

TREATMENT OF AN INTRA-ALVEOLAR ROOT FRACTURE BY EXTRA-ORAL BONDING WITH ADHESIVE RESIN

G rard Aouate



Corresponding author:
G rard Aouate
41, rue Etienne Marcel
75001 Paris

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When faced with dental root fractures, the practitioner is often at a disadvantage, particularly in emergency situations. Treatments which have been proposed, particularly symptomatic in nature, have irregular long-term results. The spectacular progress of bonding materials has radically changed treatment perspectives.

Among these bonding agents, the 4-META/MMA/TBB adhesive resin may show affinities for biological tissues. It is these properties which can be used in the treatment of the root fracture of a vital tooth.

"Two excesses: excluding what is right and only admitting what is right"; Pascal, "Thoughts", IV, 253.

"I ask your imagination in not going either right or left"; Marquise de Sévigne, "Letters to Madame de Grignan", Monday 5 February, 1674.

Facial trauma represents a major source of injury to the integrity of dental and periodontal tissues. The consequences on dental prognoses are such that they have led some clinicians to propose treatment techniques for teeth which, otherwise, might have been condemned to extraction.

We will not discuss the related manifestations of dento-alveolar trauma but will focus our attention on high dental root fractures.

When dealing with the treatment of horizontal root fractures (HFR), the consultation results, and, indeed, most of the available literature, provide the practitioner with a great variety of treatment options, most of which offer uneven results which are also short-term. Each author offers cautious progress, but the general consensus is that there is no consensus.

Proposed treatments all tend towards the same goal: eliminate the fracture line, either by restorative dentistry techniques or by techniques of partial root resection or, ultimately, total amputation (extraction).

Techniques which are devoted to preserving the tooth fragments have used various methods of joining them together, such as:

- cyanoacrylic glue (Oliet, 1984),
- composite materials (Hasegawa et.al., 1988; Munksgaard et.al., 1991; Serfaty, 1991),
- glass ionomer cements (Trope and Rosengerg, 1992; Stewart, 1990)
- attempts at laser dental fusion (Zakariassen KL et.al., 1988),
- close approximation of the separated fragments and their subsequent immobilization in the young patient (Michanovicz et.al., 1978).

The question of root fracture treatment, therefore, remains a challenge as long as a definitive treatment model is still uncertain and undetermined.

In 1982, Masaka, a Japanese author and clinician, treated the vertical root fracture of a maxillary central incisor in a 64 year-old woman using an original material: adhesive resin 4META/MMA/TBB (Superbond®). The tooth, treated with success, was followed for 18 years.

Extending the applications of this new material, Masaka further developed his technique in 1989 with the bonding together of fragments of a fractured tooth after having extracted it and, then, subsequently, re-implanting it.

This last procedure, in addition to the extraction and joining together of the fragments, also gave the author an opportunity to rotate the root 180° around its longitudinal axis. This positioned the destroyed tissue (periodontal ligament, alveolar bone) facing healthy tissue (alveolar bone, periodontal ligament) (Masaka, 1982; 1985; 1995; Masaka and Irie, 1998).

In 1989, after a long period during which there was much documented use of Superbond applied to the dentin of vital teeth, Masaka performed a direct pulp cap (Masaka, 1991), and ascertained the preservation of pulpal vitality. These results were confirmed by other authors who concluded that the adhesive resin 4-META/MMA/TBB displays a strong affinity with the pulp with which is it capable of creating a biological joint (Inoue and Shimono, 1992; Miyakoshi et.al., 1994). The 4-META/MMA/TBB is a chemically polymerized resin which achieves, at the same time, a liaison with the dentin via a smear layer (Nakabayashi et.al., 1991; Nakabayashi and Pashley, 1998) and with the metallic or ceramic prosthetic structure.

Among its other properties, this material also achieves a high level of dentin and enamel adhesion (17 and 15 Mpa respectively), as well as a remarkable impermeability (the best results when compared to similar materials tested). (Cooley et.al., 1991; Nakabayashi and Saimi, 1996.)

Therefore, it would seem that, when considering the 4 META/MMA/TBB adhesive resin:

- its adhesion to the dental substrata,
- the relative absence of cytotoxicity (Kamal



Fig. 1: The patient, Mrs. B., presented for emergency consultation on March 22, 2000. Five hours previously, she had suffered a fall, without any memory of specific details, preceded by a loss of consciousness.

Fig. 2: Tooth #11 seems to be the only tooth adversely affected as a consequence of this facial trauma. It is the only mobile and displaced tooth. The clinical signs associated with the radiographic examination and pulpal vitality tests of neighboring teeth eliminated them from immediate inclusion in our treatment plan. Periodic examination will be necessary for these adjacent teeth, the object being to maintain their tissular integrity. A rapid and complete diagnosis must be reached, based on whether we are dealing with a non-fractured tooth (tooth, root) luxated out of the alveolus, or with a root fracture with displacement of the fragment(s). In the case of an intact tooth (non-fractured), the emergency treatment will consist of the alveolar repositioning of the traumatized tooth, then the installation of a means of non-rigid stabilization. Notice the spontaneous gingival hemorrhage at the marginal gingiva.



Fig. 3: The retro-alveolar radiograph confirms the findings of the clinical examination and permits us to propose the diagnosis of root fracture with luxation and extrusion of the coronal fragment. Radiographic examination does not reveal fracture of the alveolar bone. The apical root fragment is in its original position, which signifies that the vascular-nerve bundle at the apex has not suffered severe bruising.

Table 1

The use of adhesive resin 4-META/MMA/TBB is indicated in the following clinical situations:

- orthodontic bondings, either surgical or non-surgical;
- the stabilization, by bonding, of a mobile tooth in emergency treatment;
- the bonding of cast splints, prosthetic restorations, and inlays;
- the repair of fractured cosmetic elements;
- the reinforcement of roots which have been extremely weakened by a bonded casting;
- the preservation of roots which have been vertically fractured and of roots which have iatrogenic perforations;
- indirect and direct pulp capping.

et.al., 2000),

- its biocompatibility,
- are the qualities of the material which are the most significant.

The clinical applications of 4-META/MMA/TBB adhesive resin, (Table 1), have broadened therapeutic possibilities, and the abundant documentation associated with the precepts set forth by Masaka (Masaka N., 2000), have led us to perform and present the following clinical case.

Clinical Case

Mrs. B, 49 years of age, presented for emergency consultation after a traumatic dental injury (Fig. 1).

History of the trauma

The patient fell, after a momentary loss of consciousness caused by self-medication of a contra-indicated substance. On the telephone, the patient described with precision the

type of injury sustained some hours before. She was instructed to come to our office immediately. The circumstances of the accident, the eventual possibility of associated manifestations, as well as an evaluation of the prior condition, are absolutely necessary in order to not risk overlooking any major associated pathology.

Examination and Diagnosis

Examination and diagnosis must be accomplished rapidly and in a manner which adequately determines the degree of involvement of the superficial and deep dental-periodontal tissues (Fig. 2).

Radiographs allow us to establish a positive diagnosis and to ascertain a differential diagnosis: root fracture with displacement of only one or of several fragments; single root fracture or multiple fractures; fracture limited to one tooth or to several teeth; nature of the injury in terms of subluxation (no displacement of the fragments) or luxation (displacement of the fragments) (Fig. 3).



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Fig 4: The classic approach, which is to manually reposition the displaced fragment before stabilizing it, is not the approach which we have used. The reason for this is that an incorrect repositioning may give rise to the interpositioning of fibrous tissue.

Our treatment choice is based on the direct visual re-assembly of the tooth fragments by bonding with the 4-META/MMA/TBB resin adhesive (Superbond®). After local anesthesia, we chose to save the first fragment of tooth, examine it.

Fig. 5:clean the alveolus with gentle rinsing, and then extract the apical fragment.

Fig. 6: The bonding protocol must scrupulously respect the manufacturer's instructions. The coronal piece of tooth must undergo scaling without polishing as well as mechanical bacterial decontamination with air-abrasion, carefully avoiding the apical vascular-nervous bundle.



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With the patient in question, the recent nature of the dental trauma and the fact that treatment will be initiated which will join the fractured parts together are positive factors in the prognosis.

Situated at the apical third of the root, the fracture involves the cementum, the dentin, and the pulp.

Based on the classification of the World Health Organization (WHO), modified by Andreasen (Andreasen, 1981; Andreasen and Andreasen, 1990; 1994), the diagnosis is that of a high root fracture.

Treatment

Since the patient was in no physical pain at this stage of the consultation, although visibly still suffering from the shock of her injury, we were faced with the decision of either extraction or preservation of the tooth.

A decision to extract would leave us with the need for restorative treatments, such as bonded

restorations, conventional fixed bridges, implants, dental transplantation, or a removable prosthesis. Recourse to extraction, which implies that the tooth is not restorable, is more in line with an older established way of thinking than with an approach which takes advantage of the spectacular progress made in the field of adhesive dentistry.

Despite the attempt to save the tooth, the eventual possibility of having to extract was not excluded, but our suggestion that the tooth be preserved using bonding techniques in a single clinical visit was met with the patient's approval (Fig. 4, 5, 6 and 7).

Discussion

Root fractures, while they are relatively infrequent, present difficulties, in terms of treatment, since they involve pulpal, cemental, dentinal and ligamental tissues whose biologic responses to injury are not identical.

Four types of tissular reactions to root fractures



Fig. 7: We then proceed, before actual bonding, with trying the two parts together. This all must be done as quickly as possible and in a humid environment, since it has been estimated that after 60 minutes of being dry the periodontal ligament cells are seriously affected (Andreasen, 1990). Notice the vital pulpal tissue bordering the fracture which will undergo direct pulp capping with Superbond®.

Fig. 8 and 9: We must, again, stress the importance of strictly respecting the rules of adhesion of the adhesive resin. Etching the root surfaces is done with the green activator (aqueous solution of 10% citric acid and 3% ferric chloride) for 10 seconds. This is followed by rinsing and drying in a humid environment.

To the MMA monomer (methyl methacrylate activated by a catalyzer with a TBB base, obtained by partial pre-oxidation of tri-n-butyl boran) is added the polymer PMMA (polymethyl methacrylate) which is ivory in color and applied to the fracture lines with a brush. The excess is eliminated. Setting time is 8 minutes.

without displacement involving the pulp have been described (Andreasen, 1981; Andreasen and Andreasen, 1990; 1994):

1. Healing by apposition of the dentinal and cemental fragments if the fracture is reduced,
2. Healing with interposition of fibrous tissue, if the fracture is not reduced,
3. In the case of an immature tooth, healing with interposition of bone tissue, the coronal fragment independently finishing its apical edification,
4. Absence of healing due to pulpal necrosis and the interposition of granulation tissue.

Our treatment proposal for this high root fracture (HRF) relies on the physical-chemical properties of the 4-META/MMA/TBB adhesive resin, which has proven itself clinically for 18 years.

The two tooth fragments, apical and coronal, were extracted, and, after appropriate treatment, we proceeded with their reunion by bonding. This has a double goal: it permits the repositioning of the coronal portion which has

been luxated; it permits a direct pulp capping of the exposed pulps in order to promote the obtaining of a dentinal bridge obturating the canal opening (Fig. 9, 10, 11, 12, 13, 14, 15 and 16).

Favorable results with this procedure may only be achieved if at least two indispensable conditions are met: extra-oral working time must be less than sixty minutes, and the fragments to be re-implanted must be kept, at all times, in a wet environment. During the working time, bacterial invasion is limited by covering the fragments with a compress impregnated with a mixture of isotonic physiologic serum and an antibiotic such as Lysocline®.

Negative responses to thermal tests, performed at 6 months, resulted in the performance of endodontic treatment, the goal being to avoid any eventual failure resulting from a periodontal lesion of endodontic origin via the accessory canals. Kasahara et.al., 1990,



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Fig. 10: The bonded #11 is immediately re-implanted, then stabilized, taking into account the occlusion, and its two neighbors, using, this time, transparent Superbond powder. The patient is put on antibiotic therapy for 6 days. The stabilization will remain in place for a 3-month period.

Fig. 11: Post-operative radiograph taken immediately after the immobilization of #11.

Fig. 12: Follow-up one month post-operatively. The superficial periodontium shows normal healing. Pulpal response to vitality tests is uncertain.

Fig. 13: Follow-up six months post-operatively. During this time, the loss of coronal tooth substance was restored with a composite restoration. We noted the absence of any clinical signs or symptoms.

Fig. 14: Palatal view. The fibro-edematous appearance of the gingiva is probably related to the patient's tobacco consumption (30 cigarettes per day).

risks of ankylosis and of resorption are the principal factors which may interfere with long-term success.

Conclusion

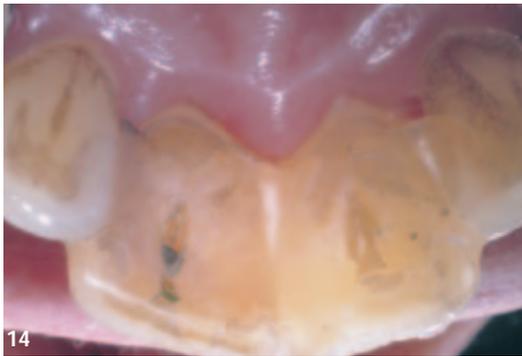
The progress of adhesive dentistry has, historically, been primarily concerned, and spectacularly so, with the hard dental tissues of the clinical crown up to the border of the biologic space. The establishment of the existence of a hybrid layer has encouraged researchers and clinicians, enabling them to move back the boundaries of understanding. The structure of this hybrid layer comes neither from the dentin, (or the cementum, or the bone tissue), nor from the resin, but is a hybridization of the two.

Several innovative researchers have ventured towards the deeper periodontal tissues and their efforts have met with uneven success.

studied 510 maxillary incisors and showed that more than 60% of them had accessory canals). (Fig. 17).

Pulpal necrosis generally remains confined to the coronal fragment, while the apical fragment remains vital (Andreasen Horting-Hansen, 1967).

Follow-ups on re-implanted teeth show that the



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A resin adhesive, 4-META/MMA/TBB (Superbond®), which does not need an adhesion promoter, has proven its usefulness, in very diverse clinical situations, over an 18-year period.

Among its remarkable properties, we see the absence of cytotoxicity with regard to pulpal cells and very high adhesion values to dental substrata. The 4-META/MMA/TGG resin, by its similarity to the dentin, achieves a hybrid layer with the bone (Sakai et.al., 2000a; 2000b), which, if this phenomenon is confirmed, will facilitate a major advance in the progress of bonding: biological bonding via a hybrid layer from the tooth to bone tissue. Masaka predicted the saving of teeth judged to be unsalvageable, and described two protocols: one without extraction and the other with



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Fig. 15 and 16: At six months, radiographic examination of the #11 area using the long-cone technique (Fig. 16), and tomographic scanner image (Fig. 17). (Radiologists Pasquet and Cavézian). In a frontal view, the thickness of the cuts is 4 mm. The examination shows a scar or a root fracture in the apical third of #11.

We may also note an apparent gap at the apical third of the root of #21. This may be interpreted in two ways. Either it is a root fracture of #21 which was present during the first consultation and escaped our clinical notice, or it represents a weakening of the root without fracture which was present, then became established over subsequent weeks. In either case, whatever the hypothesis, spontaneous healing occurred.

We see neither periapical radiolucency nor any sign of bone demineralization at the level of the fracture of #11.

Fig. 17: At this stage, since the pulp did not respond to thermal tests, we decided to perform endodontic treatment on the coronal portion. This was done in order to not compromise our results due to any eventual periodontal lesion of endodontic origin via the accessory canals.

Stabilization, achieved by bonding, was removed on October 30, 2000, seven months after the initial trauma.

Fig. 18. On January 23, 2001, eleven months after bonding. The buccal clinical appearance. Teeth #12 and 21 respond positively to thermal testing.

Fig. 19: Palatal clinical appearance.

ESSENTIAL POINTS TO REMEMBER:

- Emergency dental treatment requires a precise diagnosis and a treatment which is complete and adequate.
- The prognosis of traumatic dental lesions depends on factors whose principal elements are the rapidity of the intervention as well as the means which we use to re-assemble the tooth fragments (recovered by the patient or his/her relatives) or to re-attach the tooth to the periodontal tissues.
- If performed under the same conditions as those employed during a periodontal surgical procedure, or implantology, the techniques of re-implantation associated with adhesive resins permit us to significantly improve the prognosis.
- The adhesive resin 4-META/MMA/TBB (Superbond®), with 18 years of evidence of root bonding in several clinical cases, seems to embody the properties which will lead to maximum success.

extraction. Studied over a 17-year period, the cumulative survival rate (the Kaplan-Meier rate) is 65% at 10 years.

The above factors are the ones which inspired us in our treatment of this HRF and over the 11-month follow-up period since treatment (Fig. 18 and 19).

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