

POST-TRAUMATIC DEFORMITY OF MANDIBULAR CONDYLE: DESCRIPTIVE REVIEW AND PROPOSAL OF TREATMENT ALGORITHM

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ABSTRACT

Condyle, along with the glenoid fossa and its associated soft tissue components and muscles of mastication, perform various important functions such as mastication, speech, and swallowing. Condyle also act as growth center in child. Hence, any defect in the anatomical form of mandibular condyle affects both the appearance and function. Deformity of mandibular condyle can be acquired due to several reasons. Post-traumatic deformity is a common cause, second to ankylosis. These deformities result due to lack of treatment or inadequate management of condylar fracture. It affects both form and function of lower jaw, compromising facial appearance and occlusion. Many options have been proposed for its treatment, ranging from conservative management to surgical intervention. Conservative management options described in literature include physiotherapy, forceful jaw opening, occlusal grinding, tooth extraction, prosthetic rehabilitation, and orthodontic correction. Surgical management involve condylectomy, orthognathic surgery, autogenous grafts, and prosthetic joint replacement. However, the choice of appropriate treatment depends on variables such as age of patient, timing of intervention, and degree of deformity. There is lack of literature reviewing multiple treatment options for post-traumatic deformity of mandibular condyle. This paper presents a descriptive review of various options for management of post-traumatic deformity of condyle. Treatment algorithm for its management is also presented.

KEY WORDS: temporomandibular, defect, joint, orthognathic, joint replacement.

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INTRODUCTION

The mandibular condyle, along with the glenoid fossa and soft tissue components including joint ligaments, capsule, disc, and muscles of mastication, form the temporomandibular joint (TMJ) complex. TMJ complex help in performing important functions of speech, mastication, and swallowing. In formative years, condyle also plays a critical role in growth of mandible. Therefore, any deformity of condyle acquired during

lifetime of an individual affect both facial aesthetic and function.

CAUSES OF ACQUIRED DEFORMITIES OF MANDIBULAR CONDYLE

Mandibular condyle deformity can be acquired due to various reasons (Table 1). TMJ ankylosis following trauma or infection in preauricular region are the most common

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TABLE 1. Various causes of acquired deformities of mandibular condyle

Ankylosis
Post-traumatic deformity
Temporomandibular joint tumors
Condylar resorption
Condylar hyperplasia
Osteomyelitis
Previous failed reconstructions
Temporomandibular joint defects after radiation therapy
Juvenile rheumatoid arthritis
Severe degenerative joint disease
Severe inflammatory joint disease

TABLE 2. Variables in determining appropriate treatment

Degree of deformity/displacement of mandibular condyle
Severity of malocclusion
Unilateral or bilateral fracture
Time between injury and treatment
Availability of stable dentition

TABLE 3. Management options for post-traumatic condylar deformity

Conservative	Surgical
Functional therapy	Sub-condylar osteotomy
Tooth grinding	Orthognathic surgery (ramus osteotomy/ Le Fort osteotomy)
Extraction of interfering teeth	Temporomandibular joint reconstruction
Prosthetic treatment	
Orthodontic treatment	

causes. Other reasons of acquired condylar deformity include malunion or non-union of condyle fracture, ablation defect after removal of benign or malignant tumor, osteomyelitis of condyle, advanced degenerative or inflammatory arthritis of TMJ, idiopathic condyle resorption, and previous failed reconstruction [1].

POST-TRAUMATIC DEFORMITY OF MANDIBULAR CONDYLE

Condylar fractures are common injuries, comprising approximately 25-30% of all mandibular fractures [2]. Inadequate initial management or non-intervention of condylar fracture results in malunion or non-union. The extent of fracture displacement and involvement of single or both condyles determine the presentation

of post-traumatic deformity. Unilateral fracture causes asymmetric discrepancy with loss of posterior facial height on affected side, and open-bite on contralateral side with deviation of chin to the ipsilateral side. Whereas, bilateral malunited condyle fracture result in symmetric deformity with anterior open bite.

PREVENTION OF POST-TRAUMATIC CONDYLAR DEFORMITY

An important issue to consider is whether the primary treatment of condyle fracture influence the risk of post-traumatic condylar deformity. The adequacy of management of condyle fracture with open and closed methods continue to be a subject of debate. Closed reduction of condyle fractures with severely displaced condyle increases the likelihood of deformed condyle with compromised function, occlusion, and/or esthetics. Ellis *et al.* studied facial asymmetry after closed and open treatment of condyle fracture and stated that the decrease in lower posterior facial height in non-surgically treated group (4.72 mm) was higher, as compared to surgically treated group (0.08 mm) [3]. Severe fracture angulation, displacement, and dislocation as well as bilateral fractures increase the likelihood of closed treatment failure and post-traumatic condylar deformity. There is an emerging consensus for open treatment of condyle fractures in recent literature. A randomized study of open versus closed treatment of condylar process fractures advocated the use of open reduction and internal fixation for fractures with a deviation of more than 10-45 degrees or a shortening of the ascending ramus greater than or equal to 2 mm, irrespective of the fracture level [4]. Surgical treatment, regardless of the method of internal fixation used, has shown statistically superior mouth opening, lateral excursion, protrusion, and subjective symptom of pain and discomfort [5].

Few authors advocate closed reduction over surgical intervention [6, 7]. The justification provided is, the incidence of malocclusion associated with malunited condyle fractures is quite low, with reported range varying from 1.4 to 13% [8]. This small percent of cases, which present with persistent malocclusion and/or facial asymmetry, not amenable to conservative management, can be adequately treated by secondary orthognathic surgery with highly reliable and stable results [6].

MANAGEMENT OF POST-TRAUMATIC CONDYLE DEFORMITY

Choice of treatment of post-traumatic condyle deformity depends on various factors, including timing of intervention and degree of deformity (malocclusion and/or facial asymmetry) (Table 2). Treatment options can be grouped as conservative and surgical (Table 3).

CONSERVATIVE MANAGEMENT

METHODS OF CONSERVATIVE MANAGEMENT

Minor post-traumatic discrepancy, especially those presenting not too late after the initial trauma, can be managed conservatively. Such patients with associated malocclusion and mandibular hypomobility can be treated by functional therapy. Patient is taken under general anesthesia, and forceful mouth opening (termed as “forced dilatation or brisement”) is performed to achieve adequate inter-incisal opening (about 50 mm). Intra-operatively, the mandible is mobilized into occlusion. Any minor discrepancy, which may persist post-operatively is corrected using elastic traction-assisted guidance of occlusion. Physiotherapy is essential in these patients to maintain adequate mouth opening during post-operative period.

Other conservative treatment used for management of post-traumatic condylar deformity include selective

tooth grinding or extraction of teeth interfering with occlusion. Prosthodontic rehabilitation with tooth replacement or orthodontic-assisted correction of malocclusion has also been used. Acrylic occlusal guiding plate can be applied for correction of jaw deviation and deprogramming of muscles of mastication (which get used to new condylar position post-trauma) [9].

TIMING OF INTERVENTION FOR CONSERVATIVE MANAGEMENT

Post-traumatic condylar deformities can be successfully corrected with conservative modality, when the intervention is performed early. Considerable bony and soft tissue remodeling occurs around TMJ in the first few months after fracture. Late correction provides significant resistance due to the fibro-osseous remodeling in the altered joint space, resulting in failure of conservative management [10]. It is recommended to use conservative treatment for correction of condyle deformity within the first three months of condyle fracture (Figure 1) [6].

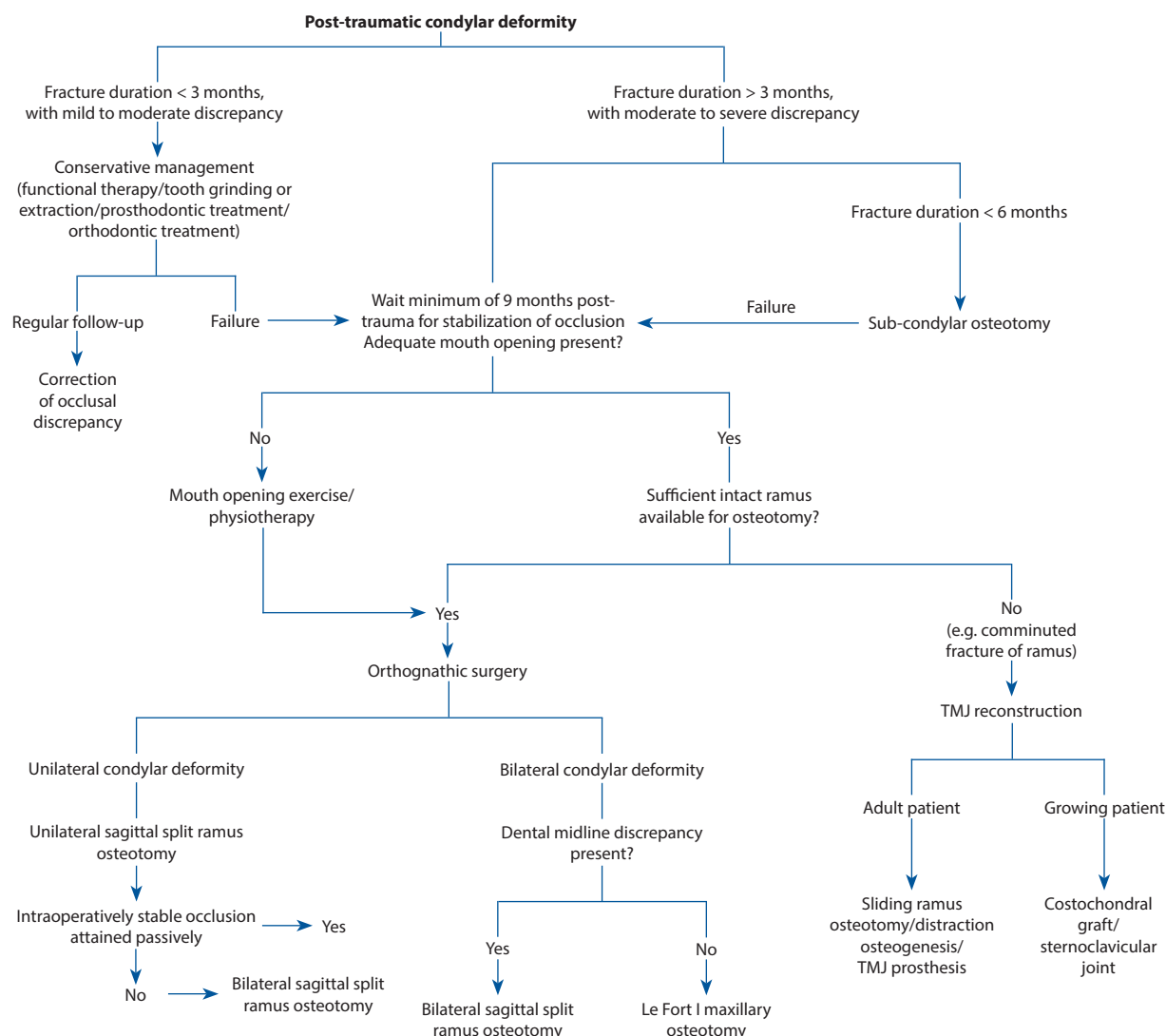


FIGURE 1. Treatment algorithm for management of post-traumatic condylar deformity

SURGICAL MANAGEMENT

The surgical options for management of post-traumatic condylar deformity not amenable to conservative management include sub-condylar osteotomy, orthognathic surgery, TMJ reconstruction, or combination of these procedures.

SUB-CONDYLAR OSTEOTOMY

Surgical treatment needs to be undertaken when there is failure of conservative management or when correction of old post-traumatic condylar deformity is required. The use of sub-condylar osteotomy appears a logical surgical option, as it attempts to correct the discrepancy by directly addressing the site of deformity. The approach to access the malunited condyle fracture is through retromandibular or preauricular incision. However, preauricular approach can be more convenient and provide better access to perform osteotomy, grafting, and fixation for high condylar neck as well as capsular malunited fractures [11]. The osteotomy is made at or near the old fracture site to allow realignment of the malunited condylar fragment. An adequate proximal segment of condyle should be maintained to ensure viable blood supply. Due to possible avascular necrosis, the osteotomy should be performed at the site of fracture (which many not always be at sub-condyle level). After positioning the fractured condyle back into the glenoid fossa and, more importantly, restoration of the posterior ramus height and occlusal discrepancy, the osteotomy site is fixed with miniplate. While fixa-

tion, it should also be remembered that remodeling at the fracture site makes the bone soft, creating a retention of bone screw less stable at that region. Hence, the screw should be placed away from the callus. Guidelines for sub-condylar osteotomy for management of post-traumatic condylar deformity is enumerated in Table 4.

Sub-condylar osteotomy is not the commonly used treatment option for management of post-traumatic condylar deformity. Open reduction of malunited old condyle fracture can be much more difficult, as compared to open reduction of a fresh fracture. After a few weeks of the condyle being out of the fossa, making room for it within the fossa becomes an extremely difficult maneuver, requiring extensive dissection. This can compromise the vascular supply to the condylar fragment, especially if the segment is short, increasing the likelihood of its avascular necrosis and failure of treatment. Chen *et al.* recommended that sub-condylar osteotomy for correction of condylar deformity should be performed within 6 months of their initial trauma (Figure 1) [12].

ORTHOGNATHIC SURGERY

Anatomical reduction of displaced condylar fracture within glenoid fossa after a prolonged interval can be very difficult, if not impossible, due to fracture consolidation and fibro-osseous changes within the TMJ. Adaptation of muscles of jaw to the new position of condyle makes the reduction further difficult. In such cases, sub-condylar osteotomy is not preferred, and osteotomy is performed at remote site for correction of occlusal and skeletal discrepancy.

Orthognathic surgery is commonly used option for management of delayed post-traumatic condylar deformity, as it provides safe and stable results [6]. The choice of surgery depends on the type of fracture. Post-traumatic malocclusion due to unilateral condylar process fracture is corrected with ramal osteotomies. Managing anterior open-bite due to bilateral condylar deformity is more challenging and can be corrected by bilateral sagittal split ramus osteotomy or Le Fort I maxillary osteotomy (Table 5).

A pre-requisite for taking patients for orthognathic surgery is the presence of adequate mouth opening. Post-traumatic condylar deformity often leads to hypomobility. Attempting orthognathic surgery, which requires intra-oral access is extremely difficult in such patient. The post-surgical scarring further reduces mouth opening, resulting in compromised function [13]. Patient with reduced jaw movement should be subjected to physiotherapy before the planned orthognathic procedure. Once the patient achieves full range of mandibular motion, the orthognathic surgery can be planned and performed.

Patients with congenital skeletal discrepancy undergoing orthognathic surgery usually require pre-surgical orthodontics for correction of the natural dental compensation to mask the skeletal deformity. However,

TABLE 4. Guidelines for sub-condylar osteotomy for management of malunited condyle fracture

Recommended to perform it within 6 months of initial trauma
Popular approach used is through retromandibular incision
Osteotomy is made at or near the old fracture site
An adequate proximal segment of condyle should be maintained to prevent necrosis

TABLE 5. Choice of orthognathic surgery for management of post-traumatic condylar deformity

Type of deformity	Post-traumatic malocclusion with asymmetry due to unilateral condyle fracture	Post-traumatic malocclusion with symmetric open-bite due to bilateral condyle fracture
Treatment options	Sagittal split ramus osteotomy (unilateral/bilateral) and vertical ramus osteotomy	Bilateral sagittal split ramus osteotomy and maxillary osteotomy (Le Fort I)

patients with post-traumatic condylar deformity undergoing orthognathic surgery rarely require per-surgical orthodontics. However, pre-surgical orthodontic treatment may sometimes be required to achieve alignment and leveling of arches.

ORTHOGNATHIC SURGERY FOR MANAGEMENT OF UNILATERAL DEFORMITIES

Unilateral deformity presents with contralateral posterior open bite, deviation of chin to the affected side, and ipsilateral ramal height shortening. These deformities can be addressed using unilateral or bilateral sagittal split osteotomy. Unilateral osteotomy on side of fractured condyle would be simpler and tempting to pursue. However, there is risk of the mandible to deviate back to the fracture side post-operatively. More stable result is obtained when the osteotomy is done on both sides. The choice between unilateral or bilateral osteotomy can be made intraoperatively. Sagittal split osteotomy is initially performed on the side of fracture. Once the distal segment is separated for the proximal segment, the mandible is manipulated to see how passively it rotates into occlusion with maxillary dentition. When the movement is not passive, it is recommended to perform osteotomy on both sides (Figure 1).

Beside sagittal split ramus osteotomy, vertical ramus osteotomy (intraoral or extraoral) has also be used for management of post-traumatic unilateral condylar deformity. Rubens *et al.* recommended that the choice between sagittal split and vertical ramus osteotomy should be made based on the predominant moment required for correction of the discrepancy [14]. Sagittal osteotomy is preferred when greater horizontal movement is required, and vertical ramus osteotomy is undertaken when more vertical movement is required form correction of malocclusion.

ORTHOGNATHIC SURGERY FOR MANAGEMENT OF BILATERAL DEFORMITIES

Management of post-traumatic malocclusion following bilateral condylar fracture is more complex. The treatment options include bilateral sagittal split ramus osteotomy (BSSO) with counterclockwise rotation of the distal segment of mandible and Le Fort I maxillary osteotomy with posterior impaction, and subsequent autorotation of mandible closing the anterior open bite. The choice to perform mandibular or maxillary surgery depends on the position of lower dental midline. When the lower dental midline is shifted, the open-bite is corrected using BSSO, with correction of midline discrepancy. In contrary to Le Fort I osteotomy, BSSO does not cause change in the inclination of maxillary anterior teeth, thus avoiding the need of post-

surgical orthodontics. Also, surgery involving mandible (which is the affected jaw, due to post-traumatic condylar deformity) is better accepted by the patient. The major disadvantage of BSSO procedure is the instability of result, when greater degree of rotation (> 4 degree) is required for correction of open-bite [7]. Le Fort I osteotomy is preferred in such situation, as it provides stable results. Le Fort I osteotomy is undertaken when greater degree of rotation is required for closure of anterior open-bite and no correction of dental midline is required (Figure 1).

OPTIMAL TIME FOR ORTHOGNATHIC SURGERY FOR MANAGEMENT OF POST-TRAUMATIC CONDYLAR DEFORMITY

The literature suggests that a minimum interval of nine months from the initial injury should elapse before orthognathic procedure, to produce satisfactory results [6]. This time period is necessary for completion of remodeling of the neo-condyle and formation of a stable joint. By nine months, the occlusion is stabilized as the fracture healing is completed, thus creating a strong base for surgery. Performing secondary surgery prematurely, when the structural integrity of the joint cannot withstand orthognathic surgery, will most often result in unstable outcome and failure [14].

TEMPOROMANDIBULAR JOINT RECONSTRUCTION

TMJ reconstruction for correction of post-traumatic condylar deformity is infrequently used. This appears to go against the general rule that "a deformity is best managed by operating directly on the defect". It would seem logical that a malunited condyle can be best treated by reconstructing the deformed condyle. However, it is not the case. The reason for that is orthognathic surgery provides more predictable and stable results in managing post-traumatic condyle deformity.

However, when the degree of mandibular ramus deformity is more (e.g. severely comminuted ramus fracture or severe shortening of ramal height), and when large degree of mandibular movement is needed to correct the occlusal discrepancy, TMJ reconstruction is preferred over orthognathic surgery (Figure 1) [6]. Indications for TMJ reconstruction for management of post-traumatic condylar deformity is specified in Table 6. The options for

TABLE 6. Indications for temporomandibular joint reconstruction

Severely deformed/comminuted ramus
Severely shortened mandibular ramus
Large jaw movement required to attain pre-trauma occlusion
Patients with post-traumatic ankylosis

TABLE 7. Options of temporomandibular joint reconstruction

Autogenous reconstruction	Non-vascularized graft	Graft from distant site
		Costochondral graft
		Sternoclavicular joint
		Iliac crest graft
		Cranial bone graft
		Graft from local site
		Coronoid process
		Ramus (sliding osteotomy)
		Distraction osteogenesis
	Vascularized graft	
Alloplastic reconstruction	Free fibula	
	Metatarsophalangeal joint	
	Scapular tip flap	
	Stock prosthesis	
Custom made prosthesis		

TMJ reconstruction vary from autogenously harvested bone graft to metallic prosthetic joint (Table 7).

Costochondral graft (CCG): It is most commonly used autogenous graft for TMJ reconstruction. Although prosthetic TMJ has become popular and commonly used for TMJ reconstruction in recent times, CCG permits growth and therefore remain the first choice in growing children (Figure 1) [15]. The rib commonly harvested is fifth to seventh rib. Right side is preferred over left to prevent pericardial damage. When bilateral reconstruction is required, it is advisable to harvest alternate ribs. A 2-3 mm cap of cartilage is retained over the rib bone graft. Retaining larger length of cartilage is not advisable due to risk of its shear fracture. The limitations of CCG include donor site morbidity, pleural tear, and pneumothorax. Costochondral cartilage may show unpredictable growth, with both under and overgrowth reported in literature [16].

Sternoclavicular joint: It is an alternative to CCG. The proximal end of superior half of clavicle with its sternal head is used as graft and closely resembles the anatomy of condyle. The cartilage of the joint has similar growth potential as that of condyle. The drawbacks of sternoclavicular joint graft include visible scar below collar bone and the risk of damage to underlying major vessels while graft harvesting. To avoid the risk of clavicle fracture after harvesting, the shoulder is kept immobilized for 2-3 months [15].

Sliding ramus osteotomy: When sufficient bone is available in ramus of mandible, it can be used for reconstruction of the condylar deformity. This eliminates additional surgical site for both harvesting, as both harvesting, and reconstruction is done from adjacent areas.

A preauricular incision is used to approach the deformed condyle and condylectomy is performed. An additional submandibular or retro-mandibular approach is performed to place osteotomy cut on ramus. A vertical ramus osteotomy cut is placed. The vertical cut in ramus is placed extending from sigmoid notch down to the lower border in front of angle of mandible. The cut should be designed in such a way to allow the osteotomized bone to slide up superiorly and fit into the glenoid fossa, and at the same time, remain in contact with the ramus along its length. The osteotomy line should also allow to preserve the integrity of inferior alveolar neurovascular bundle. Medially, the attachment of medial pterygoid muscle is preserved and act as the vascular pedicle of the osteotomized bone. The upper part of the bone can be reshaped to mimic the condyle head. Fixation using two miniplates is done and the function of new joint and occlusion is verified. The angle is reshaped and rounded. Another variant of the osteotomy cut is using reverse L-design rather than a vertical ramus cut. The posterior ramus is slid superiorly, and the gap created can be bridged with bone graft from local or distant site. Coronoid process can be harvested from the same surgical approach and can be used for grafting the gap. This reverse L-design preserves the anatomical contour of mandible angle [17].

Transport distraction osteogenesis (TDO): TDO for reconstruction of deformed condyle was first reported by Stucki-McCormick in 1997 [18]. TDO in recent times has proved to be a promising treatment option for TMJ reconstruction. It has all the advantages of autogenous bone grafting, without the need of donor site. The technique of DO includes a reverse L-osteotomy, as done in sliding ramus osteotomy. The vertical arm of L parallels the vector that moves the new condyle into glenoid fossa. The distraction devise is fixed on either side of the horizontal arm of the L osteotomy. After a week of latency period, a distraction is performed usually at rate of 1 mm per day. The distraction is discontinued after desired occlusion is attained. After period of consolidation, the distractor device is removed.

Vascular fibula bone graft: Fibula bone is by far the most popular vascularized graft used for TMJ reconstruction. Its advantage is due to its tubular shape and adaptability to the glenoid fossa. Vascular graft for condylar reconstruction is indicated when long span of reconstruction is required, for example, after resection of large tumor. Its application for post-traumatic condylar deformity correction is rarely indicated, except when there is an extensive comminuted ramus-condyle fracture with bone loss, which requires grafting. There are 3 ways, in which fibula can be used for TMJ reconstruction [19]. When the condyle can be preserved, it is fixed with the distal end of fibula bone. However, when it is not possible to preserve the condyle head, the distal pole of the fibula graft can be directly placed in the glenoid fossa. The third approach of using free fibula is where a prosthetic condy-

lar head component is fixated to the distal end of fibula and abutted into the glenoid fossa.

Prosthetic TMJ replacement: Prosthetic replacement of condyle has become more popular over the last few decades. These devices were met with skepticism, when they were initially used in the 90s. However, this method is now considered as safe and reliable procedure for management of deformed condyle. It is used for reconstruction of condyle defect after tumor resections, post-traumatic condyle deformities, ankylosis, severe degenerative/inflammatory diseases, and previous failed autogenous reconstructions. However, it should not be used in children where growth is desirable. It is also contraindicated in patients with uncontrolled systemic diseases, psychiatric instabilities, active infections at surgical site, known allergies to prosthetic components, and uncontrolled parafunction habits [1].

The alloplastic TMJ is broadly classified into stock and custom-made prosthesis. Stock prosthesis are available in different sizes. An appropriate size is chosen, which will fit the defect of the given patient. The Biomet prosthesis (Biomet, Jacksonville, FL) is the most popular stock device. It has a fossa component, which comes in 3 sizes (small, medium, and large) and is made of ultrahigh molecular weight polyethylene. One of the potential disadvantages of stock prosthesis is the need of removal of bone from the eminence and glenoid fossa to fit the fossa component. The mandibular ramus component is made of a cobalt-chrome alloy and comes in three different lengths (45, 50, and 55 mm) and 2 different widths (standard and narrow). Custom-made prosthesis is “made to fit” device, which is designed to exactly fit the defect after resection of tumor or deformity. The TMJ Concepts prosthesis (TMJ Concepts, Ventura, CA, USA) is custom-made alloplastic TMJ. It is fabricated after thin-cut maxillofacial CT scan data is used for the construction of a stereolithographic model. The prosthetic design is prepared after a wax-up is done in the stereolithographic model. Alternatively, computer aided designing and manufacturing (CAD/CAM) can be applied. The use of CAD/CAM allows reduction of laboratory time and provides precise fit of the custom-made TMJ prosthesis [20]. The fossa component is made of titanium mesh base, with ultrahigh molecular weight polyethylene articulating surface. The ramus component is made of titanium, with a condylar head of chrome-cobalt-molybdenum alloy. With advancement in biotechnology, precision-driven 3D-printed prosthesis is expected to become more efficient and common modality of reconstruction of condylar deformities.

CONCLUSIONS

Management of post-traumatic deformities involving mandibular condyle though rare, presents a challenging situation for any surgeon working in head and neck region. Although various modalities of treatment have been

reported, there is no consensus on the best and most efficient treatment method. This is due to lack of widely accepted management protocol. The choice suited for managing a given deformity varies based on patient-related factors, degree of deformity, and timing of intervention. This descriptive review is an attempt to describe the available treatment options. Algorithm for management of post-traumatic deformity of mandibular condyle is expected to help in decision making, thus improving treatment outcome.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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