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Fusion and gemination of teeth: review of the literature, treatment considerations, and report of cases

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Teeth with aberrant root morphology present the endodontist with diagnostic and treatment challenges. This review of the literature is focused on the classification, aetiology, prevalence and diagnosis of different types of double teeth, namely fused or geminated teeth. Cases are included to illustrate the various treatment considerations when managing these variations of dental anatomy.

Review of the literature

Dental hard tissue anomalies manifesting as 'double teeth' have been described using various terms: fusion or synodontia, gemination, concrescence, twinning or schizodontia, double, fused or connated teeth, and odontoma[1–6]. Fusion and gemination describe an abnormality in which one tooth has combined with another or enlarged itself to the point of doubling or nearly doubling its tooth substance[7,8]. In 1963, Tannenbaum and Alling[1] published a diagrammatical classification, which later was adopted by Pindborg[2]. Classically, such abnormalities of tooth morphology were divided into gemination, fusion, twinning and concrescence (Fig 1).

Gemination is defined as a single enlarged or joined (double) tooth where the number of teeth present is normal if the anomalous tooth is counted as one. Gemination is thought to be due to an incomplete attempt of one germ to divide into two[2] (Figs 2a and 2b). Geminated teeth demonstrate two crowns or one

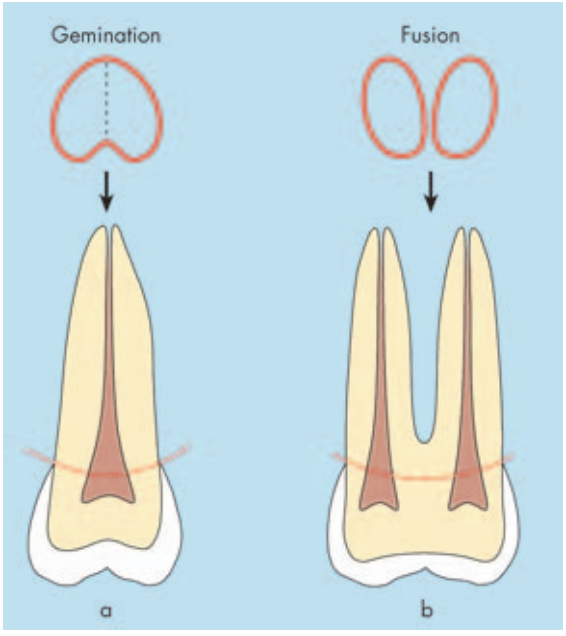

Fig 1 Schematic drawing of different types of double teeth (modified from Hülsmann et al[54]).

Fig 2a Maxillary right first premolar with a double crown.

Fig 2b The radiograph shows the presence of a single root with two distinct crowns. Although the tooth is rotated, there is still crowding.

Fig 3a A lateral mandibular incisor with an atypically broad crown with an incisal groove (reproduced from Hülsmann et al[54]).

Fig 3b The radiograph showing the presence of a single root with an incompletely divided crown (reproduced from Hülsmann et al[54]).

Fig 4 This lateral mandibular incisor shows a double crown. As only one root was present this represents a typical case of gemination (reproduced from Hülsmann et al[54]).

large partially separated crown sharing a single root or root canal (Figs 3a and 3b, Fig 4). The commonly affected teeth are the permanent maxillary incisors and the deciduous mandibular incisors[4] (Fig 5). Sometimes, the anomaly may occur bilaterally[9].

Fusion (synodontia or false gemination) is defined as a union between the dentin of two or more separately developing teeth (Figs 6a and 6b). The fusion may be total or partial and leads to a reduced number of teeth in the dental arch[1]. According to Pindborg[2], it is very rare that two teeth are united by enamel only. The fusion may be partial or total depending on the stage of tooth development at the time of union. The aetiology of this anomaly still is unknown; the influence of pressure or physical forces producing close contact between two developing teeth and thus resulting in fusion

Fig 5 Geminated deciduous tooth.

Fig 6a Clinical view of a maxillary central incisor fused to a supernumerary tooth. The normal lateral incisor is positioned palatally.

Fig 6b Corresponding radiograph demonstrating the fused crowns with separate roots and the superimposed normal lateral incisor.

is discussed as one possible reason[6]. Lowell and Solomon[10] suggest that close contact between two tooth germs leads to necrosis of the intervening tissue, allowing the enamel organ and the dental papilla to unite. Genetic determination was evident in some of the cases presented in the literature[11–14]. The most commonly affected are incisors, but fusion of premolars and molars has also been described[15-19].

The fused teeth may appear as one large tooth, as one incompletely fused crown, or as two crowns sharing completely or incompletely fused roots (Fig 7, Figs 8a to 8c, Fig 9). The diagnosis of fusion is best reserved for two completely or incompletely fused teeth that have arisen in the place of two normal teeth[4]. Nevertheless, fusion may occur between a normal tooth and a supernumerary tooth; in this case, it is difficult to differentiate from gemination[3,4,6,9,12,13,20,21]. Therefore, Brook and Winter[13] recommended the use of the neutral term 'double tooth' to describe both anomalies. Killian and Croll[12] suggested the designation 'dental twinning' as a basic diagnostic term for all joining defects, and Mader[6] proposed the term 'fused teeth', because it is already a commonly accepted term and appropriately describes what has occurred. The current literature recommends the term 'double' or 'connated' teeth[3,4,22]. In the past, the union of a supernumerary tooth and a normal tooth was referred to as diphyodontic gemination or odontoma[1]. Munro[23] presented 31 cases of gemination and fusion in the deciduous dentition and reported several abnormalities in

Fig 7 Fused tooth with one extremely broad root canal and a double crown. The extension of the root suggests fusion rather than twinning (reproduced from Hülsmann et al[54]).

Fig 8a Extracted fused deciduous maxillary incisor (reproduced from Hülsmann et al[54]).

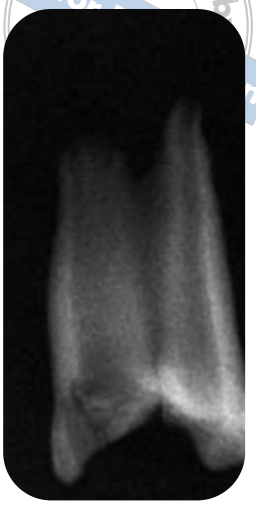

Fig 8b Corresponding radiograph demonstrating two roots and two crowns, suggesting fusion or concrescence (reproduced from Hülsmann et al[54]).

Fig 8c Following horizontal sectioning it is evident that even the dentine is fused and that there is a communication between the two pulp systems (reproduced from Hülsmann et al[54]).

Fig 9 Extracted fused deciduous maxillary incisor.

the permanent dentition following fusion of two deciduous teeth: missing teeth, teeth with abnormal form, and extra teeth.

'Twinning' (schizodontia) has been used previously as a synonym of gemination, but it actually means that the tooth bud cleavage is complete. This results in formation of an extra tooth, which is usually a mirror image of its adjacent partner[1].

'Concrescence' is the union of two completely separate teeth that are joined only by their cementum[1]. If the union has occurred during tooth development, the condition is called true concrescence, which is most

Fig 10 Concrescence of two maxillary molars.

often seen between second and third molars in the maxilla, where lack of space may be responsible for the anomaly (Fig 10). Acquired concrescence occurs after completion of root formation and may be a result of union of two types of teeth with hypercementosis associated with chronic inflammation[2].

Many of these dysplasias may be caused by local metabolic interferences[10,24] or by chance[6]. Others have suggested an evolutionary phenomenon[5] or a form of atavism[5,25]. Caliskan[26] presented a case of a triple tooth, in which three teeth were presumed to have geminated due to trauma. Nevertheless, fusion has been reported to accompany exencephaly in mouse embryos, induced by large doses of vitamin A, by riboflavin deficiency, and by injection of trypan blue. In an inbred strain of Lakeland Terriers, fusion of the first and second incisors has been shown to be inherited, with the cause, in this case, identified as the persistence of the interdental lamina[2]. However, the aetiology remains uncertain and may be of ectodermal, mesodermal or composite origin[1]. Several authors[2,10,24,27,28] also suggest that heredity is an aetiological factor.

Two-rooted incisors

In rare cases, normal maxillary incisors may present with double roots and a similar appearance as fused teeth[29–31]. According to Vertucci[32] this occurs only infrequently. These teeth show a regular formed crown with normal mesio-distal dimensions.

Prevalence of double teeth

The prevalence of fusion and gemination varies in retrospective studies, with review of the early literature suggesting from 0.1–1% for both dentitions[13,33]. Buenviaje and Rapp[34] examined 2439 children, ranging in age from 2 to 12 years. They found fused teeth in 0.42% and geminated teeth in 0.08% of the subjects. In Jordanian adults, the prevalence of fused and geminated teeth was 0.19% and 0.22% respectively[35]. Blaney et al[36] estimated the prevalence of tooth fusion at 0.5–2.5% in the primary dentition, while the prevalence in the permanent dentition seems to be clearly lower. In 1987, Duncan and Helpin[9] reviewed 17 studies on fusion and gemination. They found a prevalence for double teeth in the primary dentition ranging from 0.1–0.9% for unilateral and 0–0.04% for bilateral presentation. In the permanent dentition, the prevalence for double teeth ranged from 0–0.2% unilaterally and 0–0.05% bilaterally. The reviewed literature indicated the sex of the patient was irrelevant. It was concluded that although not statistically validated, it would appear that Americans with Indian origin, Orientals, and Mexicans show a higher prevalence of unilateral or bilateral fusion[9].

Pulp anatomy in double teeth

From an endodontic point of view, the inner anatomy of double teeth, the anatomy of the pulp system/s, is of main interest. The variation in morphology and anatomy of the root canal system/s may present additional challenges if such teeth need endodontic treatment. Additionally, orthodontic, aesthetic, or prosthetic reasons may require extraction or hemisection of part of a double tooth, which also will require root canal treatment[37-42].

As radiographs can only help with pre-operative diagnosis, the final decision on treatment strategy in some cases can be made only during treatment when the root canal anatomy can be inspected. Advanced technology such as computed tomography in such cases may provide important pre-operative information on the inner tooth anatomy facilitating treatment planning.

Geminated teeth show one main root canal, which may present with a large, voluminous pulp chamber or even two chambers. As these terminate into one main root canal it is not possible to maintain the vitality of the pulp and endodontic treatment will be necessary in most cases before the size of the crown can be reduced[43]. Libfeld et al[44] reported on a case of endodontic therapy of bilaterally geminated permanent maxillary incisors demonstrating the variability in developmental anatomical anomalies. Both teeth diagnosed as geminated were found to have significant differences in their root canal configurations. In the left there seemed to be two root canals coronally, which ended in a common, single apical foramen. In the right, starting coronally as one, the root canal ended in two separate apical foramina.

In fused teeth there may exist two separate root canal systems as shown in Cases 2 and 3, but there

also may exist two endodontic systems with minor or major communications that will require endodontic treatment of both roots or the root remaining after hemisection. Budd et al[45] described a large fin connecting both canals of the left fused incisor, which complicated the obturation of this tooth because of the difficulty inherent in placing gutta-percha into these areas. Indra et al[21] presented a case of a maxillary lateral incisor fused to a supernumerary tooth with two separate root canals and a common coronal pulp chamber. This phenomenon, from a theoretical point of view, might also be interpreted as a double-rooted incisor, but the atypically large mesio-distal extension of the tooth crown supported the diagnosis of a fused tooth.

Reeh and ElDeeb[46] described a fused tooth that was not a viable candidate for separation, due to the extent of fusion and the resultant canal morphology. The lateral incisor had two apices and an extensive web-like communication of the pulp system with the cuspid in the apical third of the root, which was not evident until completion of obturation. The appearance of the canal morphology was similar to that described by Tagger[37] as 'Siamese gemination'. In another case a communication between the root canals of the fused permanent maxillary lateral incisor was demonstrated by the flow of cement between them, but no gutta-percha entered into the spaces between the root canals[47].

Peyrano and Zmener[48] presented a case of a tooth that showed radiographically three independent root canals with separate foramina, whereas the post-obturation radiograph revealed the presence of many small communications that were not evident in the pre-operative radiograph. Spatafore[49] reported a case of a fused central maxillary incisor with a supernumerary tooth, which presented with two crowns joined by enamel, two roots joined by dentine, and two canals joined at the apex. In a further case report it was possible to distinguish the midroot communication between the root canals of the fused maxillary lateral incisor only after obturation[50].

Endodontic treatment considerations in double teeth

In the majority of cases, treatment of double teeth is needed due to orthodontic or aesthetic reasons. Irregular shapes in the mesio-distal dimension of roots and/or crowns, frequently accompanied by crowding of the anterior teeth, will require orthodontic treatment including extraction of the malformed tooth.

Geminated teeth

As only one root is present, the ideal treatment option should be grinding and re-contouring of the crown; sometimes a prosthetic crown may be indicated. This may compromise the pulp and then root canal treatment is necessary. The literature and the case reports on geminated teeth do not suggest any major problems with root canal treatment of single

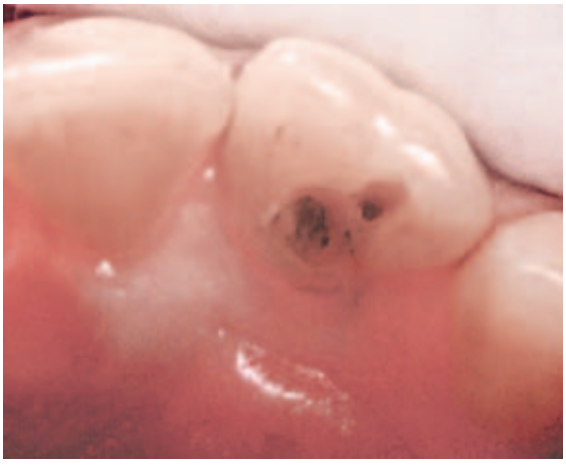

Fig 11a Clinical view of two access cavities of a geminated incisor (courtesy of Dr Teeuwen, Geilenkirchen, Germany).

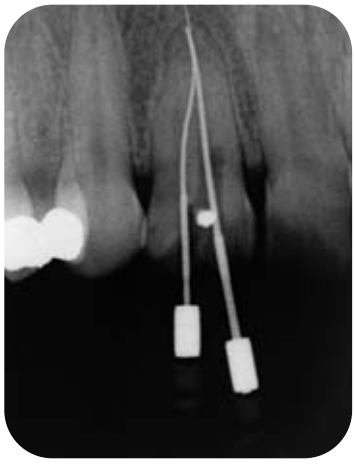

Fig 11b The corresponding radiograph demonstrates two separate pulp chambers uniting into one common root canal (courtesy of Dr Teeuwen, Geilenkirchen, Germany).

rooted geminated teeth. If the pulp system is also geminated, preparation of two access cavities should be performed, as the two pulp system is joined somewhere apically[43] (Figs 11a and 11b).

Fused teeth

In fused teeth the indication and treatment required will be dictated by orthodontic and aesthetic considerations. If two regular teeth have fused, the resulting dental structure occupies less space than two single teeth and extraction or hemisection of the roots will not be necessary. If a normal tooth and a supernumerary tooth have fused, apart from crowding, aesthetic and periodontal problems may occur. The buccal and palatal grooves between the two crowns extending apically to the root substance will allow plaque accumulation and cause periodontal problems. If the fused tooth has two separate roots, hemisection of one root may be indicated[6,36,38,41,45,51], provided the roots are separated. The separation of the fused tooth into two single incisors may represent a possible treatment option as described in previous reports[44]. This would solve aesthetic problems, but will only be an option in cases without additional orthodontic problems.

If the pulp systems of both roots are connected, root canal treatment of the remaining root will be necessary. Sometimes such communications only become evident during or after the hemisection procedure[37,38,48,52,53].

If removal of one of the roots is not indicated, root canal treatment will only be performed because of caries, pulpitis or for restorative reasons. In such cases the decision as to whether root canal treatment of a single affected root or both roots has to be performed depends on the inner anatomy of the tooth and the presence of communications between the two pulp systems, respectively. Root canal treatment of a single root or both roots[21] has been described in previous case reports.

Case reports

Case 1

A 27-year-old male was referred by his dentist complaining of pain and swelling from the maxillary left anterior region. Clinically, the maxillary left central incisor has an unusual width (Fig 12a). The palatal aspect looked similar to a talon cusp but was restored with tooth-coloured filling material in the area of the cingulum (Fig 12b). The tooth was slightly yellowish and discoloured. It was also tender to percussion and palpation, and there was a labial swelling. Probing depths were 3 mm or less, the tooth was unresponsive to thermal sensitivity testing and there was perceptible mobility. The patient reported that the cusp had been ground down repeatedly during orthodontic treatment in his youth; he was unaware of another family member having a tooth of a similar appearance. Teeth 12, 11, 22, and 23 gave normal responses to percussion, palpation, and sensitivity testing. Tooth 11 had no signs of abnormalities, but the teeth

Fig 12a Pre-operative view of a maxillary left central incisor with unusual coronal width.

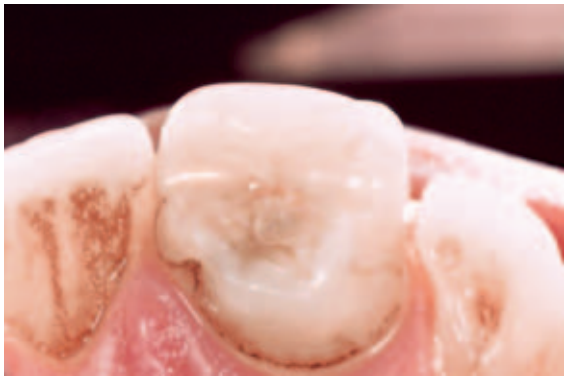

Fig 12b Palatal view showing a kind of a talon cusp at tooth 21 and palatal invagination at tooth 22.

Fig 12c Corresponding radiograph demonstrating fusion of tooth 21 with a supernumerary tooth combined with a dental invagination.

12 and 22 showed deep palatal invaginations at the foramen caecum (Fig 12b). A periapical radiograph revealed aberration of the root anatomy of tooth 21, and an area of periapical radiolucency. Teeth 12 and 22 showed signs of enamel invaginations. Radiographic examination (Fig 12c) suggested the following possibilities: (a) fusion, caused by the union of tooth 21 with a supernumerary tooth; (b) fusion, caused by the union of tooth 21 with a mesiodens with dens invaginatus, ending as a blind sac; (c) multiple canals; (d) open foramens; (e) diffuse external lateral root resorption; or (f) internal root resorption.

The diagnosis for tooth 21 was double tooth with necrotic pulp with a chronic periradicular periodontitis undergoing acute exacerbation. A decision was made to perform conventional root canal treatment on the double tooth. The tooth was anaesthetised and an access cavity was prepared after isolation with rubber dam. The tooth revealed two main canals (one buccal and one palatal) and an irregular canal, which seemed to widen into a 'resorption cavity'. Upon access into the palatal canal, there was purulent discharge, which was allowed to drain. With the aid of a dental operating microscope, the irregular distopalatal canal was enlarged and it was possible to see the very smooth floor of the resorption cavity. Working length of the canals was determined with an apex locator (Root ZX, Morita Europe, Dietzenbach, Germany) and a radiograph. After cleaning and shaping the root canal systems and irrigating with 5% sodium hypochlorite, calcium hydroxide was placed and the tooth was temporarily sealed. At the third appointment, the root canals were dry after the calcium hydroxide was removed with irrigation. The root canals and the resorption cavity were obturated with warm vertically compacted gutta-percha using System B (EIE Analytic, Orange, CA, USA) for the down-pack. The coronal parts of the main canal and the invagination were back-filled with an Obtura gun (Obtura II, Spartan, Fenton, MO, USA) (Fig 13).

The patient returned every 6 months for clinical and radiographic follow-ups, and apical repair was first observed after 18 months. At the last recall, at 4 years, periapical repair was nearly complete (Fig 14).

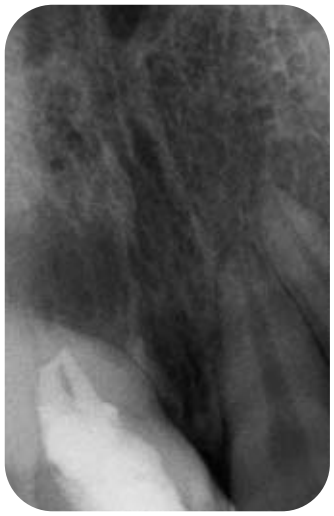

Fig 13 Post-obturation radiograph.

Fig 14 The radiographic control after 4 years demonstrates periapical repair.

Fig 15a Pre-operative buccal view of a fused tooth showing a broad crown, a large enamel projection and a longitudinal groove extending into the gingival sulcus (reproduced from Hülsmann et al[54]).

Fig 15b Pre-operative palatal view of the fused tooth with a second large enamel pearl and again a longitudinal groove extending into the gingival sulcus. Slight bleeding could be provoked by pocket probing (reproduced from Hülsmann et al[54]).

Case 2

A 10-year-old girl was referred by the Department of Orthodontics for consultation and treatment of an abnormal central right maxillary incisor. Her medical history was non-contributory. Clinical examination revealed a maxillary central right incisor fused to a supernumerary tooth. On the buccal and the palatal aspects, there were deep grooves, separating both crowns, which extended into the gingival sulcus (Figs 15a and 15b). Large enamel pearls were detected between the two crowns. The tooth responded normally to pulp testing. Periodontal probing revealed 4 mm pockets on the buccal and the palatal aspects below the longitudinal grooves. Radiographic investigation showed a fused tooth with two distinct roots. No connection between the two separate root canal systems could be detected radiographically (Fig 15c).

Fig 15c Pre-operative radiograph of the fused tooth showing two separate roots. No communication of the pulp systems can be detected (reproduced from Hülsmann et al[54]).

The diagnosis was tooth fusion between the maxillary right central incisor and a supernumerary tooth with probably two separate root canal systems.

Treatment was recommended because of aesthetic and orthodontic problems and in order to prevent periodontal disease due to the presence of buccal and palatal grooves.

For orthodontic and restorative reasons, a decision was made to remove the mesial part of the fused tooth. As the internal anatomy of the pulp system/s could not be determined from radiographs, it was decided first to perform a pulp extirpation on the mesial part of the tooth. The tooth was anaesthetised and isolated with rubber dam. An access cavity was prepared in the mesial part of the tooth and the pulp extirpated. With a pair of 5x microscope loupes and a curved probe the cavity was investigated for any connection between the two root canal systems. As no communication could be detected, the mesial part of the fused tooth was cleaned and shaped, dressed with calcium hydroxide, and sealed.

One week later the patient reported that she was symptom-free. The distal part of the tooth responded normally to pulp testing. The tooth was anaesthetised and buccal and palatal mucogingival flaps were elevated (Fig 16a). The crown was divided with a diamond bur (Fig 16b) and the mesial part of the tooth was removed (Fig 16c). The crown of the remaining tooth was restored, after acid etching with a dentine bonding system and a hybrid composite.

Fig 16a Peri-operative view: the separation between the roots could be probed only after osteotomy of the bone (reproduced from Hülsmann et al[54]).

Fig 16b Peri-operative view following separation of the crowns (reproduced from Hülsmann et al[54]).

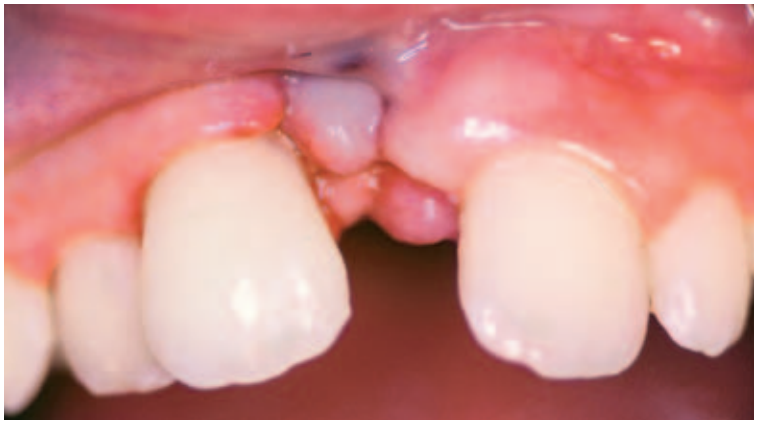

Fig 16c Peri-operative view following suturing. Still no restorative treatment has been performed. The enamel pearls have been smoothed (reproduced from Hülsmann et al[54]).

Fig 16d Post-operative radiograph (reproduced from Hülsmann et al[54]).

Fig 17 Review radiograph three months post-operatively following placement of the orthodontic appliance (reproduced from Hülsmann et al[54]).

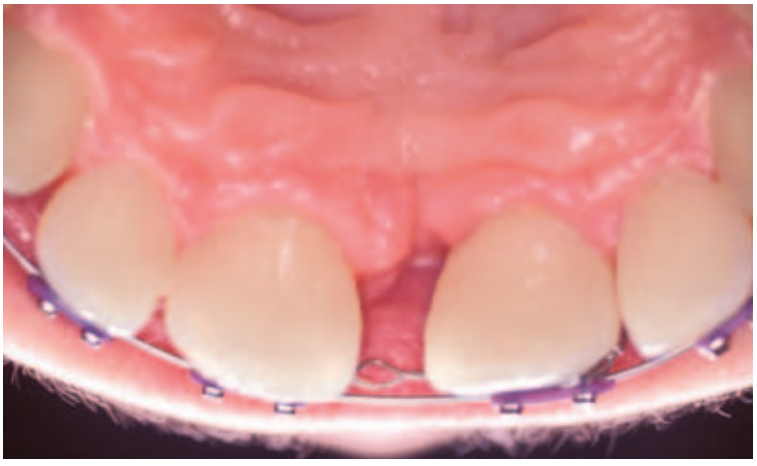

Fig 18 Review 6 months later: the tooth has been restored, orthodontic treatment already has resulted in narrowing of the diastema between the central incisors (reproduced from Hülsmann et al[54]).

Fig 19 Clinical view of a maxillary central incisor fused to the lateral incisor tooth. The shape and position of the double tooth require intervention.

Fig 20 The corresponding radiograph showing fusion of the crowns of the maxillary incisors and the presence of clearly separate roots.

Fig 21 The crowns have been separated and the lateral incisor been extracted. The longitudinal groove at the fusion site still has to be smoothed. A composite restoration may be necessary to improve aesthetics.

At a separate recall one week later, the patient complained of slight thermal hypersensitivity, but the pulp responded positively to sensitivity testing (Fig 16d). Wound healing was uneventful. Six months post-surgery, orthodontic treatment resulted in narrowing of the space between the distal part of the fused tooth and the left central incisor (Fig 17). The hemisected tooth still responded normally to sensitivity testing, and the hypersensitivity had almost completely resolved. The radiograph showed no signs of periapical pathosis, although a slight widening of the periodontal ligament space was visible, possibly due to orthodontic movement of the tooth (Fig 18).

Case 3

A 12-year-old girl presented with severely malformed crowns of the maxillary left incisors (Fig 19). There were no clinical symptoms except slight bleeding on probing cervically between the crowns. The radiograph revealed the existence of two separate roots with fused crowns, one of these in a rotated position (Fig 20). A decision was made to hemisect the tooth and to extract the distal part, probably tooth 22. Following anaesthesia the crowns were separated, leaving the crown of tooth 21 intact. Following separation of the crowns, the distal root was removed (Fig 21). No communication of the two endodontic systems was detected.

Fig 22 The control radiograph shows an incorrect separation leaving a spar of the removed lateral tooth.

A radiograph revealed the remnant of a lateral spar of the removed segment (Fig 22). Following removal of this spar, the socket was sutured.

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