interact with zinc oxide eugenol based sealers compensating ZnO-eugenol chelate formation by forming calcium eugenolate[35]; additionally it might aggravate apical microleakage jeopardising the outcome of the treatment.

Endodontic treatment is usually performed over more than one session. **Temporary seal of the access cavity** is, therefore, necessary in order to protect the pulp cavity between appointments. It prevents the antiseptic from leaking into the oral cavity, a possible cause of mucosal irritation, and prevents saliva from entering into the pulp cavity, a common cause of contamination and infection of the root canal. Several temporary filling materials, such as gutta-percha, zinc oxide with eugenol, zinc-phosphate cement, I.R.M., Cavit-G, Caviton and others, have been thoroughly studied by many researchers under different conditions[1,2,5,14,19,27,29,34,37,41,42,45,53,58]. The only issue on which researchers unanimously agree, is that no material among those currently used can meet all requirements of an ideal temporary filling material[1,2,5,34,45,53]. Discrepancies in literature findings, especially regarding particular properties of temporary filling materials, may be easily explained since they can be attributed to the different experimental designs,

methods, and conditions adopted depending on the protocol of each study. Clearly, several independent variables, such as temperature[19,41], mastication forces[34], contact with antiseptics[5,45,58], time[31], and many more have an impact on temporary filling material properties and their sealing ability. For example, the sealing capacity of IRM can be reduced dramatically by increasing the powder to liquid ratio required for the preparation of the obturating mixture[2].

Access cavity sealing, although a relatively simple procedure compared to the delicate manipulations required for instrumentation and root canal obturation may also cause iatrogenic errors. Its apparent simplicity may be deceptive for the overconfident practitioner since, if the temporary seal is not properly effected especially in relation to the oposing and adjacent teeth, it leads to iatrogenic damage with severe consequences and intense symptomatology (Tables 1.1 and 1.2).

Proper temporary seal of the access cavity is important even after the completion of root canal treatment. Coronal microleakage can adversely affect the long-term prognosis of the therapy[46]. Studies have shown that exposure of the coronal part of obturated canals to oral fluids may result in recontamination of the root canal[18,24,54]. Among the variables which affect coronal microleakage are the type of sealer and the obturation technique employed[33], the presence of smear layer[12], and the presence of post space preparation[18,28].

The final stage of endodontic treatment is the **obturation of root canals** with a volumetrically stable biocompatible material. A variety of materials have been used for this purpose. Gutta-percha however, remains the dominant filling material in modern endodontics. Regarding obturation techniques, several have been used, lateral compaction* being the most commonly employed. The most popular types of sealers are based on zinc oxide and eugenol (Grossman's sealer, Kerr sealer, Procosol, Tubliseal, Roth). Epoxy resin (AH-26), polyvinil resin (Diaket), calcium hydroxide sealers (CRCS, Sealapex, Apexit), plastic containing cements (Endofill, Hydron- Endoseal), glass ionomer cements (Fuji I, Keatac-Endo, Endion) and silicon (RSA Roeko seal) are some of the eugenol-free sealers.

Risks during root canal obturation (Tables 1.1 and 1.2) usually relate to the level of the obturation in relation to the radiographic terminus of the canal (underfilled, overfilled, underextended, overextended obturation of root canal), or the "quality" of the obturation (incomplete obturation). They may also implicate the force exercised upon the spreader / plugger during lateral and / or vertical compaction (vertical fractures) and, finally, the coronal overextension of the filling material in the pulp chamber (tooth **discoloration).**

Diagnostic errors resulting in treatment of the wrong tooth (Fig 1.6) as well as errors in treatment planning (Fig 1.7) are not included in this text.

References

1. *Anderson RW, Powell BJ, Pashley DH.* Microleakage of three temporary endodontic restorations. J Endod 1988; 14: 497.

2. *Anderson RW, Powell BJ, Pashley DH*. Microleakage of IRM used to restore endodontic access preparations. Endod Dent Traumatol 1990; 6: 137.

3. *Best EJ, Gervasio WR, Sowle JT, Winter KL, Gurney BF.* A new method of tooth length determination for endodontic practice. Dent Digest 1960; 66: 450.

4. *Bregman RC.* A mathematical method of determining

* The fifth edition of the Glossary - Contemporary Terminology for Endodontics by the American Association of Endodontists emphasises the use of the word compaction instead of the previously used condensation. This word is used throughout this book.

the length of a tooth for root canal treatment and filling. J Can Dent Assoc 1950; 16: 305.

5. *Blaney TD, Peters DD, Setterstrom J, Bernier WE*. Marginal sealing quality of IRM and Cavit as assessed by microbial penetration. J Endod 1981; 7: 453.

6. *Bramante CM, Berbert AA.* A critical evaluation of some methods of determining tooth length. Oral Surg Oral Med Oral Pathol 1974; 37: 463.

7. *Buttler TK,Crawford JJ*. The detoxifying effect of varying concentrations of sodium hypochlorite on endotoxins. J Endod 1982; 8: 59.

8. *Bystrom A, Sundqvist G.* Bacteriologic evaluation of the efficacy of mechanical root canal instrumentation in endodontic therapy. Scand J Dent Res 1981; 89: 321.

9. *Bystrom A, Claesson R, Sundqvist G.* The antibacterial effect of camphorated Paramonochlorophenol, camphorated phenol and calcium hydroxide in the treatment of infected root canals. Endod Dent Traumatol 1985; 1: 170.

10. *Bystrom A and Sundqvist G.* The antibacterial action of sodium hypochlorite and EDTA in 60 cases of endodontic therapy. Int Endod J 1985; 18: 35.

11. *Bystrom A, Happonen RP, Sjogren U, Sundqvist G.* Healing of periapical lesions of pulpless teeth after endodontic treatment with controlled asepsis. Endod Dent Traumatol 1987; 3: 58.

12. *Chailertvanitkul P, Saunders WP, Mackenzie D.* The effect of smear layer on microbial coronal leakage of gutta-percha root fillings. Int Endod J 1996; 29: 242.

13. *Cormier CJ, von Fraunhofer JA, Chamberalin JH.* A comparison of endodontic file quality and file dimensions. J Endod 1988; 14: 138.

14. *Deveau E, Hildebert P, Neut C, Boniface B, Romond C*. Bacterial microleakage of Cavit, IRM and TERM. Oral Surg Oral Med Oral Pathol 1992; 74: 634.

15. *Everett FG, Fixott HC.* Use of incorporated grid in the diagnosis of oral roentgenograms. Oral Surg Oral Med Oral Pathol 1963; 16: 1061.

16. *Georgopoulou M, Kontakiotis E, Nakou M.* In vitro evaluation of the effectiveness of calcium hydroxide and Paramonochlorophenol on anaerobic bacteria from the root canal. Endod Dent Traumatol 1993; 9: 249.

17. *Gerstein H.* Internal and external resorption. Review and case report. Rev. Esp. Endodoncia 1983;1: 39.

18. *Gish S P, Drake DR, Walton RE, Wilcox L.* Coronal leakage: bacterial penetration through obturated canals following post preparation. J Am Dent Assoc 1994; 125: 1369.

19. *Gilles JA, Huget EF, Stone RC*. Dimensional stability of temporary restoratives. Oral Surg Oral Med Oral Pathol 1975; 40: 796.

20. *Grahnen H, Krasse B.* The effect of instrumentation and flushing of non vital teeth in endodontic therapy. Odontol Rev 1963; 14:167.

21. *Harrison JW, Baumgartner CJ, Zielke DR.* Analysis of interappointment pain associated with the combined use of endodontic irrigants and medicaments. J Endod 1981; 7: 272.

22. *Harrisson JW, Hand RE.* The effect of dilution and organic matter on the antibacterial property of 5.25% sodium hypochlorite. J Endod 1981; 7: 188.

23. *Hasselgren G, Olsson B, Cvek M*. Effects of calcium hydroxide and sodium hypochlorite on the dissolution of necrotic porcine muscle tissue. J Endod 1988; 14: 125.

24. *Imura N, Otani SM, Campos MJ, Jardim EG , Zuolo ML.* Bacterial penetration through temporary restorative materials in root- canal-treated teeth in vitro. Int Endod J 1997; 30: 381.

26. *Iqbal MK, Saad NA*. Microleakage of cavit in varnish-lined, matrix- supported endodontic access preparations. J Endod 1998; 24: 465.

27. *Jacquot BM, Panighi MM, Steinmetz P, G'Sell C*. Micrroleakage of Cavit , Cavit W, Cavit G and IRM by impedance spectroscopy. Int Endod J 1996; 29: 256.

28. *Khayat A, Lee SJ, Torabinejad M.* Human saliva penetration of coronally unsealed obturated root canals. J Endod 1993; 19: 458.

29. *Lamers AC, Simon M, Van Mullen PJ.* Micro-leakage of Cavit temporary filling material in endodontic access cavities in monkey teeth. Oral Surg Oral Med Oral Pathol 1980; 49: 541.

30. *Lambrianidis T, Molyvdas I, Kolokouris I, Lyroudia K.* Histological study of the effect of root canal antiseptics on oral mucosa. Experimental investigation on dogs. Hellenic Stomatolagical Rev 1986; 30: 117(in Greek).

31. *Lambrianidis T , Margelos I, Beltes P.* Removal efficiency of calcium hydroxide dressing from the root canal. J Endod 1999; 25: 85.

32. *Maddox DL, Walton RE, Davis CO.* Incidence of post treatment endodontic pain related to medicaments and other factors. J Endod 1977; 3: 447.

33. *Madison S, Swanason K, Chiles SA.* An evaluation of coronal microleakage in endodontically treated te-

eth. Part II. Sealer types. J Endod 1987; 13: 109-12.

34. *Maerki HS Jr, Huget EF, Vermilyea SG, de Simon LB.* Stress relaxation of interim restoratives. Oral Surg Oral Med Oral Pathol 1979; 47: 479.

35. *Margelos J, Eliades G, Verdelis C, Palagias G.* Interaction of calcium hydroxide with zinc oxide -eugenol type sealers: A potential clinical problem. J Endod 1997; 23: 43.

36. *Margelos I, Magnissalis EA, Zinelis S, Lambrianidis T.* Clinical relevance of standardization of endodontic files, according to ISO 3630-1. J Endod: 2002: 000

37. *Mayer T, Eickholz P.* Microleakage of temporary restorations after thermocycling and mechanical loading. J Endod 1997; 23.320.

38. *Morfis AS, Kontakiotis EG.* Tooth length determination with the use of a mathematical rule. Int Endod J 1990; 22: 62.

39. *Morse D.* Microbiology and pharmacology**.** In**:** Cohen S and Burns RC, Eds Pathways of the pulp, 3rd Ed, CV Mosby Co, St Louis, 1984, p. 405-24.

40. *Oguntebi BR.* Dentine tubule infection and endodontic therapy implications Int *Endod J.* 1994; 27: 218.

41. *Oppenheimer S, Rosenberg PA.* Effect of temperature change on the sealing properties of Cavit and Cavit G. Oral Surg Oral Med Oral Pathol 1979; 48: 250.

42. *Pai SF, Yang SF, Sue WL, Chueh LH, Rivera EM.* Microleakage between endodontic temporary restorative materials placed at different times. J Endod 1999; 25: 453.

43. *Pashley El, Birdsong NL, Bowman K, Pashley DH.* Cytotoxic effects of NaOCl on vital tissue. J Endod 1985; 11: 525.

44. *Qualthrough AJE, Whitworth JM, Dummer PMH*. Preclinical endodontology: an intermational comparison. Int Endod J 1999 ;32:406.

45. *Rutledge RE, Montgomery S.* Effect of intracanal medicaments on the sealing ability of TERM. J Endod 1990; 16: 260.

46. *Saunders WP, Saunders EM.* Coronal leakage as a cause of failure in root canal therapy: a review. Endod Dent Traumatol 1994; 10: 105-8.

47. *Schilder H.* Filling root canal in three dimensions. Dent Clin North Am, 1967; 11: 723.

48. *Schilder H, Yee FS.* Canal debridement and disinfection. In: Cohen S and Burns RC, Edrs Pathways of the pulp, 3rd Ed., C.V. Mosby Co, St Louis, 1984, p. 175-204.

49. *Senia ES, Marshall FJ, Rosen S.* The solvent action of sodium hypochlorite on pulp tissue of extracted teeth. Oral Surg Oral Med Oral Pathol 1971; 31: 96.

50. *Siqueira JF, Lopes HP.* Mechanisms of antimicrobial activity of calcium hydroxide: a critical review. Int Endod J 1999; 32: 361.

51. *Sjogren U, Figdor D, Spangberg L, Sundqvist G.* The antimicrobial effect of calcium hydroxide as a short-term intracanal dressing. Int Endod J 1991; 24: 119.

52. *Spangberg L.* Endodontic treatment of teeth without apical periodontitis. In: Ostravik D, Pitt Ford Edrs, Essential Endodontology. Prevention and treatment of apical periodontitis. Blackwell Science, London 1998, p. 211, 223, 232.

53. *Teplitsky P, Meimaris IT.* Sealing ability of Cavit and TERM as intermediate restorative materials. J Endod 1978; 14: 278.

54. *Torabinejad M, Ung B, Kettering JD.* In vitro bacterial penetration of coronally unsealed endodontically treated teeth. J Endod 1990; 16: 566-9.

55. *Turner JE, Anderson RW, Pashley DH, Pantera EA Jr.* Microleakage of temporary endodontic restorations in teeth restored with amalgam. J Endod 1990; 16: 1.

56. *Waltimo T, Siren E, Torkko H,Olsen I, Haarapasalo M*. Fungi in therapy – resistant apical periodontitis. Int Endod J 1997; 30: 96.

57. *Waltimo T, Siren E, Orstavik D, Haapasalo* M. Susceptibility of oral Candida species to calcium hydroxide in vitro. Int Endod J 1999; 32: 94.

58. *Webber RT, del Rio CE, Brady JM, Segall RO.* Sealing quality of a temporary filling material. Oral Surg Oral Med Oral Pathol 1978; 46: 123.