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Case Report

Fragment Reattachment of Immature Permanent Incisors: Clinical Procedures and the Development of an Algorithm

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Abstract

Reattachment of fractured fragments provides the easiest and most aesthetic rehabilitation of fractured teeth, wherever possible. In clinical practice, these cases may have a wide spectrum of presentations, which includes different dehydration times of the fractured fragments, various methods of storage of the fragments, and many reattachment techniques. However, no well-defined protocol exists to guide the reattachment of fractured teeth in such different clinical scenarios. An attempt to develop an algorithm to guide the reattachment of fractured teeth in varied clinical scenarios has been made, using the reports of such cases treated at our center and reviewing the various fragment reattachment techniques mentioned in the literature. This report also describes, in detail, two cases of fractured immature permanent incisors with different extraoral dry time periods (60 days and 18 h) that were successfully treated by reattachment of fractured fragments. Fragment reattachment was found to be a functional and aesthetically acceptable treatment option in restoring the integrity of fractured permanent incisors irrespective of the time elapsed, as the fracture provided the dehydrated fragments was rehydrated before reattachment.

Keywords: Algorithm, dental trauma, reattachment, rehydration, permanent incisor

Introduction

Traumatic dental injuries are common in young children between 6 and 13 years of age, and the degree of damage varies from a simple enamel fracture to avulsion. These injuries may be associated with pulpal involvement or bone fracture.[1] Dentists often treat dental trauma as an emergency to restore the aesthetic, functional, and emotional discomforts[2] that tooth fractures normally entail. The restorative choice is based on the extent of the fracture, patient's age, tooth eruption, root formation, aesthetic expectations, amount and quality of remaining tooth, and pulpal and periodontal involvement. If the pulp becomes exposed, the priority is to preserve vitality using a conservative approach (pulp capping or pulpotomy), depending on the degree of bacterial contamination, root formation, pulp status, and bleeding. In the case of immature young permanent teeth, the main objective of pulp therapy is to maintain pulp integrity, to allow apexogenesis. Besides pulp therapy, the aesthetic and functional restoration of such teeth forms an essential part of the treatment. A perfect

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reproduction of the natural dental color, optical properties, shape, and surface texture is challenging and requires great skill and dexterity when performing coronal reconstruction. Fragment reattachment, wherever possible, serves as a conservative treatment approach, retaining the original tooth color and structure and giving a positive attitude to the patient, both emotionally and economically.[3-5] The procedure is reasonably simple with a long-term, predictable clinical outcome.[3,4] Most of the time, the fractured segment is brought immediately to the dental clinic by the patients for reattachment. However, in a few cases, the fractured fragment is exposed to the extraoral environment to a greater extent due to either the inability to locate and retrieve the fractured fragment or the ignorance among the patients and their parents regarding the possibility of reattachment. This prolonged extraoral time results in dehydration of the fragment with impairment of the aesthetic and mechanical properties. Rehydration of the dehydrated fractured segment has been added as a step in the treatment protocol to increase its durability.[6,7]

This report describes in detail the successful management of two cases reported to our center with fractured immature permanent incisors wherein the fractured fragments had very different extraoral dry time periods. The report also summarizes the methods of fragment reattachment performed in ten more similar cases at our center. From our clinical experience and the available literature, an algorithm that aids decision-making in such clinical scenarios has been proposed.

Case Presentation

Case 1

A 9-year-old male child with a primary complaint of broken upper front teeth due to trauma presented to our clinic. A brief history revealed that the patient had suffered trauma to the upper front teeth because of hitting against a steel rod 2 h prior to reporting. A thorough history and examination revealed that there were no other associated injuries.

Intraoral examination revealed a complicated crown fracture with pinpoint pulpal exposure in the maxillary right central incisor and an uncomplicated (Ellis class II) fracture in the maxillary left central incisor (Figs. 1a, b). The patient had acute pain with severe tenderness on percussion. No mobility was evident, and the surrounding intraoral soft tissues appeared normal. The intraoral periapical radiograph (IOPAR) of the traumatized teeth revealed the root development to be at Nolla's stage 9 in both (Fig. 2a).

On considering factors such as the type of trauma, status of the pulp, and stage of root development, mineral trioxide aggregate (MTA) pulpotomy was initially planned to induce apexogenesis in the maxillary right central incisor followed by coronal reconstruction using direct resin composite in both the teeth.

MTA pulpotomy was carried out for the maxillary right central incisor, and radiographs were recorded to ascertain the adequacy of the MTA plug (Fig. 2b). The access cavity was sealed with glass ionomer cement, and an appointment was scheduled for the coronal reconstruction of the tooth. However, due to personal reasons, the patient missed his appointment. After 2 months, the patient's mother contacted us with the fractured tooth fragment of the maxillary right central incisor wrapped in a piece of paper. On evaluation, it was found that the fractured fragment was fully dehydrated with chalky white color showing complete loss of luster on both enamel and dentinal surfaces although no cracks were evident.

Preparation of the fragment

The dehydrated fragment was immediately placed into the saline solution and subjected to topical fluoride varnish application (Fluoritop SR Varnish, ICPA Health Products Ltd; 22.6 mg F/22 600 ppm) for 30 min and again placed into saline for rehydration until reattachment (Fig. 1c). The patient then reported for treatment after 3 days. The rehydrating fractured fragment, which remained in saline for 72 h, was then reattached.

The coronal tooth fragment was initially secured by a piece of sticky wax to facilitate proper fragment

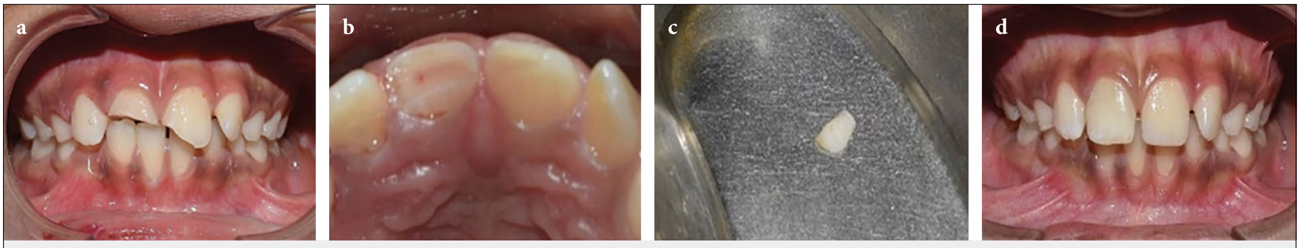

Figure 1. (a) Ellis Class III fracture in 11 and Ellis Class II fracture in 21. (b) Pinpoint pulpal exposure evident in 11. (c) Fragment received after 2 months, placed in saline for rehydration. (d) At 12-month follow-up postoperatively

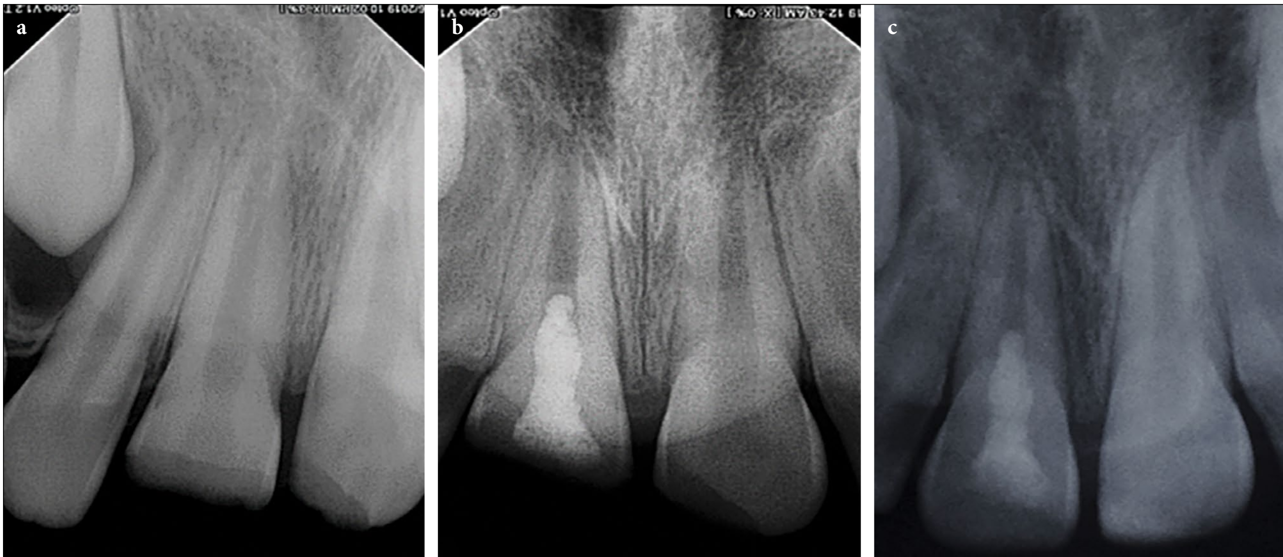

Figure 2. (a) Preoperative IOPAR of 11 and 21, showing Nolla's stage 9 root development. (b) Placement of MTA plug in 11 to induce apexogenesis. (c) Twelve-month follow-up showing continued root development and apex closure

IOPAR: Intraoral periapical radiograph, MTA: Mineral trioxide aggregate

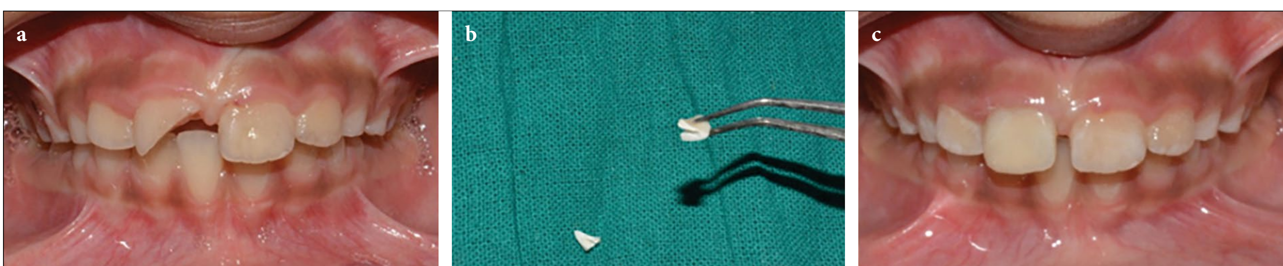

Figure 3. (a) Complicated crown fracture of 11. (b) Fractured fragment retrieved as two units. (c) Reattached fragment after final finishing

handling. The tooth was prepared by enamel beveling, and vertical grooves of approximately 1 mm were placed on both the fractured segment and the tooth surface. Both the surfaces were then treated with 37% phosphoric acid gel for 30 s, followed by adequate rinsing. The bonding adhesive system was applied to the etched surfaces and light cured for 20 s. Flowable composite resin was applied to both the fragment and the tooth surface. The fractured segment was accurately placed on the tooth, ensuring a perfect fit between the segments. After establishing a proper position of the fragments, excess resin was removed, and the tooth was light cured for 20 s on each surface and subjected to finishing and polishing.

Postoperative instructions were given to the patient, and he was periodically reviewed at 1, 3, 6, 9, 12, and 18 months. It was observed that the tooth was asymptomatic, clinically sound, and functionally stable. Aesthetically, the reattached segment was comparable with that of the sound tooth structure despite the prolonged extraoral dry time of the fragment (Fig. 1d). The radiographic evaluation at the periodic follow-up visits showed continued root development with apical closure evident at 12 months (Fig. 2c).

Case 2

An 8-year-old male child presented to our clinic with a fractured upper front tooth following a fall while playing at home the previous day. The patient had recovered the fractured fragments (2 fragments) at the injury site and secured them in a plastic bag under dry conditions. Examination revealed a complicated crown fracture in relation to the maxillary right central incisor with a pinpoint pulpal exposure (Fig. 3a). A radiograph revealed an immature fractured incisor at about Nolla's stage 8 of development (Fig. 4a).

Because of the immature stage of the root development and the pinpoint exposure of the pulp, it was decided to carry out MTA pulpotomy similar to the previous case (Fig. 4b).

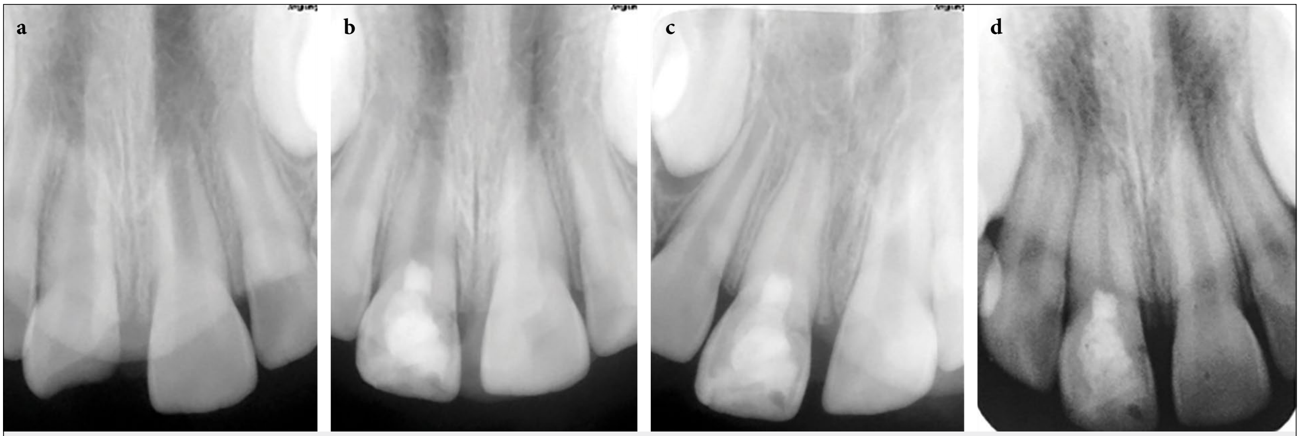

Figure 4. (a) Preoperative IOPAR of fractured 11 revealing Nolla's stage 8 of root development in 11. (b) Postoperative IOPAR after MTA pulpotomy and fragment reattachment in 11. (c) At 9-month follow-up, IOPAR revealed continued root development. (d) At 18-month follow-up, IOPAR revealed completed root development

IOPAR: Intraoral periapical radiograph, MTA: Mineral trioxide aggregate

The fractured fragments were retrieved and evaluated for their fit with the fractured tooth surface during the initial clinical evaluation (Fig. 3b). The fractured dentinal surfaces of the fragments appeared chalky white while some luster was evident on the enamel surface. A careful inspection of fragments did not reveal any cracks or craze lines. Owing to their dehydrated appearance and a dry storage time of approximately 18 h, the retrieved fragments were placed in normal saline for rehydration for 30 min (duration of the procedure). The two fractured fragments were first reattached to each other extraorally using flowable composite resin. Then, the fractured surfaces of the tooth and the fractured segments were prepared to form internal dentinal grooves with a round bur. Following this, the fractured surfaces were etched with 37% phosphoric acid for 15 s, washed with a gentle stream of water, dried, and a thin layer of the dental adhesive was applied and cured for 30 s. The two fragments were then approximated using flowable composite resin on the interface and cured for 40 s after removing the excess with a microbrush. Final finishing was done (Fig. 3c), and a postoperative radiograph was taken to ensure an adequate approximation of the reattached fragments (Fig. 4b).

The patient was discharged with relevant instructions. At the 1-month recall, the pulp sensibility status of the tooth was recorded with an electric pulp tester and was found to be similar to the adjacent sound tooth. The tooth was clinically sound, and the appearance of the reattached fragment matched the adjacent tooth structure. A radiograph recorded to rule out any periodontal changes secondary to trauma revealed a healthy periapical area.

The patient was recalled every 3 months for clinical and radiographic evaluations. After about 18 months, complete apical closure was noted in the treated tooth (Nolla 10) with a sound periapical area (Fig. 4d). At 30 months, the patient remained clinically asymptomatic with the reattached fragments remaining functionally and aesthetically adequate.

Ten unpublished clinical cases of fractured incisors treated at our institute by reattachment of the fractured fragments are summarized in Table 1 to represent the common clinical practice and aid in the development of a protocol.

Discussion

The simple and complex coronal fractures occur in children with the prevalence of 28%-44% and 11%-15%, respectively.[1] For the coronal reconstruction of such teeth, reattachment of the fractured fragment presents one of the most conservative techniques to restore tooth integrity while recovering approximately 37%-50% of the tooth fracture resistance.[3-5] This recovery may increase up to 89% with the placement of retentive features such as internal dentinal grooves.[8,9]

Numerous factors, such as the duration and media used to store the tooth fragment, type of material used for adhesion, use of materials to protect the dentin-pulp complex, and technique used for the reattachment procedure, play an important role in determining the longevity of the reattached tooth fragment [3,7-9].

Hydration of the fractured fragment has a considerable effect on the fracture strength and appearance of the restoration,[6,7,10] with the dry fragments exhibit-

Table 1. Summary of cases with different extraoral dry times of fractured fragments

Serial no.	Age/ gender	Fractured teeth	Fracture type	Extraoral dry time	Rehydration solution	Rehydration time	Treatment	Outcome
1	9 years/M	11	Ellis III	30 min	Saline	15 min	Direct pulp capping followed by fracture reattachment	Follow-up: 30 months Fragment intact
2	14 years/M	21, 22	Ellis III	7 days	Saline	24 h	Simple reattachment followed by pulpectomy	Follow-up: 18 months Fragment fractured again and was reattached
3	10 years/M	11, 21	Ellis II-11 Ellis III-21	13 h	Saline	24 h	Reattachment (dentinal grooves) followed by MTA pulpotomy	Follow-up: 24 months Fragment intact
4	9 years/M	11, 21	Ellis II- 11 Ellis III-21	4 h	Saline	30 min	Enamel bevel followed by reattachment MTA Pulpotomy in 21	Follow-up: Intact till 7 months Lost to follow up
5	8 years/M	11, 21	Ellis III-11, 21	13 days	Saline	>24 h	MTA apexification-21 Revascularization-11 Fracture reattached with simple procedure	Follow-up: 18 months Fragment intact
6	3 years/M	51	Ellis IX	1 day (fragment loosely attached with the tooth)	Saliva	Intra oral	Simple reattachment procedure	Follow-up: 15 months Fragment intact
7	9 years/M	21	Ellis II	>24 h	Saline	24 h	MTA pulpotomy with simple reattachment procedure	Follow-up: 20 months Fragment intact
8	8 years/M	21	Ellis III	>2 h	Saline	30 min	MTA pulpotomy with simple reattachment procedure	Follow-up: 18 months Fragment intact
9	8 years/F	11	Ellis II – 11	27 days	Milk	Washed with saline	Enamel bevel followed by reattachment	Follow-up: 24 months → discoloration at reattachment interface Removed with polishing Fragment intact
10	12 years/M	11	Complicated crown root fracture	2 days (fragment loosely attached with the tooth)	Saliva	Intraoral	Conventional endodontic treatment followed by simple reattachment procedure	Follow-up: 12 months Fragment intact

MTA: Mineral trioxide aggregate

ing less than half of the fracture resistance of those rehydrated in saline.[11] Thus, rehydrating the dehydrated tooth fragment is important in the treatment of fractured teeth and can help prevent bonding failures.

In 2017, Poubel et al[10] reported the effects of different dry and wet storage times on reattached fragments and found that rehydrating a tooth fragment for 15 min before bonding with a multimode adhesive appears to maintain sufficient moisture to increase reattachment strength even when the dry time was up to 24 h. In their in vitro study, Capp et al[12] found that fragment dehydration for 48 h causes a reduction in fracture strength, which gets recovered by 30-min rehydration. In an in vitro study, Shirani et al[6] concluded that specimens of dehydrated tooth fragments rehydrated for 24 h exhibited stronger bonds in comparison to a 30-min rehydration schedule and that the dehydration seemed to plateau at 6 h of dry storage beyond which no significant effect of dehydration was noted on the fracture resistance. Madhubala et al[13] designed a humidification chamber and assessed its efficacy in improving the rehydration of tooth fragments and subsequent fracture resistance after reattachment. The authors found that fragment reattachment after rehydration for 15 min in the humidification chamber showed better fracture resistance than the composite restorations.

Thus, drawing from the available reports of rehydration of dehydrated tooth fragments, it seems reasonable that for a dry storage period of up to 6 h, rehydration of the fragment for 15-30 min should suffice. For tooth fragments with longer periods of dry storage, deferring the reattachment till the next appointment, usually after 24 h, seems prudent to allow maximum recovery of fracture strength. However, these conclusions are based on the evidence from the limited literature available and are an area that needs to be explored further to substantiate more concrete recommendations.

In the first case, the fragment had an abnormally extended dehydration time of 2 months, which is unexplored in the available literature, and thus it was decided to rehydrate the fragment for the maximum recommended period, which is 24 h. However, the fragment was left in its rehydrating solution for >72 h as the patient could not report for his scheduled appointment. In the second case, the fragment was rehydrated for 30 min, after a dry time of about 18 h, which has been the most frequently reported period for rehydration in clinical reports. However, in both cases, restorations appeared functionally and aesthetically adequate at subsequent follow-up periods of 18 months and 30 months, respectively. Thus, from these case reports, it can be suggested that even if the fragment remains dehydrated for long periods of time and presents a contrasting color to the natural shade, reattachment remains a viable treatment option after sufficient rehydration of the fragments.

Another factor that plays an important role in the success of fragment reattachment is the storage media. Unlike the well-established protocols on storage for avulsed teeth, no particular guidelines exist for storing a tooth fragment even though most reports support the idea that the fragment should be kept hydrated. Various storage media such as milk,[10,14,15] normal saline,[10,14] coconut water,[15] egg white, and 50% dextrose[15,16] have been used, and it has been suggested that all these storage media, in particular hypertonic solutions, have positively influenced the bond strength of the fragment resulting in higher fracture resistance when compared with storage in tap water or dry conditions.[16]

The use of a storage medium for a fractured fragment also depends on its availability. In India, coconut water and milk are readily available, making them potential storage mediums for the fractured fragment. In the present cases, 0.9% normal saline, being readily available in the clinic, was used as the storage medium for rehydration of the fractured fragment, which has been suggested as a superior storage media in terms of recovery of fracture resistance.[9]

Apart from the hydration time, storage media, material used, and the design of preparation also govern the fracture strength of the reattached tooth.[7,8,15-18] In the present case, the reattachment was performed with additional surface modifications using enamel bevel and vertical grooves of 1 mm on both the tooth and the fragments. A systematic review of clinical reports and observational studies on fragment reattachment techniques has concluded that simple reattachment can be considered a preferred technique wherever there is complete fragment adaptation, compared with other reattachment techniques using overcontouring and dentinal groove preparation.[7] However, internal grooves and outer bevels have shown significantly higher fracture strength recoveries than simple reattachments in in vitro investigations.[9,18] The use of remineralizing agents such as fluoride varnish and casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) paste on the fractured fragments prior to reattachment has also been reported as measures to improve bond strength but with little evidence.[19]

Considering the lack of well-defined recommendations for performing tooth fragment reattachments to restored fractured incisors, we propose a step-by-step algorithm (Fig. 5) to aid in decision-making in various clinical scenarios requiring tooth fragment reattachment based on the limited evidence available on the topic and our clinical experience with such cases. We hope this will inspire more research in the field and eventually lead to the development of evidence-based, meticulous, step-by-step guide in addressing tooth fragment reattachments.

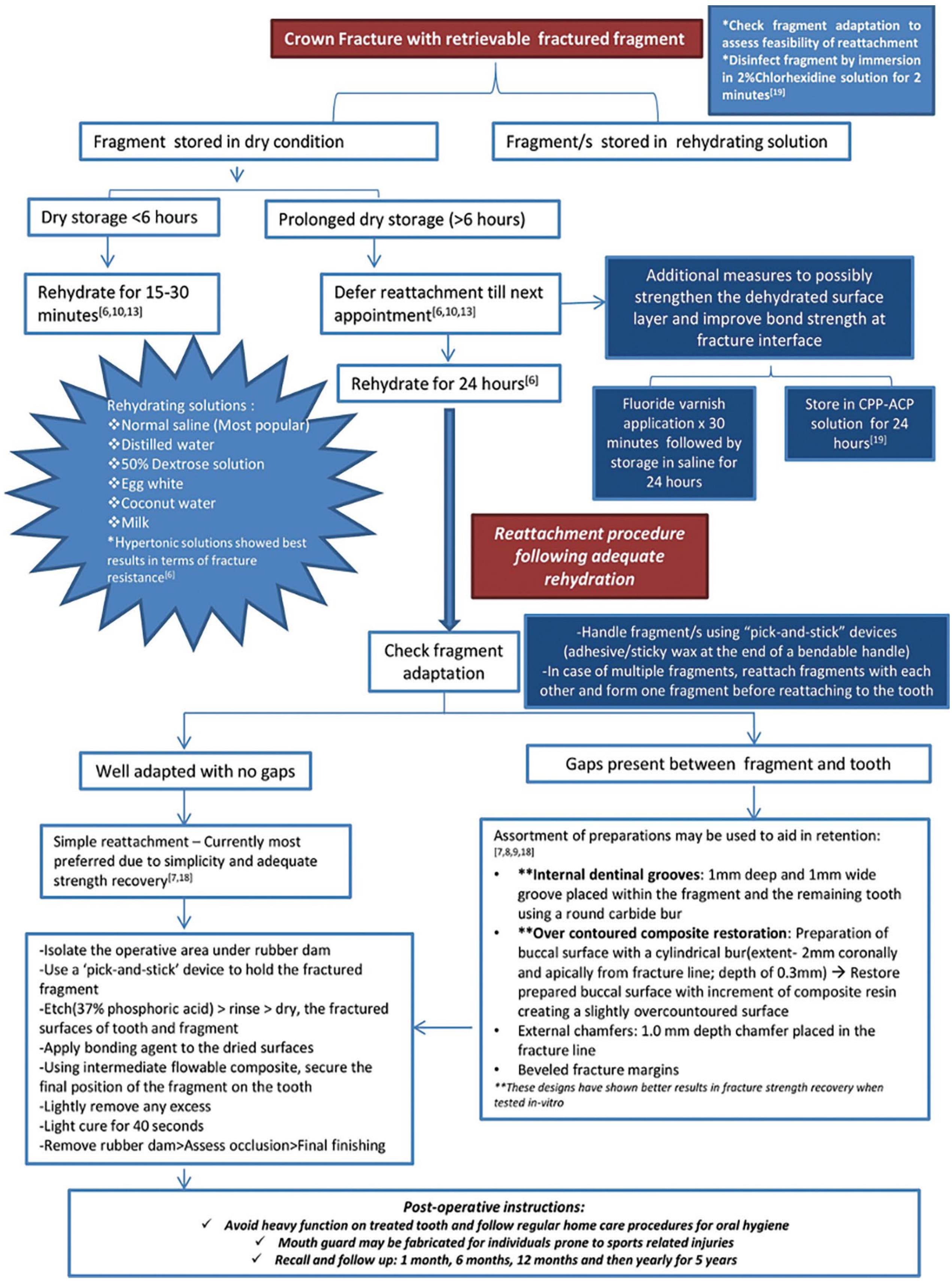

Figure 5. Step-by-step algorithm to aid in decision-making when reattaching a fragment to a fractured permanent incisor

Conclusion

- Two cases presented with fractured fragments exposed to highly varying dry time periods (60 days and 18 h) and were thus subjected to different rehydration regimes. In both cases, the reattached fragments appeared aesthetically and functionally stable at subsequent examinations.
- A concise, step-by-step algorithm has been proposed based on available literature and the authors' clinical experience, to aid dental practitioners in managing fractured permanent incisors with retrievable fragments.

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