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Early detection of pulp necrosis and dental vitality after traumatic dental injuries in children and adolescents by 3-Tesla magnetic resonance imaging

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ABSTRACT

Objectives: More than 50% of all children suffer a traumatic dental injury (TDI) during childhood. In many cases, dentists apply root canal treatment (RCT), which is performed on an average of 7–10 days after replantation. Our aim was to evaluate whether RCT is necessary in many cases, and whether revitalization of affected teeth is possible and measurable by visualization using 3T magnetic resonance imaging (MRI).

Material and methods: Seven healthy children with TDI were treated by repositioning of the affected teeth and reduction of alveolar process fractures followed by splinting. Two weeks after initial treatment, splints were removed. After 6 weeks, all children received 3-Tesla (3T), three-dimensional, high-resolution MRI with a 20-channel standard head and neck coil. The mean age of the children (male/female = 5:2) was 10.8 years (range, 8–17 years). In addition, all children received conventional dental examination for tooth vitality and dental sensitivity to cold and tenderness on percussion.

Results: 3T MRI provided excellent images that allowed fine discrimination between dental pulp and adjacent tooth. Using four in-house optimized, non-contrast-enhanced sequences, including panoramic reconstruction, the assessment and analysis of the dental pulp was sufficiently feasible. We could demonstrate reperfusion and thus vitality of the affected teeth in 11 sites. In one child, MRI was able to detect nonreperfusion after TDI of the affected tooth. MRI results were confirmed by clinical examination in all cases. As a consequence of this expectant management and proof of reperfusion and tooth vitality by 3T MRI, only one child had to be treated by RCT.

Conclusion: 3T MRI is a very promising tool for visualization and detection in the field of dental and oromaxillofacial diseases. By using new 3T MRI sequences in children with TDI, we could demonstrate that RCT are not necessary in every case, and thus could prevent unnecessary treatment of children in the future. Larger studies should follow to confirm the potential benefit in clinical practice.

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1. Introduction

Traumatic dental injuries (TDI) are considered a serious public health problem, especially in children (Unal et al., 2014). Most teeth affected by dental trauma are the maxillary central incisors (Francisco et al., 2013). Nearly one-fourth of all schoolchildren and almost one-third of adults have experienced trauma to the permanent dentition (Glendor, 2008). The prevalence of TDI ranges from 6.4% to 37.9% in 6- to 17-year old children (Brüllmann et al., 2011, Brüllmann and Mouratidou, 2014). TDIs present with different etiologies associated with age. In boys at the age of 8–11 years, playground accidents and cycling are common causes of TDIs. In contrast, in adolescents, sport activities and assaults are the main causes of TDIs (Emerich and Wyszkowski, 2010; Cetinbaş et al., 2008; Bücher et al., 2013). Several classification systems have been suggested for TDIs to allow treatment decisions; nevertheless, an ideal and generally accepted classification has still not been established. Such a classification should include all possible sites and should be applicable to both primary and permanent dentition (Andreasen and Andreasen, 1994, 2000; Toprak et al., 2014). The most commonly used classification and guidelines for the evaluation and management of traumatic dental injuries was recently published by the International Association of Dental Traumatology (IADT) (Flores et al., 2001; Toprak et al., 2014). Traditional treatment of teeth following TDIs includes reposition and semi-rigid fixation of the affected teeth using different treatment procedures, e.g., flexible wire-composite splints, twist-flex splints, or deep drawing templates. Follow-up procedures for avulsed permanent teeth is recommended in all cases. As advocated in the current treatment guidelines for avulsed permanent teeth, initial root canal treatment (RCT) is recommended after a period of 7–10 days postreplantation, especially in permanent teeth with closed apexes (Flores et al., 2007). For permanent teeth with open apexes, the guidelines recommend to allow for possible revascularization of the tooth pulp. If that does not occur, root canal treatment may be recommended (Flores et al., 2007). In teeth with open apexes that have been replanted immediately or kept in appropriate storage media, pulp revascularization is possible. Root canal treatment should be avoided unless there is clinical and radiographic evidence of pulp necrosis (Flores et al., 2007; von Bühren et al., 2014). However, early clinical and radiological investigations after dental trauma cannot reliably assess the chance for revascularization, so verification of revascularization remains uncertain.

In recent years, magnetic resonance imaging (MRI) has become more and more one of the leading imaging techniques in the field of head and neck imaging. Even without the use of ionizing radiation, soft tissues as well as bone marrow can be shown in excellent image quality (Gahleitner et al., 1999). As recently published, diagnostic capabilities have progressed over the last decades, and also the detection of oral and maxillofacial pathologies including the dental pulp have recently reached the level of clinical application (Assaf et al., 2014). For patients with TDIs, first-line investigations are currently periapical radiographs and panoramic radiographs, eventually complemented by conventional computed tomography (CT), or cone beam computed tomography (CBCT) (Flores et al., 2007; Toprak et al., 2014). In comparison to these imaging techniques, MRI is superior for the visualization of soft tissues, including the dental pulp (Assaf et al., 2014). CT or CBCT scans are preferred for the detection of hard tissue pathologies of oral and maxillofacial structures (Kataoka et al., 2005). Useful sequences for the diagnostic imaging of the different structures of the oral cavity, with or without the administration of contrast-enhancing substances, are native T1-, fat-saturated T1- (fsT1), fat-saturated T2- (fsT2), and constructive interference steady-state sequences (CISS) (Keberle et al., 2002; Assaf et al., 2014). The use of 1.5-Tesla (T) MRI for oral and maxillofacial structures, especially dental and periodontal structures, seemed to be insufficient and thus has not been used in routine clinical practice until recently (He et al., 2013). The only exception was the visualization of the temporomandibular joint (TMJ) and salivary glands at 1.5T (He et al., 2013; Assaf et al., 2014). Although 3T MRI allows better image quality, e.g., for the demonstration of incisive canals by using modified T2 sequences (Krasny et al., 2012), 3T MRI also allows one to verify pathologies of further anatomical structures, e.g., salivary glands or cystic lesions (Habermann et al., 2007; Petridis et al., 2007; La'Porte et al., 2011; Assaf et al., 2014). One of the major limitations of MRI, compared with other imaging techniques such as CT or CBCT, is the long scanning time required due to diverse sequences with different image contrast (T1, T2, CISS), which makes its application tricky, especially in children. Besides, the use of contrast agents such as gadolinium (Gd) should be used very restrictively in children.

The aim of this study was to evaluate whether 3T MRI, using four in-house optimized, non–contrast enhanced sequences, offers new opportunities to approve the revascularization of teeth after TDIs, especially after avulsion and distinctive luxation of teeth. Using 3T MRI for verification, we hope to prevent some children in the future from having to undergo root canal treatment after TDIs, especially in cases in which posttraumatic clinical examination cannot reliably verify a revascularization of teeth.

2. Material and methods

2.1. Patients

This prospective study included seven healthy children with the diagnosis of dental trauma (2 girls, 5 boys), mean age 10.6 years (range, 8–7 years). Initial diagnosis was an avulsion of tooth 11 in 3 children (43%), an extrusion and lateral luxation of teeth 12, 11, and 21 in 1 child (14.25%), an intrusion of tooth 11 combined with a subluxation of teeth 12 and 21 in one child (14.25%), an extrusion and lateral luxation of teeth 12 and 11 in 1 child (14.25%), and a subluxation of tooth 12 in 1 child (14.25%) (Table 1).

2.2. Treatment protocol

All children were first seen at the emergency room of our university medical center. Initial examination was performed by a specialist in oral and maxillofacial surgery. All children received individual imaging to exclude dental fractures of the affected teeth. Only children without dental fracture were included to this study. All children were then treated using semi-rigid fixation of the affected teeth using flexible wires. Regarding to the current guidelines (Flores et al., 2007), semi-rigid fixation was kept for minimum of 14 days, extended to a maximum of 21 days (Table 1). Clinical follow-up examinations were performed after 7, 21, 42 days, 3 months, and 6 months, including vitality testing of teeth by cold test. Finally, after a period of 6 weeks posttrauma, MRI was performed to evaluate whether changes of dental pulp could be made visible to verify a possible revascularization of the dental pulp (Table 1).

2.3. Methods

This study was a human observational study and conformed to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement guidelines. All children underwent MRI investigation as part of a clinical trial study that was approved by the local ethics committee (PVN3827). All children, as well as their parents, gave informed consent prior to the MRI