EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Volume: 7
Issue: 8
161-166
Year: 2020

POST-TRAUMATIC MAXILLOFACIAL DEFORMITIES: A NARRATIVE REVIEW

Dr. Sweta Singh*

Consultant and Head, Dental Services, Paras Hospital, Ranchi, Jharkhand.

***Corresponding Author: Dr. Sweta Singh**
Consultant and Head, Dental Services, Paras Hospital, Ranchi, Jharkhand.

Article Received on 02/06/2020 **Article Revised on 23/06/2020** **Article Accepted on 14/07/2020**

ABSTRACT
Post-traumatic maxillofacial deformities (PTMDs) are very difficult to correct, and if they do occur, their impact can be devastating. It may sometimes be impossible for patients to return to normal life. The aim of surgical treatment is to restore the deformed bone structure and soft tissue to create symmetry between the affected side and the opposite side. In the process of managing PTMD, correcting enophthalmos is one of the most challenging aspects for surgeons because of difficulties in overcoming the scar tissue and danger of injuring to the optic nerve. In this article, surgical options for reconstruction of the face and medial wall, floor, lateral wall, and roof of the orbit and maxilla and mandible repair are explored and described. Dental and plastic surgeons should join emergency trauma teams to implement an overall treatment plan containing rational strategies to avoid or minimize PTMD. To optimize aesthetic improvement, additional cosmetic procedures such as facial contouring surgery, blepharoplasty and rhinoplasty can be used.

KEYWORDS: Post-traumatic maxillofacial deformities; Orbital fractures; Dental surgery.

INTRODUCTION
For a variety of reasons, trauma patients can experience unsuccessful initial management and the associated morbidities of a post-traumatic craniofacial deformity that would benefit from secondary correction. Experienced surgeons recognize the challenge of restoring premorbid form and function to patients with established deformities after craniofacial trauma.

Advanced trauma life support (ATLS) is the first step that should be applied in emergency cases. Airway obstruction should be evaluated as soon as possible since the mid-face is the beginning of the respiratory pathway. Hemorrhage and secretions may obstruct the oropharynx and nasopharynx. Removal of fractured teeth, clots, and loose dental crowns or dentures is important to open the oral airway. Packing should be used to control acute bleeding. Intubation to secure the airway in instable mid-face fractures is the next step that should be considered in emergency patients.[1,2] It is important to keep the airway open in mid-face fractures because there is always the potential of airway obstruction due to displacement of bones or severe bleeding in such cases. Cervical spine injuries are common in facial fractures. The incidence rate of cervical spine trauma in pediatric facial fracture cases is almost 3.5%.[3] whilst this number is much higher in adult trauma patients.[4] According to the possibility of spinal injuries in facial trauma patients stabilizing the cervical spine by a rigid collar is necessary until the spinal injury is ruled out. After providing a secure airway, ATLS protocol can continued. When the patient is stable, facial examination to detect the mid-face fractures is executed.

DISCUSSION
The factors that lead to persistent deformities after craniofacial trauma includes: 1. severe comminution (especially that which requires bone grafting) 2. lack of definitive treatment 3. excessively delayed initial treatment 4. inadequate initial surgical repair.

1. Maxillofacial fractures
Le Fort fractures Classification: Le Fort fractures are classified as three types. Le Fort I injury is defined as separation of maxilla from the mid-face (Figure 1A). Nasal septum, lateral nasal walls, lateral maxillary sinus wall, and pterygoid plates are involved in these kinds of fractures. Le Fort II fracture is also called the pyramidal fracture pattern which is identified by the separation of nasomaxillary complex (Figure 1B). Nasal and lacrimal bones, nasofrontal suture, infraorbital rims, and pterygoid plates are involved in this fracture pattern. Le Fort III also known as craniofacial dissociation is detected by the separation of the whole mid-face from the skull (Figure 1C). This fracture occurs in nasofrontal and zygomaticomaxillary sutures, zygomatic arch, and pterygoid plates.

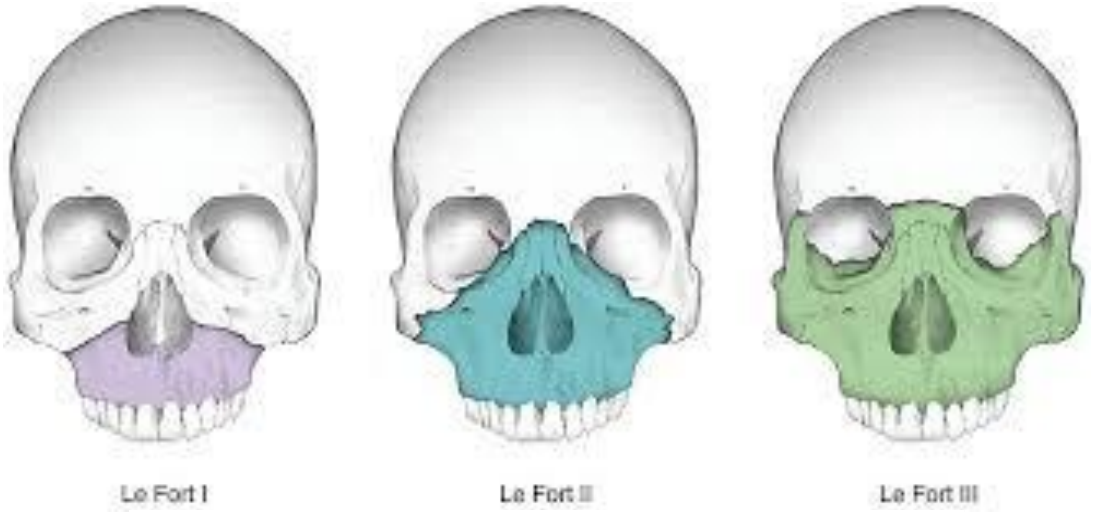

Figure 1: (A, B, C). a three-dimensional view of Le Fort I, II, III fracture.

Clinical presentation

As an initial examination mobility of maxilla is evaluated. The maxillary arch is grasped by thumb and pointing fingers of one hand and the mobility is checked by the other hand on pyriform aperture, nasofrontal suture, and zygomaticofrontal suture. In Le Fort fractures, lateral and medial pterygoid muscles pull the fracture segment posteriorly and inferiorly lead to an anterior open bite deformity. So malocclusion is an important sign in diagnosing the Le Fort fractures. Epistaxis is a common sign in all three patterns of Le Fort fractures. Hypoesthesia of the infraorbital nerve is seen in types I and II of Le Fort fractures. Bilateral periorbital ecchymosis which is called raccoon eyes is a classic sign of Le Fort II and III fractures. The clinician should be aware of the possibility of cerebrospinal fluid (CSF) leak in Le Fort II and III fractures.

Surgical considerations

The decision to choose whether the open or closed technique in Le Fort fractures is dependent on the mobility of the maxilla and severity of maxillary displacement results in malocclusion. Minor maxillary displacement and malocclusion and low mobility of fractured segment are the indications of closed treatment. Closed technique could be performed by either maxillomandibular fixation (MMF) or skeletal suspension (Figure 4). The method of choice in the treatment of mobile maxilla with severe malocclusion is open reduction and internal fixation (ORIF). In the Le Fort I pattern lateral nasal walls and zygomatic buttresses are used to provide stability by four plates. Displaced Le Fort II fracture is treated by ORIF of bilateral infraorbital rims and zygomatic buttresses simultaneously using a miniplate to fix the nasofrontal suture. Mobile mid-face and aesthetic problems following Le Fort III fracture (dish-face deformity) are the main indications of ORIF treatment. The number of fixations is dependent on the extent of comminution and dislocation. Bilateral zygomatic arches and zygomaticofrontal sutures and nasofrontal sutures should be fixed in severely displaced cases.

2. Palatal fractures

Classification

Hendrickson et al.[5] classified the palatal fracture into six patterns anatomically (Figure 5). Computed tomographies (CTs) in coronal and axial views are helpful in detecting the palatal fractures. Alveolar fracture is classified as type I palatal fracture in which it is categorized into two subcategories of anterior and posterolateral fractures. Anterior type I palatal fracture involves the incisor teeth and involving the posterior teeth it is defined as type 1b palatal fracture. Type II palatal fracture is defined as sagittal fracture which is less common in adults. Type III and IV fractures are the most common palatal fractures in adults.[5] Type III is also called para-sagittal fracture which occurs in the thin part of the palate lateral to the attachment of vomer bone to the maxilla. The anterior limit of the fracture is between canine teeth which extend to the pyriform aperture. Type III fracture pattern extends posteriorly to the tuberosity or track approximate to the midline. Type IV fracture also known as para-alveolar fracture is a variant of the type III pattern. The fracture line in this pattern tracks medial to the alveolar bone of maxilla. The type V pattern is a complex fracture with comminution fragments. The transverse palatal fracture is classified as the type VI pattern which is the least common palatal fracture type.

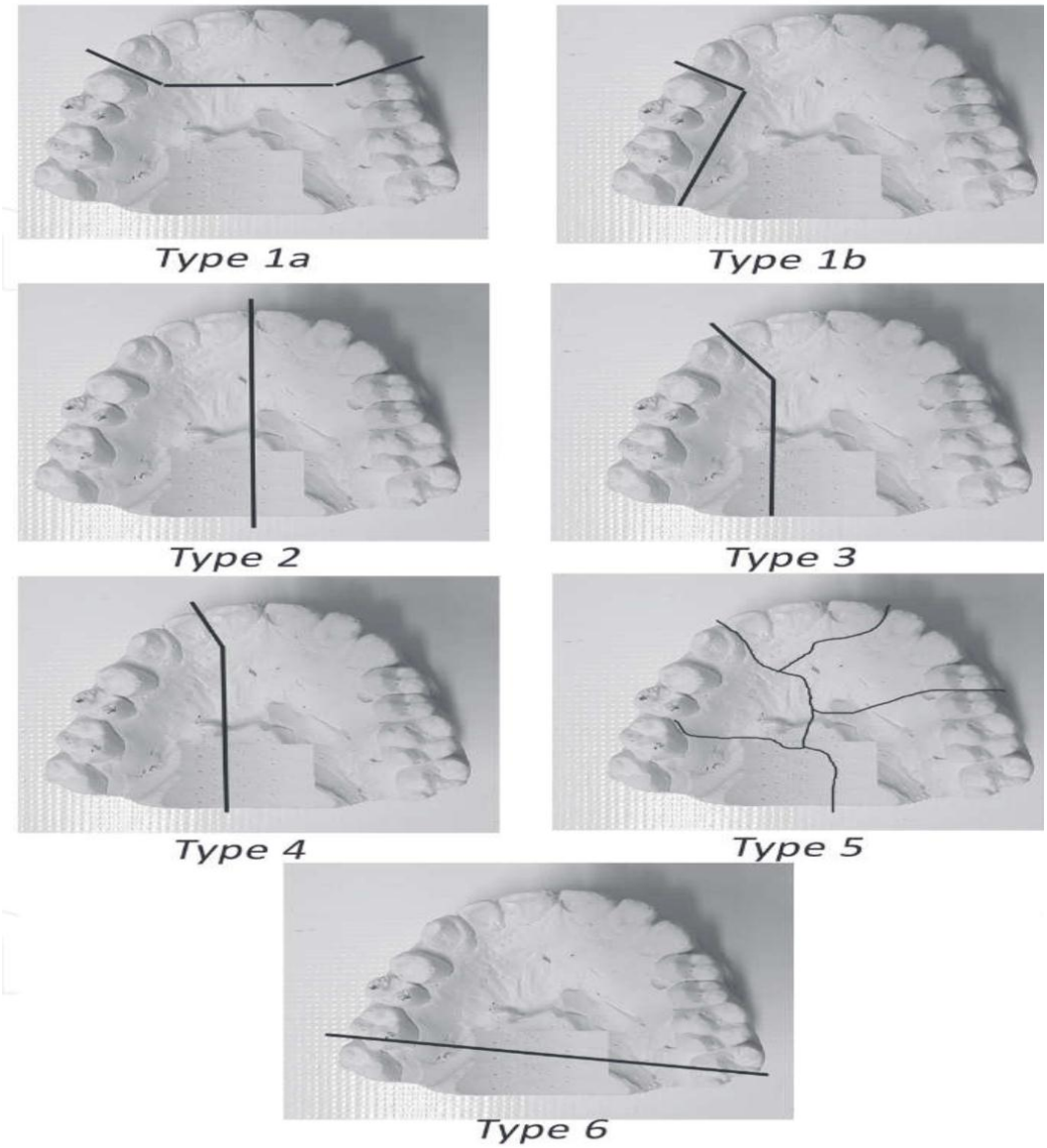

Fig. 2: Palatal fractures classification.

Clinical presentation

Mobility of alveolar segments should be checked for the entire maxillary arch. Displacement of fractured segments results in malocclusion which is an important sign to the clinician in diagnosing the palatal fracture. Ecchymosis of the palate may also indicate the line of fracture.

Surgical considerations

When the occlusion is good enough and the fractured segment is either minimally displaced or not displaced at all the surgeon may decide to follow the patient and choose no intervention. MMF is the treatment of choice in minimally displaced palatal fractures unless there is a contraindication for MMF. Gunning and palatal splints are other amenable methods for closed treatment of palatal fracture. ORIF of palatal fracture is indicated in severely mobile and displaced patterns to prevent splaying of the fragments.

3. Orbital fractures

Classification

According to the involved orbital walls there are five fracture patterns. The most common fracture of the orbit is the orbital floor fracture mostly detected as a blow-out fracture (Fig.3). Orbital roof fracture is the most common fracture in pediatric population.[6] Other less common orbital fractures involve medial or lateral wall. Combined orbital fracture especially involving all four orbital walls are the least common orbital fracture[7] patterns whilst the leading functional and aesthetic problems of this pattern are much more serious than former fracture types.

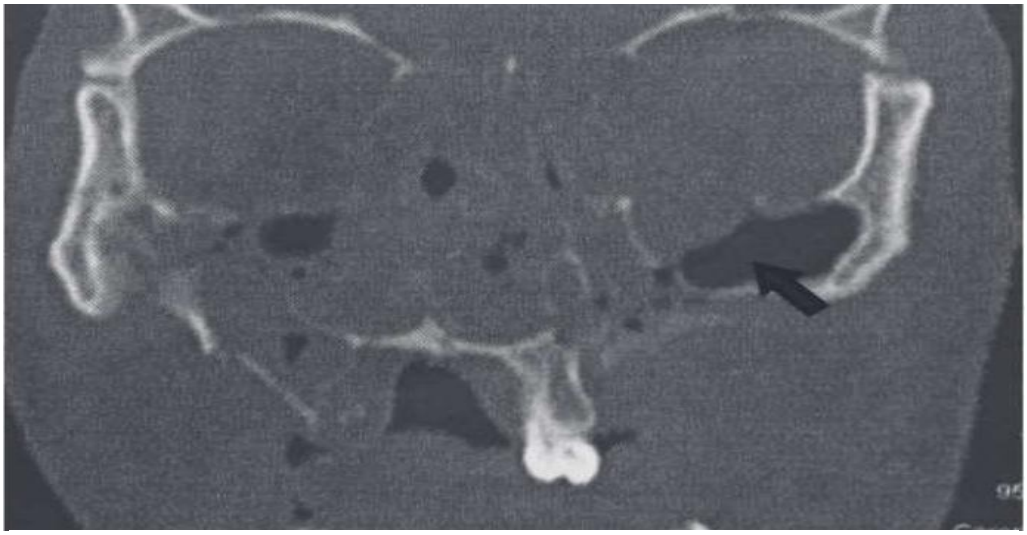

Fig. 3. Coronal CT view indicating orbital floor (blow out) fracture [indicated by arrow].

Surgical considerations

Orbital fracture cases are non- or minimally displaced should just observe. No intervention is needed when Orbital fractures do not result in any ocular problems including diplopia or enophthalmus. Orbital fracture treatment is a controversial issue among maxillofacial and ocu-loplastic surgeons. Fracture size, timing of the reconstruction, and biomaterials for reconstruc-tions are all important issues which should be considered in orbital fracture repair. The debate still is present in deciding on whether to treat an orbital fracture or not. The investigations are insufficient with high heterogeneity in this field. As a general rule it is almost acceptable that defects more than 50% of the orbital wall or 2 cm length should be treated.[8] Enophthalmus and positive-forced duction tests are two indications for management of orbital wall fractures.

4. Facial asymmetry

Facial asymmetry can be found early during the healing period secondary to inadequate reduction or as long-term sequelae after malunions or, less commonly, non-unions. During the early phases of healing, clinical diagnosis is difficult because of postoperative swelling, but if suspected, imaging such as anteroposterior cephalo-metric radiography or CT scan can confirm the diagnosis. The clinician should be cognizant of several clinical scenarios that have the potential of developing facial asymmetries. Good examples are inadequate reduction with a combination of mandibular symphysis and subcondylar fractures. In these cases, overtightening the MMF causes rotation of segments, with loss of lingual contacts and flaring of the inferior border of the mandible. Furthermore, if a segmental maxillary fracture is also encountered, the ability to re-establish anarch form is lost and facial widening or asymmetry may result. The presence of multiple unilateral mandibular fractures such as mandibular angle and condyle has also been described as risk factors.[9] Additionally severe comminution of the mandibular body resulting in an inability to obtain intimate bony contact of all the small fragments may produce a bowing of the inferior border so that the injured side is lower than the uninjured side.[10] In rare cases, facial asymmetry is caused by the loss of posterior height, such as in severe resorption or malposition of the condyle after an open approach. Usually these patients present complaining of TMJ pain and dysfunction and often require autogenous or alloplastic total TMJ replacements.

Surgical Considerations

Facial asymmetry is treated similarly as malunions/malocclusions. If the facial asymmetry is diagnosed early, the mandible is approached through the original repair. Hardware is removed, the fracture is properly reduced, and a new fixation is placed. If the facial asymmetry is due to a symphysis fracture, Ellis and Tharanon recommend pressing medially the mandibular rami until the buccal cortices begin to separate, indicating that the lingual cortices are in contact and proper reduction has been achieved.[11] Established facial asymmetries are treated similar to orthognathic surgery. Facial, dental, and radiographic analyses are performed. Determination of the osteotomies and splint fabrication is based on the results of the previous analyses and the model surgery. Surgical approach is intraoral or extraoral, depending on the location and type of the osteotomy to be used. Before cutting the mandible, all hardware are removed. After the mandible has been cut, occlusion is established and a new fixation is applied. If the original injury included a maxillary fracture, a LeFort I osteotomy might be necessary to correct the deformity. Even with best efforts, unsatisfactory results such as nonunion, malocclusion, and facial asymmetry occur during the management of mandibular fractures. A clear understanding of the nature of these posttraumatic mandibular deformities helps to avoid them. Furthermore, the clinician should be familiar with the re-operative techniques used for the management of these deformities.

5. Traumatic nasal deformities: Commonly encountered variants are: Saddle nose, Lack of structure in nasal dorsum (bone/cartilage), Scooped out appearance –lateral view, Flat nasal bridge –frontal view.

6. Zygomatic complex residual deformities

Clinical presentation

Enopthalmous, Epiphora, Removal or Reposition of malunited fragments, Inlays and Onlays. In case of trauma the zygomatic complex: bone may be Broken or dislocated. Soft tissue torn, squeezed, strangulated. Facial asymmetry, Dislocation of eyeball, Diplopia, Enopthalmous, Paresthesia of infraorbital nerve.

7. Post traumatic malocclusion

It is present following malunion of any fracture that directly or indirectly involves the alveolar segments of the maxilla or mandible. The introduction of ORIF makes direct anatomical segment reduction the primary aim. If this is achieved, a normal occlusion should automatically follow. Infection of mandibular fractures, particularly those involving the tooth-bearing segment of the mandible or angle, may result in non-union, malunion and segment displacement with malocclusion.

Surgical considerations

Maxilla repair Indications: In order to correct occlusal abnormalities due to maxillary malunion, Le Fort I osteotomy is indicated. Osteotomy at Le Fort II or III level, or variations of these procedures tailored to the individual needs of the patient, may be required in some instances where simultaneous correction of midface deformity is necessary. Le Fort I osteotomy is therefore indicated for most cases of maxillary occlusal abnormality, when segmental or one-piece maxillary repositioning is necessary. Once the correct maxillary position is established, any significant bony gaps or deficiencies are bone grafted. These insure union, stability and support for the overlying soft tissues of the cheek. the use of bone grafts in Le Fort I osteotomies to correct posttraumatic occlusion is uncommon due to the relatively small movements involved.

8. Posttraumatic mandibular deformities

Causes of posttraumatic mandibular deformities are**:** diagnostic errors**,** poor surgical technique, inadequate fracture reduction, inadequate fracture fixation**,** infection**,** and healing disorders.

Clinical presentation

Malunion of fractures behind the tooth-bearing segment of the mandible result in displacement of the whole dento alveolar arch. Severe condylar malposition with dislocation allows vertical shortening of the ascending ramus and this may be associated with restricted mouth opening or deviation on opening due to mechanical disruption of the temporomandibular joint.

Surgical considerations

Unilateral condylar malunion: The aim of treatment in unilateral cases is to restore the pre traumatic ramus height and correct posterior mandibular displacement if present. This corrects the occlusal plane and restores a normal occlusion. an osteotomy at the site of the original fracture, repositioning and if necessary inter-positional bone grafting to maintain lengthening of the ramus. a ramus osteotomy distant from the fracture site.

Bilateral condylar malunion: This results in anterior open bite and class II jaw relationship. The correction is achieved by adjusting the maxilla to accommodate this reduced posterior face height by carrying out a posterior maxillary impaction. This results in an increase of the occlusal plane angle, but this is of little significance and will result in a stable correction of the anterior open bite component of the deformity, as a consequence of mandibular autorotation.

Mandible repair Indications: Mandibular fractures are one the most common maxillofacial injuries. Their management has been traditionally regarded as one of the corner-stones of oral and maxillofacial surgery. Despite many technological and technical advances, to consistently return patients to their preinjury state remains one of the main challenges in the management of these injuries. As a result, an unavoidable number of patients develop unsatisfactory results. Diagnostic errors, poor surgical technique, healing disorders, or complications may lead to the establishment of posttraumatic mandibular deformities. Non-union, malunion/malocclusion, or facial asymmetry can be found early during the healing process or as long-term sequelae after the initial mandibular fracture repair. Although occasionally these problems can be solved in a nonsurgical manner, reoperations play an important role in the management of these untoward outcomes.

The correction of post-traumatic craniofacial deformities is recognized as a challenge to experienced surgeons. The reason for developing post-traumatic deformity of the craniofacial skeleton can be categorized into two groups: those related to the fracture itself, severe comminution and bone and soft tissue loss, and those related to the treatment, excessively delayed initial treatment, a lack of definitive treatment, inadequate initial surgical repair, and failure of hardware.[12] Malocclusion after primary treatment of maxillofacial trauma is not as frequently seen. The most common reason for malocclusion after primary midfacial trauma treatment is maxillary widening or impaction, as the anteroposterior (AP) and/or transversal dimensions have been altered during the operation, and the occlusal plane might easily become oblique and tilted. In impacted maxilla, the impaction of the nose is usually the most disturbing subjective symptom for the patient.[13] Le Fort II fractures present significant corrective challenges, because of the complex conditions associated with midface instability and malocclusion.[14] Malocclusion

and facial asymmetry can be found early during the healing process or as the long-term sequelae after the initial fracture repair. An early relapse in mild cases can frequently be managed by elastics and orthopedic appliances, but in more significant recurrences a return to the operating room may be necessary. The integration of normal bone is critical in the first 4–8 weeks, depending on the age of the patient, and the maturation slowly takes place. Soft callus formation may take approximately 2–3 weeks, but the hard callus stage lasts usually 3–4 months until the fragments are firmly united by new bone. The timing of corrective surgery should be at least 6 months after the initial injury, because the risk of remobilizing a malunion compromises the result.[15] Additionally, occlusal relapse can occur late, which consists of complex etiology of functional dental and muscular forces equilibrium and remodeling of the facial skeleton.[16] A long-term follow-up of a traumatic deformity's surgical correction is important, and management directly toward the causes is crucial.

CONCLUSIONS

The basic principles of treatment of post-traumatic residual deformities include an initial major osseous reconstructive surgery to restore an anatomically correct craniofacial architecture followed by selective procedures to address soft tissue deficits and functional deformities. Preservation of essential and basic functions will be the primary goal followed by the creation of form/function and aesthetics. Careful preoperative assessment, establishment of reasonable reconstructive goals and detailed surgical planning are critical to ensure the best possible outcome. In cases of complications such as malocclusion and temporomandibular joint disorders due to malunion, recovering the original state through reoperation is the first solution. However, if the severity of the complication is minimal and the problem is solved using non-surgical methods, if reoperation is impossible because reopening would take a long time, or if the economic condition or aftereffects of surgery is expected to be greater, the complication can be solved using nonsurgical methods such as orthodontic, prosthodontic, and splint therapy. Thereby, a clinically acceptable state can be recovered.

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