By Dr Angel Sigurðsson, USA

When treating dental trauma, the timeliness of care is key to saving the tooth in many cases. It is, therefore, important for all dentists to have an understanding of how to diagnose and treat the most common dental injuries. This is especially critical in the emergency phase of treatment. Proper management of dental trauma is most often a team effort with general dentists, pediatric dentists or oral surgeons on the front line of the emergency service, and endodontic specialists joining the effort to preserve the tooth with respect to the pulp, pulpal space and root. An informed and coordinated effort from all team members ensures that the patient receives the most efficient and effective care.

Recently, a panel of expert members of the American Association of Endodontists prepared an updated version of Guidelines for the Treatment of Traumatic Dental Injuries. These guidelines were based, in part, on the current recommendations of the International Association of Dental Traumatology (see www.iadtdental-trauma.org for more information). This article provides an overview of the AAE guidelines; the complete guidelines are available for free download at www.aae.org/clinical-resources/trauma-resources.aspx. The benefit of adhering to guidelines for treatment of dental trauma was recently shown in a study by Bucher et al. The study found that, compared with cases treated with out compliance to guidelines, cases that adhered to guidelines produced more favorable outcomes, including significantly lower complication rates. The study also found that early follow-up visits were essential to ensure prompt treatment of complications when they arose.1

Emergency care
Prior to any treatment, one must evaluate the injury thoroughly by careful clinical and radiographic investigation.

It is recommended to follow a check list to ensure that all necessary information regarding the patient and the injury is gathered, including: 1) Patient’s name, age, sex, address and contact numbers (include weight for young patients). 2) Central nervous system symptoms exhibited after the injury. 3) Patient’s general health. 4) Where, when and how the injury occurred. 5) Treatment the patient received elsewhere. 6) History of previous dental injuries. 7) Disfigurements in the bite. 8) Tooth reactions to thermal changes or sensitivity to sweet/acid. 9) If the teeth are sore to touch or during eating. 10) If the patient is experiencing spontaneous pain in the teeth. Once all of this information is gathered, a diagnosis can be made and appropriate treatment rendered. If the injured individual is not a patient of record, all necessary demographic information should be gathered as soon as the patient arrives and prior to any assessment.

In the case of avulsion and the tooth being out of its socket, one should immediately place the tooth in a physiological solution of specialized media (such as Hank’s Balanced Salt Solution) or milk, or saline if those are not available. Only after the tooth is secured in solution should one obtain the patient’s information. Once the patient is seated in the dental chair, it is necessary to do a quick central nervous system (CNS) evaluation before proceeding with further assessments.

Often, the dentist is the first health care provider to see the patient after a head injury (any dental trauma is, by definition, a head injury) and must assess the risk of concussion or hemorrhage. It has been estimated by a meta-analysis that the prevalence of intracranial hemorrhage after a mild head injury is 8 percent, and the onset of symptoms can be delayed for minutes to hours.2 The must common signs of serious cerebral concussion or hemorrhage are loss of consciousness or post-traumatic amnesia. Nausea/vomiting, fluids from the ear/ nose, atypical confusion, blurred vision or unexplained pupil, and difficulty of speech and/ or slurred speech may also indicate serious injury.1

Once the patient has been cleared of any CNS issues, the dental trauma should be assessed. The key is to obtain comprehensive information about the injury and, to do so, one must conduct thorough extra-oral and intraoral clinical exams as well as appropriate radiographic evaluations. The new AAE guidelines recommend taking one occlusal and two periapical radiographs with different lateral angulations for all dental injuries, including crown fractures. If cone-beam computed tomography is available, it should be considered for more serious injuries, such as crown/ root and alveolar fractures, as well as all location injuries.

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Table 1. Follow-Up Procedures for Fractured Permanent Teeth and Alveolar Fractures

<table>
<thead>
<tr>
<th>TIME</th>
<th>Crown Fracture</th>
<th>Crown-Root Fracture</th>
<th>Root Fracture</th>
<th>Alveolar Fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Weeks</td>
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<td></td>
<td>Uncomplicated</td>
<td>Complicated</td>
<td>Uncomplicated</td>
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<tr>
<td></td>
<td>Splint removal* clinical and radiographic control</td>
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<td>Splint removal* clinical and radiographic control</td>
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<tr>
<td>6-8 Weeks</td>
<td>Clinical and radiographic control</td>
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<td>Uncomplicated</td>
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<td>Splint removal* clinical and radiographic control</td>
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<td>Splint removal* clinical and radiographic control</td>
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<tr>
<td>6 Months</td>
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<td>Uncomplicated</td>
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<td></td>
<td>Splint removal* clinical and radiographic control</td>
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<td>Splint removal* clinical and radiographic control</td>
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<td>1 Year</td>
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<td>Uncomplicated</td>
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<td>Clinical and radiographic control</td>
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<td>Clinical and radiographic control</td>
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<tr>
<td>3 Years</td>
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<td>Uncomplicated</td>
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<tr>
<td></td>
<td>Clinical and radiographic control</td>
<td></td>
<td>Clinical and radiographic control</td>
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*Splint removal in apical third and root fractures. **Splint removal with a root fracture near the cervical area

Dental Tribune Middle East & Africa Edition  | 3/2017
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<table>
<thead>
<tr>
<th>Type of Injury</th>
<th>Follow-Up Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root fractures</td>
<td>Splint removal and clinical and radiographic examination</td>
</tr>
<tr>
<td>Luxation injuries</td>
<td>Periodic examination</td>
</tr>
<tr>
<td>Intrusion injuries</td>
<td>Splint removal and clinical and radiographic examination</td>
</tr>
</tbody>
</table>

Additionally, sensitivity tests should be conducted on all teeth involved as well as opposing teeth. Cold testing is recommended, however, if testing in young individuals. Both testing methods should be considered, especially when there is no response to one of the two. The pulp might be non-responsive for several weeks after a traumatic injury, so a pulp test should be done at every follow-up appointment until a normal response is obtained.

Once the diagnosis is confirmed and more serious complications such as CNS and jaw or other facial bone fractures have been ruled out, the emergent phase of the treatment needs to be evaluated. The aim of treating dental trauma should be to either maintain or regain pulpal vitality in traumatized teeth. This is because dental trauma most frequently occurs in preteens or young teens in whom the teeth have not yet fully developed, and root development will cease without a vital pulp.

Clinical examples

Dental trauma can be roughly divided into two groups: fractures and luxation injuries. The fractures are then divided into closed crown, crown-root, and root fractures. If the pulp is exposed to the oral environment, it is called a complicated fracture; if not exposed, it is called an uncomplicated fracture.

Crown fractures:
The first thing to do in any crown or crown-root fracture is to look for the broken-off tooth fragment. With modern bonding technology it is possible to rebuild the fragment to the tooth, which is esthetically and functionally the best solution. Prior to reattaching the tooth fragment, the remaining dentin should be immediately covering the pulp needs to be assessed radiographically and clinically. If there is at least 2/3 of the crown involved, or the height of the crown being indicated, there is no need to cover it with a protective liner. If it is estimated that the remaining dentin is less than 0.5 mm, it is advisable to cover the odontogenic tissue in the interdental space with a cavity liner, and then dimple the fragment accordingly.8 The tooth fragment kept dry, it should be rehydrated in distilled water or saline for up to 30 minutes prior to reattachment. This process will increase its bonding strength.8

In a complicated fracture, the goal is to create a bacteria-tight seal to protect the pulp, after ensuring that the pulpal wound is clean and all inflamed tissue removed.9 The two best capping materials available today are calcium hydroxide and mineral trioxide aggregate (MTA), but newer bioceramic materials are showing promise for this application. It is advisable to create a 1-mm reservoir into the pulp with a high-speed diamond bur and copious water-coupling, placing the capping materi-al, and then either reattach the tooth fragment or restore the crown with a composite resin material (Figs. 1a–c).

Crown-root fractures
One of the more challenging types of fracture to treat is the crown-root fracture because the fracture margins have to be exposed around the tooth/ tooth fragment to expose the pulp. This can be accomplished by gingival retraction if the fracture line is in the sulcus, or in more extreme cases, the tooth will have to be extruded with orthodoxodontic or surgically repositioned. In the emergency session, if the pulp is exposed, it needs to be protected in the same fashion as complicated crown fractures.

If the pulp is not exposed, all accessible exposed dentin areas should be covered for the patient’s comfort.

Pulpal survival for all these fracture types is generally good; however, endodontic considerations should be made in the lit-ler stage. Therefore, it is of utmost importance that a recall schedule is followed and that the teeth involved in the trauma are tested every time. This is outlined in Table 2 and includes the recommend- ed recall rates for most common dental injuries. It is not uncommon for there to be no response to vitality tests for up to three months, and a single response to vitality tests does not always indicate that root canal treatment is needed—especially in young and immature teeth. Rather, it is advisable to look for at least one other sign of pulp necrosis, such as vestibule swelling, perilapical lesions and/or a change of color of the crown. If no signs exist, continue to monitor the patient at regular apointments every three months, for up to one year.

Root fractures
The pulp is affected in all root frac-tures. However, if the fragments are approximated soon after the frac-ture, there is a good chance that no endodontic treatment is necessary, just observation. With good approxima-tion, it is likely that the pulp will remineralize across the fracture re-gardless of the age of the patient.27,28 If the tooth has been dry for more than 30 minutes, specialized media or milk for a few minutes will help to remineralize the root canal.29,30 If the avulsed tooth has an open apex, it is recommended to wait three weeks and watch for signs of re-eruption. If no signs exist, one can initiate orodontogenic repositioning. For intru-sion of more than 3 mm, surgical or orthodontic repositioning should be considered with three weeks.

In the case of an intruded tooth with a closed ap- ex, there is a possibility of re-eruption if the tooth is slightly intruded (less than 3 mm) and the patient is younger than 17 years old.31 If the tooth is not moving after two to three weeks, however, orthodontic extrusion or extraction and re-implantation is recommended. If a tooth is intruded more than 3 mm, orthodontic or surgical repositioning should be performed within three weeks. The risk with all intrusions is that the intruded teeth may ankylose in the infraosseous space.

Once that begins, the tooth may not be movable except possibly surgically. It is well to advise the patient and the parents/guardians that the long-term prognosis of an intruded tooth is unpredictable, as it is likely to eventually be lost due to ankylo-sis.32

Splinting of a luxated tooth is recom-mended only for teeth that are still mobile and non-repositioning. In all types of trauma cases, a splint must allow for physiological move- ment (Figs. 4a–c). (See Table 3 regarding splinting time.) When assessing luxation trauma, it is important to consider the maturi- ty of the apex. If it is still open, there is a chance that pulp survival will survive the trauma or remineralize, allowing the growth of the tooth to continue (Figs. 4a–c).

If the apex is closed, endodontic treatment is likely needed. It is ad-vise-able to follow the patient closely, and examiner should be aware if this case, a 16-pound fishing line was used as the splint on the luxated tooth. Fig. 5: Once the tooth has been repositioned, the patient bites into a softened piece of gauze which is placed next to the tooth to eventually be lost due to ankylo-sis.

Avulsion
The time outside of the socket for an avulsed tooth to be reimplanted is the PUL of its survival. If the tooth is replanted within 30 minutes, or alternative if kept in a physiological solution of specialized media or milk for a few minutes, almost all cases can be salvaged.31,32 If the tooth has been dry for more than one hour, the periodontal ligament will be injured and the tooth will likely become non-vital.33,34 If this tooth is replanted with the apex intact, the tooth needs to be stabilized with a physiological splint for two weeks.35

Table 3. Splinting Timing for Various Types of Luxation

<table>
<thead>
<tr>
<th>Type of Injury</th>
<th>Splinting Time</th>
</tr>
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<tbody>
<tr>
<td>Subluxation</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Lateral luxation</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Intrusion</td>
<td>4 weeks</td>
</tr>
<tr>
<td>Root fracture</td>
<td>4 weeks</td>
</tr>
<tr>
<td>Alveolar fracture</td>
<td>4 weeks</td>
</tr>
</tbody>
</table>

It is important to remember that dental injuries do not fall into one group or category, but often a combination of several categories. Injuries in multiple categories may impact the outcome. For example, it was recently demonstrated that the existence of a concomitant luxation injury with an uncomplicated crown fracture and non-repositionable root development are significant risk factors of pulp necrosis.36

Endodontic treatment should be performed later only if signs of pul-...
Minimally invasive implant placement without the use of biomaterials using the bone expansion technique

By Dr Gilles Chaumanet, France

The success rate in implantology is close to 96 percent. Thanks to well-established implant placement protocols, with a few differences according to the implant system used, the predictability of the result under optimum tissue conditions is quite significant. It is very different when these conditions do not meet the recognized standards in terms of volume and quality for reproducibility in implantology. For example, thin ridges, which are frequent occurrences, will require a long and costly process for patients because they entail bone augmentation or possibly support tissue grafts.

Is there a minimally invasive alternative for these patients that allows them to be treated without these problems? One line of thinking is to stop the systematic practice of implant placement without the use of biomaterials using the bone expansion technique.

The general surgical principle of modern implantology, called osteotomy, as close as possible to the dimensions of the implant that will be placed. This principle is still widely prevalent.

However, soft-tissue management has evolved, and the trend the past few years has been to manage soft tissue from the first surgical step. With the arrival of self-tapping conical implants, a new technique was developed that enables lateral as well as vertical bone crestal condensing or expanding. In addition, to isolate the epithelial and connective tissues, the use of biocompatible membranes (or native collagen membranes) is placed in the osteotomy space to facilitate bone formation inside this space.

These principles are (Fig. 2):

• Creation and maintenance of a space to facilitate bone formation inside this space.
• Stabilization of the surgical site to induce blood clot formation and facilitate healing.

Thanks to the careful choice of the healing screw or the implant abutment, it is possible to be minimally invasive, precise and also avoid the use of biomaterials simply by exploiting the biomechanical properties of bone tissue and its capacity to regenerate. Respecting guided regeneration principles, which means the correct sinus lift technique with careful selection of conical taps, was the first to demonstrate the capacity of cancellous bone to be modeled (Fig. 3).

Through two clinical cases, we will see it is possible to be minimally invasive, precise and also avoid the use of biomaterials simply by exploiting the biomechanical properties of bone tissue and its capacity to regenerate. Respecting guided regeneration principles, which means the correct sinus lift technique with careful selection of conical taps, was the first to demonstrate the capacity of cancellous bone to be modeled (Fig. 3).

Case 1

The #16 was carefully extracted by radicular separation to avoid bone fracture especially in the vestibule where the cortical bone is very thin. The lamina dura, which enables the attachment of collagen and Sharp’s fibres, presents a high potential for contamination. Consequently, a light manual curettage of the socket was carried out, followed by a superficial debridement (vaporisation) of the entire lamina dura with an Erbium laser (2,940 nm) followed by decontamination with a diode laser (940 nm).

This was a flapsless surgery. The expansion osteotomy was performed using the osteosynthesis technique. It was initiated with a very thin manual bone tap (poised) and then an automatic mechanical osteotome (Figs. 4-5) (DentsplySirona®-Aurora) was used. The use of convex inserts in the beginning enables lateral expansion of the native or healed bone and then concave inserts during the breaking of the last sub-sinus millimeter enables lateral bone recovery of this bone socket while projecting it apically.

During sinus progression PRF membranes (or native collagen membranes) are placed in the osteotomy opening to fill the in situ sinus space that is thereby gained (they also provide protection of the sinus membrane).

The Erbium laser is again passed through the osteotomy socket to vaporize the bone debris and sludge along the walls of this osteotomy. The implant is placed according to the manufacturer’s recommendations but with an even slightly higher torque if the titanium grade so allows. A healing screw that fits the diameter and height of the residual gap to be closed is carefully chosen (Fig. 6).

If the healing screw does not enable primary closure of soft tissue, PRF membranes are used to fill the gap. If this gap is too big, a mucoperiosteal detachment of 6-10 mm and then a horizontal incision of the peristium of 6-8 mm are made. This technique serves to pull the gum around the healing screw by maintaining it with two sutures. The control X-rays clearly showed good osseointegration of the implant, significant filling and regeneration in only three months, and then perfect filling and regeneration four months after surgery.

The bone remodeling around and above the implant neck also seemed to develop more rapidly.
to be well executed. The cone beam 3-D imaging in the first place showed a healthy sinus without inflammation or infection as well as bone re-modeling at the apex and around the implant (Fig. 7-8).

In the case of a trans-alveolar sinus lift combined with the placement of an implant by bone expansion, convex-tipped inserts should be used first to enable lateral expansion, and then concave inserts enable scraping of the bones of the lateral walls of the osteotomy to enable apical projection after breaking the last millimeter under the sinus floor. If a mandibular implant is to be placed completely in native bone, convex inserts suffice. The last insert that is placed is smaller in diameter than the implant that is chosen.

The advantage of this technique was noted starting in 1997 by Summers himself with the use of conical osteotomes as opposed to cylindrical os-teotomes, which were all that were available up until then. The idea was actually to enable lateral peri-implant bone condensing in order to increase notably, primary stability and compensate for the lack of vertical dimension of the sub-sinus native bone.

The objective of this technique is to maintain, if possible, the entire maxillary bone by laterally pushing back the bone with minimal trauma while creating a precise osteotomy that breaks the last millimeter of the sinus floor while protecting the sinus membrane. The consequence is the notable increase in peri-implant bone density with a high elevation of BIC (Bone-Implant Contact) and, therefore, bone stability.

Case 2
The patient presented with a fracture of 24/4 with significant periradicular infection (Figs. 9-10).

It was decided that an extraction would be performed with immediate placement and loading of an implant after complete decontamination of the extraction socket using lasers (Figs. 11-12). Next, OsseoSafe® was used (Fig. 13) to enable gentle trabecular expansion and placement of a self-tapping conical implant (Astrom® Pico® Ant hogly).

In this case, where bone recovery along the osteotomy walls was not necessary, only convex tapers were used. The palatal and substructural position of the implant is respected (Fig. 14). The gap between the implant and the vestibular cortical bone is not filled. Careful choice of the implant abutment may induce this tissue regeneration for its regeneration. For immediate post-extraction implant placement, lasers (Figs. 11, 12) and the implant abutment, enabling slight compression of soft tissue and providing the implant/prosthetic connection system with a barrier that enables the regeneration of the two families of tissues.

These minimally invasive techniques still require many improvements and more widespread validation. However, for both technical and safety reasons, the practitioner should always suggest the least invasive technique that contributes to, guides and induces this tissue regeneration for which, most of the time, we have the matrix around these traumatized zones.

Conclusion
Traumatic dental injuries present difficult challenges for both patients and their dentists. Current evidence allows the dental health care provider to manage situations that, in the past, often resulted in crippled dentition and unsightly appearance. Appropriate treatment can turn what at first glance looks like a hopeless situation into a very satisfactory outcome for patients. The endodontic specialist can play an important role in the team approach to treating patients with traumatic dental injuries.

References

Dr. Gilles Chauvinat

Dr. Gilles Chauvinat graduated from the University of Nantes in 1993. He has worked in more than 15 different countries on four continents. Since 2000, the practice of his field in his country has revolutionized his procedures. His practice is limited to oral surgery and implantology in Paris and Venice, Italy. He holds different options and post-graduates in laser, periodontology, implant therapy, oral surgery, anatomy and endodontology. He is president of SOLA France (Société pour Oral Laser Application), ambassador of Global Oral Implant Congress, active member of CENALO, member of Italian Society of Oral Surgery (SICO) and member of AG2L Academy. He lectures widely in Europe, America and the Middle East. He is in private practice in Villemeur-Lobet (France) and Venice (Italy).