This textbook comprises the historical background, etiology, epidemiology, biomechanics, classification, clinical signs and symptoms, radiographic assessment, diagnosis and various management options for condylar fractures and also encompasses a note on the dilemma of open vs closed treatment for condylar fractures.
At this moment of accomplishment, I would like to extend my heartfelt gratitude to my mentor and guide Dr. Santosh B S. His virtue of imparting knowledge with utmost patience is the key to the success of this book. It is his deep insight, keen interest, and constant guidance that have helped me to bring this piece of work to the final stage. I take this opportunity to express my profound gratitude and deep regards for his exemplary guidance, monitoring, and constant encouragement.

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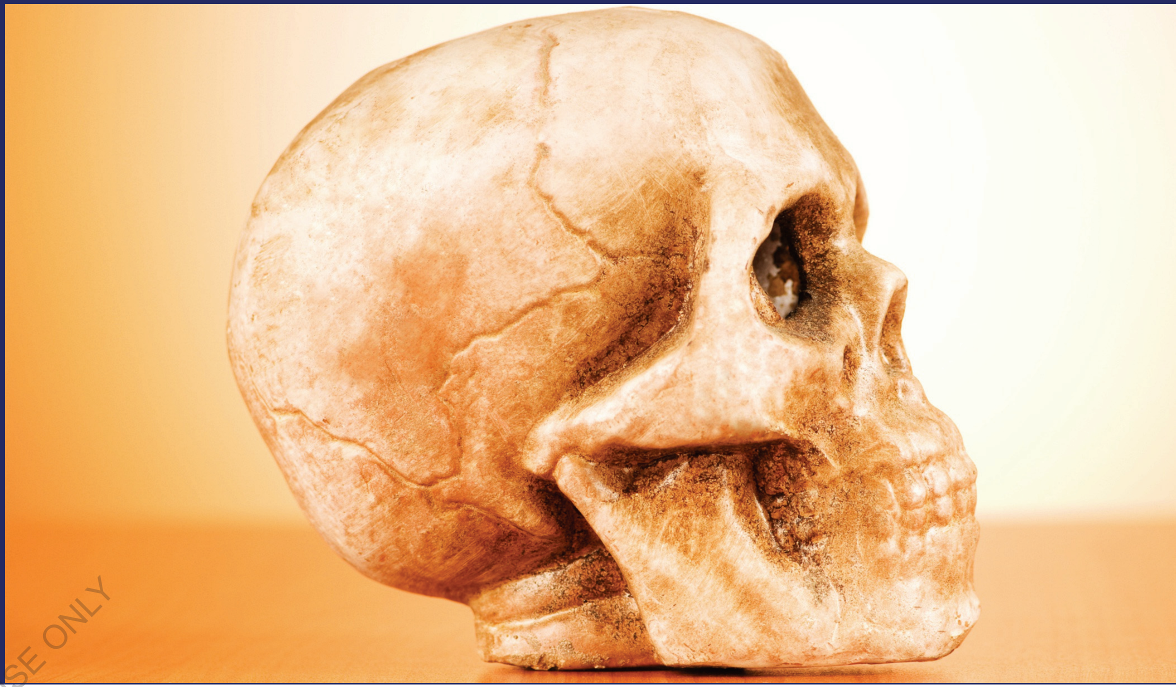
Mandibular Condylar Fractures

Tulima Begum, Santosh B S



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Dodo Books Indian Ocean Ltd., member of the OmniScriptum S.R.L Publishing group
str. A.Russo 15, of. 61, Chisinau-2068, Republic of Moldova Europe
Printed at: see last page
ISBN: 978-620-5-49341-0

CONTENTS

INTRODUCTION

The condylar process of mandible is one of the most common sites of injury to the facial skeleton. They constitute about 18% to 57% of the total mandibular fractures. Fractures of the condylar process can happen due to an indirect or a direct injury to the site. The most common etiology of a fracture of mandibular condyle is a road traffic accident. Other common causes are assault, fall from height, interpersonal violence and sports injury.[1]The fracture is usually seen to occur in the narrow section of the neck supporting the condylar head above and bears the insertion of lateral pterygoid muscle below.

The mandible plays a key role for continuity of not only the lower third but also of the entire facial skeleton, as it articulates with the skull bones through the temporomandibular joints and interacts with the maxilla through dental occlusion.[2] The condylar process fracture leads to a break in continuity of the mandible and malocclusion, internal derangements of the TMJ, restricted mandibular movements, ankylosis and reduced mandibular growth (when it occurs in children) thereby disturbing function and cosmetics.[3] This has therefore forced surgeons to attempt treating such cases by a variety of treatment protocols ranging from a conservative approach to open surgical treatment.[4] There is no general rule regarding which fractures should be treated with an open or closed approach. It was observed that fracture level, deviation of the fragments along with shortening of the ascending ramus may be the most essential factors predicting the therapeutic success. The decision of closed versus open treatment of the fractures of the condylar process remains controversial.[5]

For decades, closed reduction has been the most preferred treatment, but closed treatment needs varying periods of maxillomandibular fixation (MMF) (about 4 weeks). In the recent times, trauma surgery using open reduction and internal fixation of the fractures, open surgical management has been attempted, in which reduction of fracture segment is done and fixation by using miniplates, K wires & lag screws etc., which give better stability in minimum time and less discomfort to the patient.[6]

Several surveys and experimental studies have shown conclusively that the conservative or closed method of treating these fractures is apparently free of complication and shows satisfactory end results. However, serious late complications such as TMJ ankylosis, avascular necrosis of the condylar process, inhibition of mandibular growth and occlusal disturbances have been reported.[7]

The planned aim of surgical treatment of condylar process fracture is to restore the pre-existing anatomical relationships and acceptable function by using a stable fixation. Obtaining the pre-traumatic occlusal relationship is important, because patients can feel uncomfortable even by minor occlusal irregularities.

Various factors have to be evaluated to predict the treatment results both in closed as well as open surgical method and carefully asses to identify individual cases to know which modality of treatment would provide the maximum benefit.[8]

HISTORICAL BACKGROUND

It is essential to view historical reports in the context of their time. Historical insight improves a better understanding of current techniques and provides the basis for the development of new methods. From the time of Hippocrates, physicians have described many different techniques for treating mandibular fractures, the principle of which has always been repositioning and immobilization of the bony fragments. However, during the last fifty years excellence of anesthetic and radiographic methods, initiation of antibiotics, specially designed equipment and advances in biomaterials have allowed maxillofacial surgeons to enhance outcomes and reduction in morbidity.[9]

Re-establishing the occlusion and masticatory function is the main objective of treatment of condylar fractures. Splinting of teeth is an old way of immobilizing fractures but the introduction of modern biomaterials has changed clinical practice towards plating the bone and early functional restoration.

THE PRE CHRISTIAN ERA

The first description of mandibular fractures was in the 17th century B.C. in the 'Edwin Smith Papyrus', bought by Smith in Luxor in 1862 and later translated by Breasted.[10]

However, the documents have shown that simple fractures of the jaw were treated by bandages, which were obtained from the embalmer and were soaked in honey and egg white, and wounds were treated by the fresh meat application on the first day, a method which may have well initiated tissue enzymes and thromboplastins without any bacteria. Historically, medicine in terms of healing and religion are always been intertwined. In the Hellenic period, temples to Asklepios were built up and the secular assistants to the priests, known as Asklepiadae, helped in providing medical treatment. In the year 460 B.C, to one of these assistants, on the island of Cos a son named Hippocrates was born. He analyzed the medical problems from a more practical and mechanical perspective, depending less on religious explanations. Hippocrates not only introduced the technique of reducing a dislocated mandible, which still goes with his name, but also taught methods of immobilizing a fractured mandible. The fracture ends were reduced by hand and the site of the fracture was immobilized by gold or linen threads which were tied around the adjacent teeth. In addition to this intraoral method of immobilization, he recommended extra-oral fixation by strips of Carthaginian leather which were glued to the skin, the ends of which were tied over the skull (The barrel bandage was still in use two centuries later). According to Hippocrates, when using this method of fixation, the fracture had healed within 20 days provided that no infection developed.[11]

THE EARLY MEDIEVAL PERIOD

During the reign of the Roman Empire (23 B.C.–410 A.D.) if any true advances were made in the treatment of mandibular injuries, dependence was placed upon the traditional Hippocratic methods. The Romans followed the Greek medical thought. Aulus Cornelius Celsus, the Roman encyclopedist collected Greek and Roman medical thought in a series of volumes entitled Artes. Celsus described the treatment of fractures of the jaw in the eighth volume. In general; he adopted the treatment introduced by the Corpus Hippocraticum: "The fragments are repositioned using two fingers; they are tied together with horse hair with the two adjacent teeth, or tie them to teeth further away if they are loose." Postoperative treatment included rubbing the injury with oil, wine, or flour. He advised his patients not to speak and told them to live exclusively on liquid food for several days. About 500 AD, the Indian surgeon Sushruta wrote an exposition on operations. He recommended treating jaw fractures by using complicated bandaging and bamboo splints which were covered with a mixture of flour and glue, applied under the chin to immobilize the fractures.[12]

THE 17TH AND 18TH CENTURY:-

The association between medication and religion extended into the Christian era, however once the Pope in 1163 dominated that any operation involving the shedding of blood was incompatible with the priestly workplace, the “barbers” took over the observerships of rudimentary surgery, thus from the center Ages to the first 1700s, abundant dental treatment was provided by the so-called “barber surgeons”. This jack-of-all-trade wouldn't solely extract teeth, treat facial fractures, and undertake surgery, however they additionally cut hair, applied leeches and embalmed corpses.[13]During this era (12th to early eighteenth century), the barber surgeons used the classical treatment of fractures. When manually resetting the broken jaw, making certain that the conventional occlusion was maintained and also the teeth adjacent to the fracture line were joined by ligatures, the mandibular bone was immobilized by bandages. Varied modifications of bandages were used to immobilize the jaw by binding it to the jaw by a bandage that passed below the chin and over the head.[14]It had prevented from slithering by another bandage carried over and round the occiput.

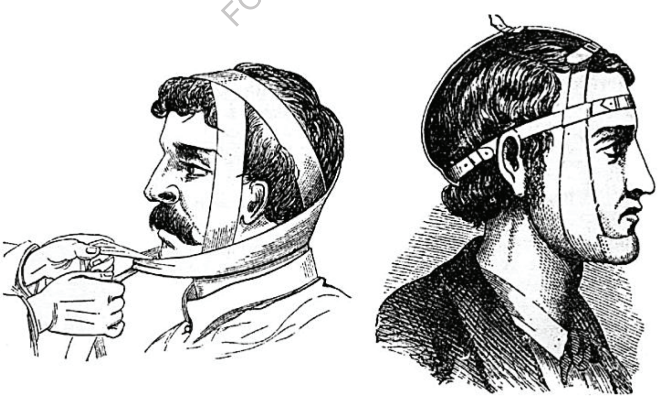

Fig 1. Bandages to immobilise the lower jaw: Garretson’s (left) and Hamilton’s (right)

Bandages to immobilize the lower jaw

The eighteenth century saw a lot of scientific approach to medication as a result of advances within the data of anatomical and physiological processes. The age of scientific odontology was ushered in by the publication of a book in large integer by Pierre Fauchard, entitled Trait´e DE chirurgic dentaire.[15] He was the first one to explain a comprehensive system to observe odontology as well as basic oral anatomy and performance, operative and restorative techniques, and construction of dentures. He is attributable with being the "Father of contemporary dentistry". Though Fauchard didn't build any special contribution to the treatment of fractures of the jaws, the impetus that he gave to the event of dental prostheses aroused others to plan techniques for the management of the fragments of the dentate jaw apart from by the employment of easy ligature of the teeth and support from a bandage.

As may well be expected, the simple ligatures used to bind round the teeth were unable to carry the fragments of jaw in a very rigid position, therefore the fracture was unstable. Bunon wanted improved stability; in 1743, he used a carved ivory block as a dental splint to which he tied all lower teeth by threads.[16]

In 1779, Chopart and Desault delineated a simple dental splint, primarily a shallow trough of iron ordered over the lower occlusal table that was clamped all the way down to the lower border of the lower jaw by an external screw device (Fig. 2).[8] Variations of this principle were utilized for a protracted time, being introduced into Germany by Rutenick in 1799, who applied more stabilization by a head harness connected to a helmet by ribbons.[17]

Fig. 2. Apparatus to immobilise a fracture mandible according to Chopart and Desault (1779)

<u>THE 19TH AND 20TH CENTURY:-</u>

At the turn of the nineteenth century, there was a gradual shift within the management of fractures of the jaw far away from general surgeons to dental surgeons as a result of the management of fractures trusted manipulating the dentition. Advancing dental materials expedited the development of dental splints. These were the domains of the dentists. The work has later on remained the remit of the dentally based most specialties.

Many refinements were introduced by up intra-oral and extra-oral splints or the utilization of either trans-mandibular or circum-mandibular wire fixation to immobilize the articulator fracture directly or indirectly. External fixation usually caused infection and also the risk of disorder. In 1826, Richard Rodgers did one among the primary open reductions. He inserted wire sutures in a case of pseudo-arthrosis of humerus bone.[11] Baudens is attributable with being the pioneer of wiring mandibular fractures, and as early as 1840[2] he used circumferential wires to immobilize an oblique fracture. Shortly after this (1847), Buck applied wire sutures on to the fractured bone by drilling holes in adjacent segments and wiring them along.[18] Modifications of this system by use of 2 double wires (R¨ose) and also the figure-of-eight wire suture (Raas) improved stability.[11] However, before the appearance of antibiotics few intraoral wounds cured without infection. Up to this time, all fractures of the jaw were reduced manually, without the help of anaesthesia. The introduction of anaesthesia by Dr. Horace Wells in 1844 revolutionized the treatment of surgery.[19] Speed was now not of preponderant importance and a degree of fineness was introduced with improved results. This additionally is applied to fractures of the jaw.

In 1855, Hamilton devised the gutta-percha splint that was ready in the patient's mouth once reduction of the fracture was done. This splint enjoyed wide application, notably throughout the American civil war.[17] Kingsley devised a splint, "Kingsley's apparatus" (Fig. 3), with connected bars by which the splint and also the jaw could be bound firmly with an outside bandage passing from one bar to the opposite beneath the chin.[12] In 1858, Hayward developed a metal splint for severely dislocated fractures, the splint being adjusted to the individual needs on the idea of a plaster model of the jaws.[19] This was a novel development. A cast was manufactured from the lower jaw bone and sectioned through the fracture site and the dental occlusion was realigned. A splint was created to the new occlusion and coated the surface of the teeth. The fragments of the jaw were forced into the splint, thus effectively reducing the fracture.

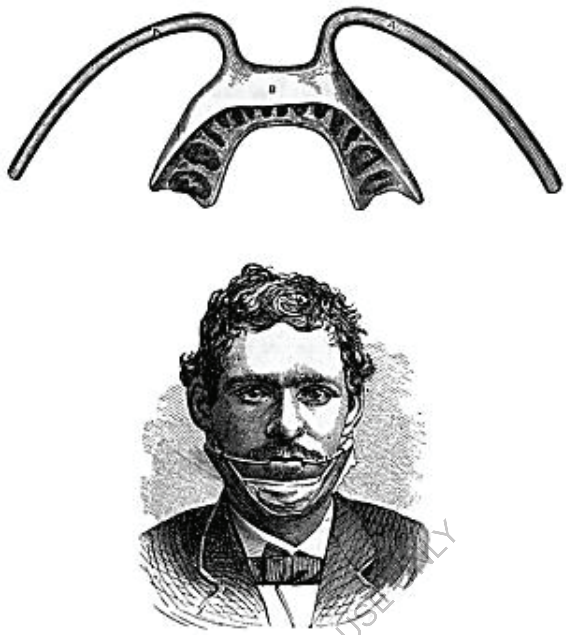

Fig. 3. Kingsley's splint (top) and applied (bottom), 1855

In 1866, Thomas Gunning designed the 'Gunning splint' for Mr. William Seward, the Secretary of State to Abraham Lincoln.[20] William Seward had bilateral fractures of the body of the mandible followed by a fall from a carriage. The splint was a single piece of volcanite with a space for eating (Fig. 4). He used screws to attach the splint to the hard palate and mandible. A different type of the Gunning splint still remains in use these days. In 1871, London dental practitioner Gurnell Hammond devised a wire ligature splint for immobilization of the mandible.[21]An impression was made of the teeth and cast in stone. The displaced segments were realigned on the stone model and a loaded iron wire was tailored to the teeth on the model. Afterwards, the bar was wired to the patient's natural teeth, thus pulling the misaligned fragments into line. This technique is still used these days in the form of arch bars.

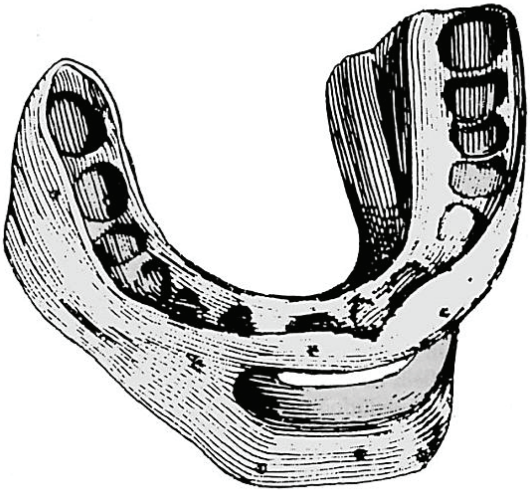

Fig. 4. The Gunning splint (1866)

In 1887, Thomas L. Gilmer reintroduced intermaxillary fixation (a technique that was forgotten for centuries) and also the employment of arch bars for inframaxillary fractures.[10] His technique continues to be superior to other ways of fixation in circumstances like communited fractures and fractures of atrophic mandible. However, the disadvantage of his technique is that it may be uncomfortable, and pain together with the modification in diet from solid to liquid can end in loss of weight and poor nutrition. Dr. Angle (1890) introduced another technique of wiring the segments of the jaw. It consisted of banding teeth on either aspect of the fracture, and bound within the bands along by wire to immobilize the fracture—Angle's apparatus (Fig. 5a). Angle's technique of fixation of a broken mandible (intermaxillary fixation) was effected by inserting bands on the teeth of the maxilla and mandible and round the short arms mounted upon these bands wrapping a wire that holds them along, thus using the maxilla as a splint (Fig. 5b).[17]

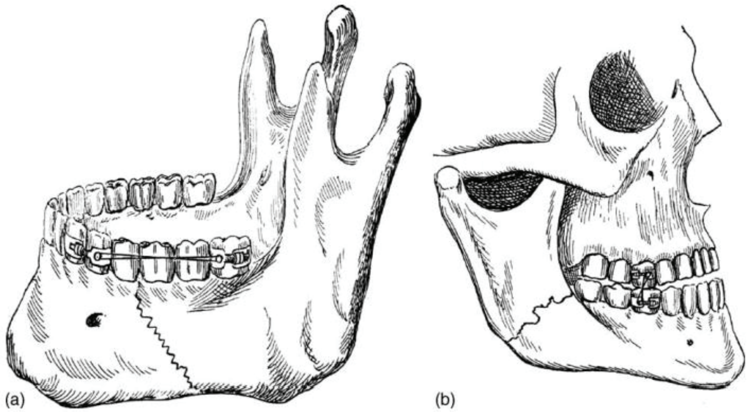

Fig. 5. Angle's apparatus (a) and Angle's intermaxillary fixation (b)

Hippocrates said: 'War is that the only correct school for a surgeon' and far impetus to the improved management of facial fractures came with the mobilization of whole nations for the first and Second World War. Trench warfare resulted in in severe maxillofacial injuries in thousands of troopers. Military surgeons were forced to improvise in fashioning appliances for their patients and infrequently created splints from coins, telegraph wire, or meat tins. The Amex casque helmet (Fig. 6) designed for the American military forces, became popular among French and British military surgeons.[22] It had steel adjustable band, fitting round the circumference of the head, with adjustable cranial bands and an adjustable perpendicular rod and a horizontal face bow. This appliance accomplished fixation of either soft tissue or bone fragments and was used for several patients with injuries of the head and jaw.

Fig. 6. Amex casque, designed by American Expeditionary Forces (World War I)

Dr. Varaztad H. Kazanjian, the chief dental officer at Harvard University was sent to England to help British in treating soldiers who were injured in the first world war.[10]He established a treatment set up for antecedently unmanageable maxillofacial injuries by wiring along tiny fragments of shattered jaw bone, and construction of special splints and internal vulcanized rubber supports that prevented the face from contracting till surgeons were in an appropriate position to graft bone and skin on to the broken areas. As a result of the extraordinary success of his techniques, British journalists dubbed Kazanjian “the soul of the Western front”. Kazanjian not only created a novel treatment for maxillofacial fractures, he additionally was a pioneer within the field of contemporary reconstructive surgery. Throughout succeeding few decades, there have been several variations of splinting and techniques of intermaxillary fixation, most notable by Robert H. Ivy (1922).[17]

He changed the technique of intermaxillary fixation by making a loop (eyelet) within the wire ligature, that later became well-liked and was called the 'Ivy loop'. Though the primary percutaneous nailing of fractured long bones was by Parkhill as early as 1897[23], the employment of Kirschner wires to treat articulator fractures was documented solely in 1932.[9]After the restoration of traditional occlusion, the broken fragments were fixed with a pin inserted trans-cutaneously. The 'fixateur externe' devised by the Ginestet, 1936 (Fig. 7), became well-liked in the treatment of complicated facial injuries encountered within the 1939–1945 war and was in common use throughout the period of the Vietnam war.[21]

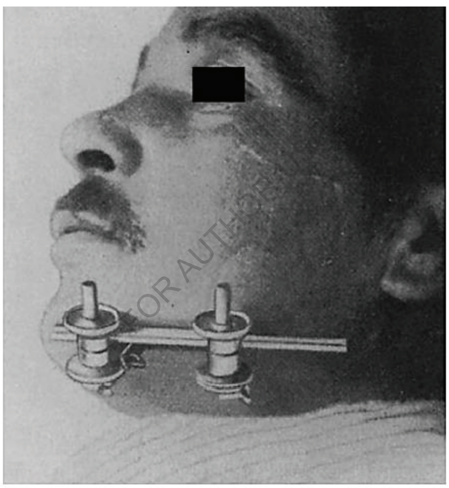

Fig. 7. 'Fixateur externe' developed by Grace George Ginestet in 1936

<u>Development of osteosynthesis:</u>

Modern traumatology started with the event of osteosynthesis, which was a serious revolution in cranio-maxillofacial surgery. Before its advent, most inframaxillary fractures were treated either by approximate fixation with the use of internal chrome steel wires, external fixation using rigid metal pins, or tailor-made silver cap splints (cast metal covering of all the teeth within the arch). The primary osteosynthesis plate was employed by British surgeon Sir William Lane over a hundred years past.[24]The concept was ahead of its times, as a result of the technology for plates to be biocompatible and therefore the downside of infection had to be overcome. It absolutely was not till 1943 that Bigelow delineated screws and bars fabricated from vitallium—an alloy of cobalt, chrome, and molybdenum—for use within the management of mandibular fractures.[25]It was solely within the late Sixties (when Luhr[26](Fig. 8a) and Perren et al.[27] introduced plates with conical or spherical screw heads and compression holes that were congruent in shape and started their large-scale production) that the way was paved for osteosynthesis to be typically accepted within the treatment of facial fractures. Pauwels reported that the foremost favourable site of internal fixation of a fractured bone was wherever the muscular tensile forces were at their greatest. Champy and Lodde within the early seventies applied this 'tension band principle' (also mentioned as Champy's principle) to the lower jaw in mathematical, biomechanical, and clinical studies.[28]

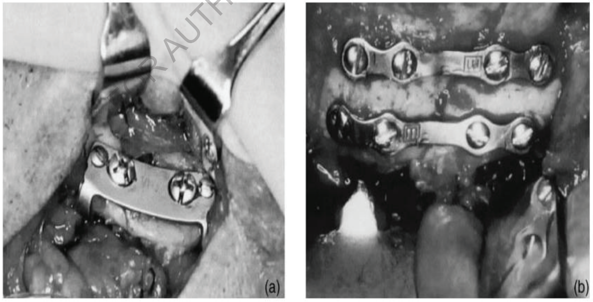

Fig. 8. Osteosynthesis plate introduced by Hans Luhr19 (a). Miniplates developed by Champy and Lodde21 (b)

The first plates were still bulky, and were designed solely to be used in jaw fractures. Miniplate osteosynthesis was first used by Michelet et al. in 1973,[29] and later developed by Champy and Lodde in 1975 (Fig. 8b).[28]Spiessl devised the lag-screw technique of osteosynthesis in1974.[30] These screws had threads on the distal finish and a sleek shank at the proximal finish that allowed compression of the segments between the outer and inner parts. Throughout the subsequent 20 years an oversized variety of modifications of plates were represented,[31-33]that brought into the current use of osteosynthesis. In the recent times, Ellis has done intensive work on non-compression, monocortical plates for jaw fractures, significantly those of the condyle and angle.[34] Today, many various systems area out there, starting from the heavy compression plates for jaw reconstruction to low profile plates for midfacial fixation. The thickness of plates ranges from 0.5 to 3.0mm and are made using stainless steel, titanium, or vitallium. Recently, perishable, self-reinforced polylactide plates and screws are used for the internal fixation of fractures of the lower jawbone with acceptable results.[35]

Reflection:

In reflecting on the advancement of technique through the nineteenth century to these days, one has to appreciate that the sort of fracture was completely different then from now. In 1895, the fractures were comparatively straight forward. Dr. F.Weisse reported to the New York Odontological Society in October 1899 that he had treated varied fractures and never seen a case wherever there was any internal or external wound except at the fracture site.[36] He reported that dental surgeons were never referred to as upon to sew a wound or to arrest undue bleeding. This contrasts with the injuries sustained in high-speed road traffic crashes of these days. Several facial fractures are still caused by social violence and might be thought simple.[37] External appliances fastened to a head cap and semi-rigid immobilisation by wire suspensions that are quite cumbersome to the patient and entail long amount of immobilisation are outmoded. These straightforward however crude techniques shouldn't be deprecated as they're effective and might be relied on whenever modern facilities aren't on the market. The improved results are obtained from a more robust scientific approach to the biomechanics underlying the performance of the jaw, and the trade of recent techniques and biomaterials to those principles. It is conjointly been created potential by the final advances, with management of infection and improved surgical instruments.

Fractures of the condylar process are recognized and treated for nearly one hundred fifty years. In all told cases there are two issues to be thought-about, diagnosis and treatment. That advances in science have brought enhancements till date as technique is concerned about there's very little doubt, however one wonders whether or not the top results obtained are commensurate with the technique used.

W.D MacLennan et al in 1949 conducted a study on 180 patients wherein 159 were males and 21 were females. Age limit of patients that was included in the study were 10 years to 35 years of age. Various treatment options used for treating the patients were conservative treatment options such as bandages, intraoral dental wiring, cast metal cap splints, gunning splint and bandages and pin fixation or direct wiring. Complications occured after the treatment were pain, limitation in movements, deviations, visual deformity and radiographic deformity.

It was observed that while no cases were managed by the open reduction method, the complications were less. Of the two patients complaining of pain, the one had severe facial injuries involving the middle and lower face, with considerable soft tissue loss locally, while the other was a case of compensation. Pain was taken as an established entity only if it is proven to be present nine or more months after the original injury. The radiographic bony defect in the condylar region is notable as it confirms the fact that a great number of such cases do heal in malposition.[38(10)]

In year 1983 Zide and Kent reported their vast experience in managing the mandibular condylar fractures. Their treatment of choice for managing the mandibular condylar fracture was closed reduction. The absolute indications for open reduction are (1) displacement into the middle cranial fossa, (2) inability to obtain adequate occlusion by closed reduction, (3) lateral extracapsular displacement of the condyle, and (4) foreign body invasion (e.g., gunshot wound). These indications exist in children as well as in adults. The relative indications of open reduction are (1) bilateral condylar fracture in edentulous patients, (2) unilateral or bilateral condylar fracture where maxillofacial splinting is impossible (alcoholism and seizures), (3) bilateral fractures along with comminuted midface fractures and (4) bilateral fractures associated along with retrognathia, prognathism or open bite.[39]

The 21st century

In year 2000 Ellis conducted a study to evaluate the surgical complications with open treatment of mandibular condylar process fractures. A total of 178 patients were included in the study with unilateral fractures of the mandibular condylar process, out of which 85 were treated closed and 93 were treated open method. A tabulated form of surgical findings and intraoperative and postoperative complications was prospectively done. There were very less intraoperative or postoperative complications. At the 6-week point, 17.2% of patients managed by open method had some weakness of their facial nerve. This had resolved by 6 months. The scars were observed either wide or hypertrophic in 7.5% of cases. Based on this study, surgical complications of open treatment of condylar process fractures that bring about permanent dysfunction or deformity are uncommon.[40]

In the previous time, closed reduction along with active physical therapy that is performed after intermaxillary fixation during the recovery period had been mainly used. However, as it has drawbacks such as metastasis of the fractured bone by muscle strength, abnormal occlusion because of inappropriate fixation, and improper function of the temporomandibular joint (TMJ) as a result of disuse atrophy of muscle due to long-term intermaxillary fixation, open reduction has been seen recently to draw attention. In particular, condyle fracture is satisfactorily managed by closed reduction. Most of the researchers recommended closed reduction due to problems in surgical approach, including infection, injury of nerve and blood vessel, and scar formation. However, when compared to previous open reduction, currently it has been seen to be more widely used by reducing complications such as TMJ pain and arthritis, and reduction in mouth opening via accurate reduction of bony fragment along with the development of surgical instruments and surgical approaches.[41]

However, it is still controversial whether to select closed or open reduction to treat condyle fracture depending on displacement severity and site of fracture. Klotch and Lundy and Widmark et al. reported that open reduction should be performed if fractured mandibular condyle displaced extensively, and that closed reduction may be performed considering variety of factors such as geriatric or pediatric patients, difficulty in the conduct of open reduction under general anesthesia, no other facial fracture, and stability of occlusion.

Haug and Assael reported that no statistically significant variation in occlusion status and complication such as restriction in mandibular movement was seen between open and closed reductions for fracture of mandibular condyle. Ellis et al. reported that complications including intraoperative hemorrhage and postoperative infection, paralysis of facial nerve, functional disorder of the auriculotemporal nerve and condyle growth disorder are greatly increased when open reduction was performed to manage condylar head and neck fractures, and that closed reduction was more superior than open reduction. Meanwhile, Brown and Jones performed rigid fixation by the use mini plate, reporting that intermaxillary fixation was not required. Tu and Tenhulzen reported that fracture fixation by the use of mini plate and screw minimized the intermaxillary fixation period and prevented the disuse atrophy of the masticatory muscle, thus achieving early opening, and that postoperative complications reduced significantly. Jeter et al. reported that relatively acceptable results were observed from closed reduction for condyle fracture, but that this method could lead to mouth opening disorder, mandibular setback, temporomandibular pain, and functional disorders after a long time following injured. They recommended that reconstruction of the fracture and rigid fixation using open reduction should be performed on patients with condyle fracture to obtain immediate mouth opening, and improvement of nutrition, maintaining good intraoral hygiene, and normal pronunciation should be performed.[42]

SURGICAL ANATOMY OF TMJ

The temporomandibular joint (TMJ) and its components often need exposure for a myriad of procedures. Arthritis, trauma, internal derangements of the TMJ, developmental disorders and neoplasia may all affect the TMJ and/or the skeletal and soft tissue parts. Various approaches to the TMJ have been proposed and employed clinically. The standard and most primary, however is the preauricular approach.[43, 44]

PRE AURICULAR APPROACH

Though the TMJ itself is relatively small, many essential anatomic structures are close by. This region has the parotid gland, superficial temporal vessels, and facial and auriculotemporal nerves.

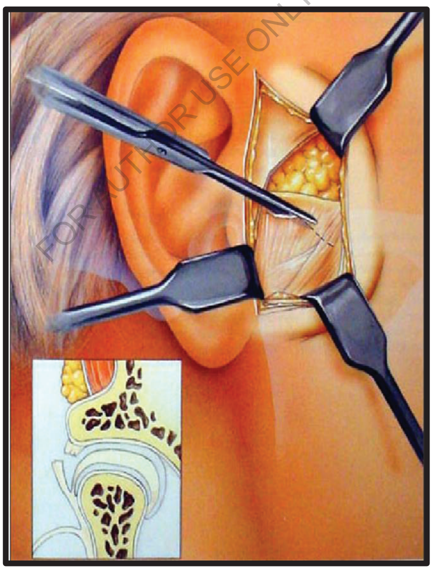

Fig.9. Preauricular approach

PAROTID GLAND

The parotid gland lies in front and below of the external acoustic meatus, below the zygomatic arch, on the masseter muscle, and behind the ramus of the mandible. The superficial pole of the parotid lies on the TMJ capsule directly. The parotid gland is enclosed in a capsule which is derived from the superficial layer of the deep cervical fascia, often known as parotideomasseteric fascia.[43]

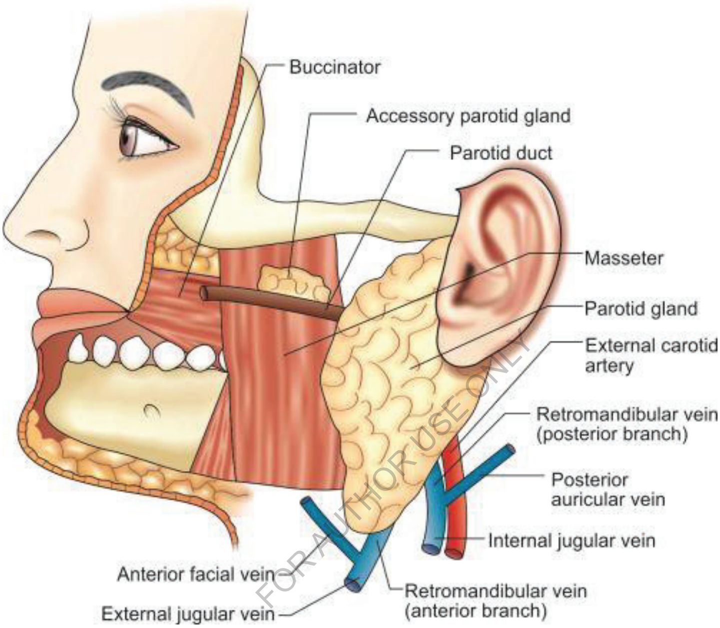

Fig.10. Parotid gland

SUPERFICIAL TEMPORAL VESSELS

The superficial temporal vessels arise from the superior aspect of the parotid gland and carry the auriculotemporal nerve along with it. The superficial temporal artery emerges in the parotid gland at bifurcation of the external carotid artery. When it crosses superficial to the zygomatic arch, a temporal branch is given over the arch. This vessel is a common source of hemorrhage. The superficial temporal artery gets divided into the frontal and parietal branches a few centimeters superior to the arch. The superficial temporal vein lies superficial and generally posterior to the artery. The auriculotemporal nerve is accompanied, and is posterior to, the superficial temporal artery.[43,44]

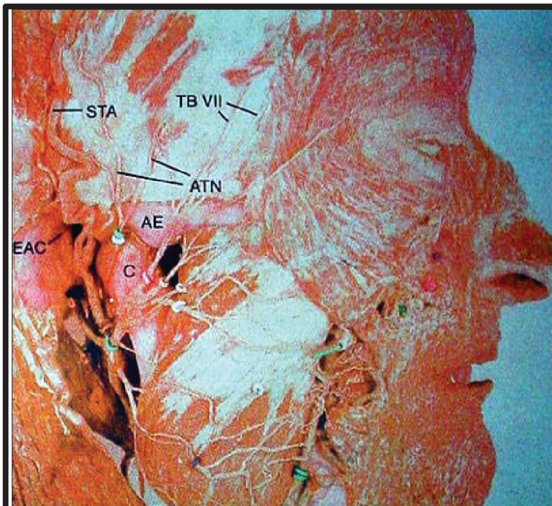

Figure 12 1 Anatomic dissection showing structures of importance : AE = articular eminence of the temporal bone; ATN = auriculotemporal nerves; C = condyle; EAC = external auditory canal (outer ear removed); STA = superficial temporal artery; TB VII = temporal branches of the facial nerve

Fig.11. The superficial temporal vessels

AURICULOTEMPORAL NERVE:

The auriculotemporal nerve supplies sensation to parts of the ear, the tympanic membrane, the external auditory meatus and the skin in the temporal area. It arises from the medial side of the posterior condylar neck and turns upwards, running over the zygomatic part of the temporal bone. Just anterior to the ear, the nerve divides into the terminal branches over the skin of the temporal area. Preauricular uncovering of the TMJ area almost always injures this nerve.[43] Damage is reduced by incision and dissection in close approximation to the cartilaginous part of the external auditory meatus. Temporal adjunct of the skin incision should be located posterior so that the main distribution of the nerve is dissected and retracted forward in the flap. Luckily, patients rarely complain about sensory disturbances resulting from damage to this nerve.

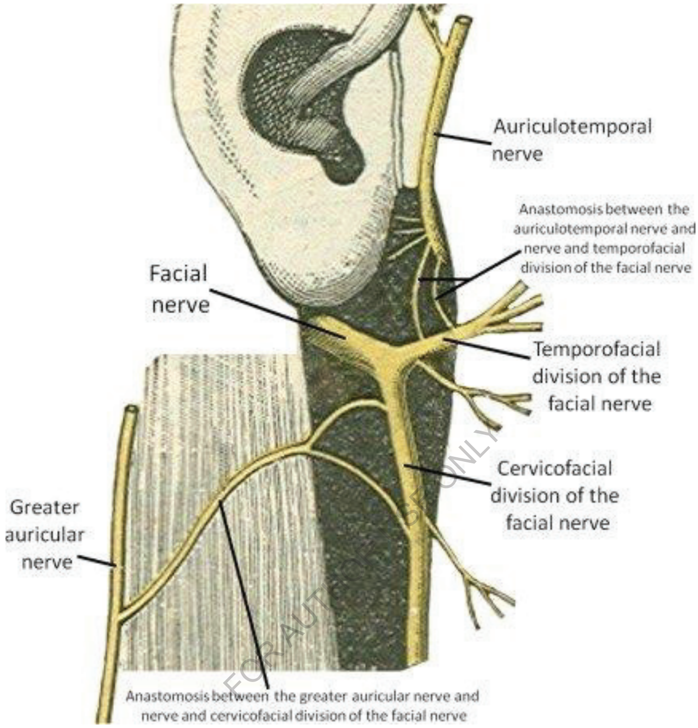

Fig.12· Auriculotemporal nerve

FACIAL NERVE:

Soon after the facial nerve exits the skull through the stylomastoid foramen, it enters the parotid gland. Here, the nerve generally divides into two main trunks namely temporofacial and cervicofacial, the branches of which variably anastomose forming a parotid plexus. The branching of the facial nerve is situated between 1.5 and 2, 8 cminferior to the lowest concavity of the bony external auditory canal.

Terminal branches of the facial nerve arise from the parotid gland and radiate towards the anterior. The terminal branches are commonly divided as temporal, zygomatic, buccal, marginal mandibular, and cervical. The location of the temporal branches has particular concern during TMJ surgery, as these are the branches most likely to be damaged.[43] As the temporal nerve branches (usually two) pass the lateral surface of the zygomatic arch, they course along the undersurface of the temporoparietal fascia. The temporal branch passes along the zygomatic arch at different locations from one individual to the other, and range from 8 to 35 mm (20 mm average) anterior to the external auditory canal. Thus, protection of the temporal branches of the facial nerve can be obtained by routinely incising the superficial layer of temporalis fascia and periosteum of the zygomatic arch not more than 0.8 cm in the front of the anterior border of the external auditory canal.

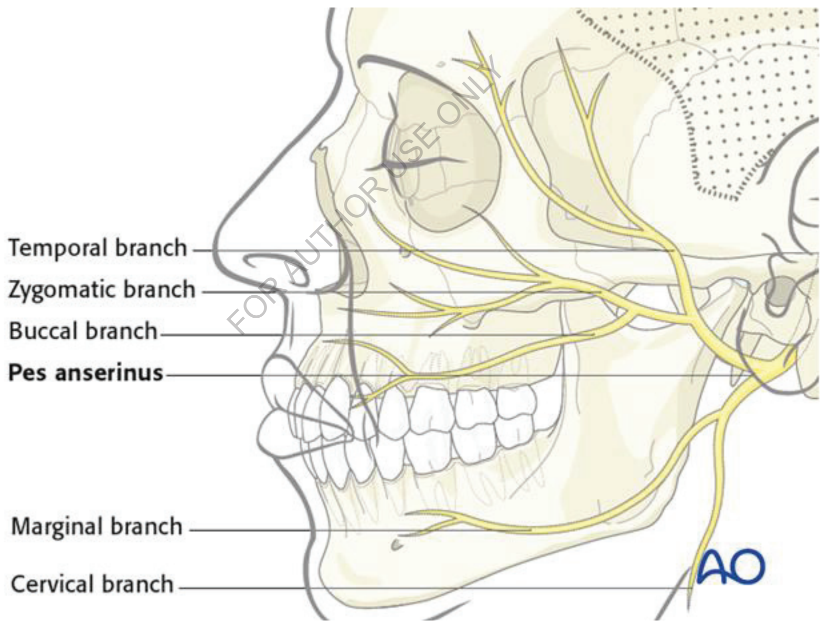

Fig.13. Facial nerve

TEMPOROMANDIBULAR JOINT

The TMJ capsule forms the anatomic and functional boundaries of the TMJ. The thin, loose fibrous capsule surrounds the body surface of the condyle and blends with the periosteum membrane of the articulator neck. On the temporal bone, the articular part capsule surrounds the articular surfaces of the eminence and fossa. Attachments of the capsule are firmly adhered to bone. On the anterior aspect, the capsule is hooked up to the crest of the articular eminence; laterally, it adheres to the edge of the eminence and fossa; and posteriorly, it passes medially on the anterior lip of the squamotympanic and petrotympanic fissure. The medial attachment runs on the sphenosquamosal suture. The articular capsule is powerfully strengthened laterally by the temporomandibular (lateral) ligament, composed of a superficial fan-shaped layer of obliquely adjusted connective tissue fibers and a deeper, slim band of fibers that run more of horizontally.[43]

The ligament is attached broadly to the outer surface of the root of the zygomatic arch and converges inferiorly and posteriorly to attach to the back of the condyle below and behind the lateral pole. The articular disk is firm but flexible with a biconcave shape. The disk is generally divided into three regions: the posterior band, the intermediate zone, and the anterior band. The central intermediate zone is greatly thinner (1 mm) than the posterior (3 mm) and anterior (2 mm) bands. The superior surface of the disk is adapted to the shapes of the fossa and eminence of the temporal bone, and the inferior surface of the disk adapts to the shape of the mandibular condyle. Posteriorly, the disk and also the posterior attachment tissues which are loosely organized (bilaminar zone, retrodiscal pad) are contiguous. The retro-discal tissues are hooked to the tympanic plate of the temporal bone posterosuperiorly and to the condylar neck posteroinferiorly. Anteriorly, the disk and the capsule and fascia of the upper head of the lateral pterygoid muscle are contiguous. The greater head of the lateral pterygoid muscle may have some fibers directly inserted into the disk anteromedially. The articular disk of the TMJ is a hypo vascular intra-articular structure that separates the the glenoid fossa from the condylar head. It is firmly bound to the condyle at its lateral pole; it is not directly bound to the temporal bone. The articular disk and its posterior attachment tissues unit with the capsule around their periphery. The disk and its attachment divide the joint space into separate upper and lower spaces. In the sagittal plane, the superior joint space is contiguous with the glenoid fossa and the articular eminence. The inferior joint space is always extended farther anteriorly than the lower joint space. The lower joint space is contiguous with the condyle and is extended only slightly anterior to the condyle along the upper aspect of the superior head of the lateral pterygoid muscle. In the frontal plane, the superior joint space overlaps the inferior joint space. Thus entrance through the lateral capsule starts from the upper compartment.

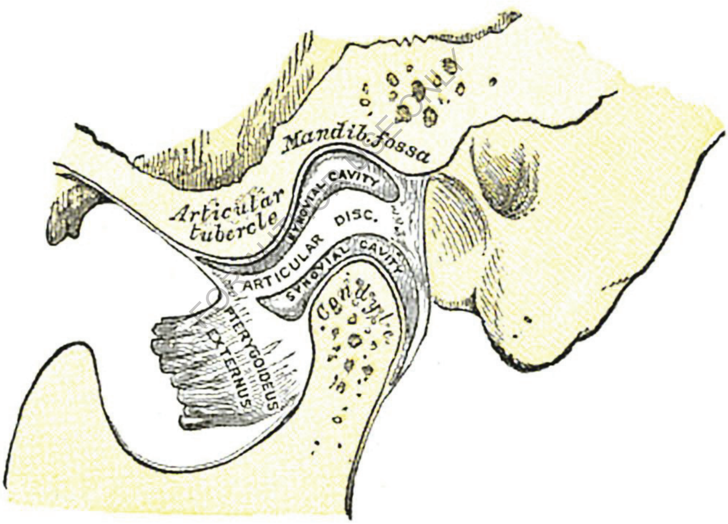

Fig.14.Temporomandibular joint

LAYERS OF TEMPOROMANDIBULAR REGION:

The temporoparietal connective tissue is that the most superficial connective tissue layer below the subcutaneous fat. This part is that the lateral extension of the galea and is continuous with the superficial musculoaponeurotic layer (SMAS). It is often referred to as the superficial temporal fascia or the suprazygomatic SMAS. It is easy to miss this layer totally during incision of the skin, as it is below the surface. The blood vessels of the scalp, like the superficial temporal vessels, line its superficial surface closely associated with the subcutaneous fat. On the other hand, the motor nerves, like the temporal branch of the nerve, run on the deep surface of the temporoparietal fascia.

In the temporoparietal region the subgaleal fascia is well developed and can be dissected as a discrete facial layer. But it is often used only as a cleavage plane in the standard Preauricular approach.

The temporalis fascia is known as the fascia of the temporalis muscle. This thick fascia originates from the superior temporal line and gets attached to the pericranium. The temporalis muscle originates from the deep surface of the temporal fascia and the full of the temporal fossa. Inferiorly, the temporal fascia splints into medial border of the zygomatic arch at the level of the superior orbital rim. A small amount of fat between the two layers is sometimes referred to as the superficial temporal fat pad. A large vein usually runs just deep to the superficial layer of temporalis fascia.[44]

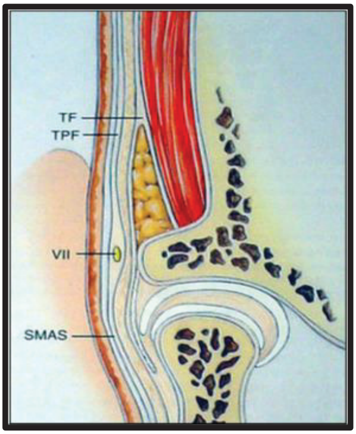

Fig.15. Layers of temporomandibular region

BIOMECHANICS OF CONDYLAR FRACTURE

Joint mechanics:

As previously mentioned, the TMJ disk separates the joint into a superior and an inferior compartment. It is the inferior compartment that is responsible for rotational movement, and the superior compartment where the translational movement of each condyle takes place. Because of these two unique properties the TMJ is termed a ginglymoarthrodial joint. Not all animals are capable of the translational component. It is hypothesized that the translational component may provide for further opening without impinging on cervical structures.[45] Mandibular function is often described as a class III lever in which force is applied between the fulcrum and load[46] (Fig. 16). The TMJ acts as the fulcrum in this system, with the musculature applying force between the joint and the masticatory load, and ultimately transmitting variable loads to the TMJ during mastication.

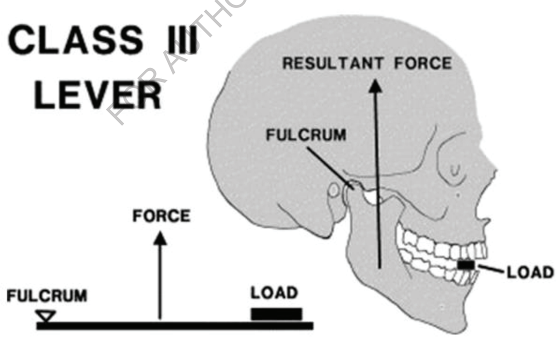

Fig. 16.The mandible may function as a class III lever system, in which the muscle force is between the TMJ (fulcrum or axis) and the occlusal load.

Fracture patterns and symptoms:

The U-shaped mandible distributes forces that are applied to it. As a weaker area, fractures are often seen in the subcondylar region, caused by tensile stress when a force is applied elsewhere, which supports the frequent finding of a second, distant mandible fracture, such as a contralateral parasymphysis fracture. This fracture is also often quoted as a potential defense mechanism that prevents the intracranial intrusion of the condyle into the middle cranial fossa above through the roof of the glenoid fossa, which can be less than a millimeter thick.[47]

Signs and symptoms of condylar fractures include pain over the preauricular area and limited incisal opening. Unilateral condylar fractures produce an ipsilateral premature occlusion, with a contralateral open bite, owing to the loss of vertical height. Deviation to the affected side on opening is common because of the interruption of the action of the lateral pterygoid muscle. Laterotrusive movements are limited away from the fractured side, but may be preserved toward the fracture. Bilateral condylar fractures, usually sustained by an indirect blow to the chin, as seen in the socalled guardsman fracture, produce an anterior open bite caused by the bilateral loss of height with premature posterior contact. The condylar head is usually displaced anteriorly and medially in the direction of the force from the lateral pterygoid muscle, although lateral displacement and complete disarticulations are also possible.

Adaptations to fracture:

When a condylar fracture is sustained, the patient adapts to the injury with skeletal, muscular, and dental compensations. Surgeons minimize dental compensations and malocclusions by treating condylar fractures either with open reduction and internal fixation or with maxillomandibular fixation. Ellis and Throckmorton[46] studied the masticatory function of patients with condylar fractures, and showed that patients increase the masseter activity on the nonfractured side, and decrease activity on the injured side, which transfers load away from the injured condyle (Fig. 17). This adaptation acts as a neuromuscular splinting mechanism. It is most evident when the occlusal load is on the opposite side, because this creates more stress on the injured condyle.[46] In a separate study these investigators also noted that less neuromuscular compensation is required if open reduction of fragments is undertaken.[48]

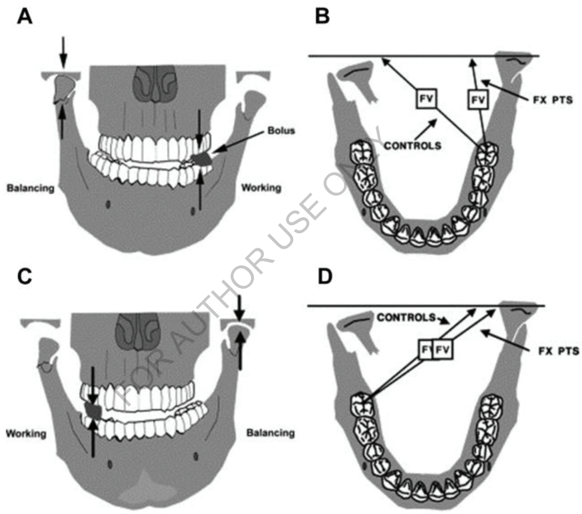

Fig. 17. What happens with unilateral condylar process fracture. When biting on the side opposite the fracture, the fractured joint is expected to be loaded more than the nonfractured side joint (A). However, it has been shown that, in patients with such injuries, the mean force vector (FV) moves toward the uninjured side so that the relative loading of the damaged joint is reduced (B). This process occurs by selective increase in the muscles on the nonfractured side and a relative decrease in the activity of the muscles on the featured side. When biting on the fractured side (C), it would normally be expected that the uninjured joint would have most of the loads. There is less need for neuromuscular compensations to occur in this instance because the major loads would occur to the uninjured joint, not the fractured joint (D)

With closed treatment, and on healing, the mandibular condyle often reestablishes an articulation that is more anterior and lower on the eminence, which may reduce the translational component of mandibular opening. In theory, this skeletal compensation is avoided with open reduction of the fracture. As previously mentioned, historically most condylar fractures were treated closed, and decades of literature have revealed a small numbers of complications, because of the remarkable ability of these skeletal, dental, and neuromuscular adaptations. However, a recent meta-analysis reported a statistically significant reduction in the incidence of malocclusion and lateral deviation on opening, as well as improved protrusive and laterotrusive movements with surgical therapy compared with closed management.[49] A lower incidence of infection was the only variable studied that favored closed management, whereas differences in maximum opening and pain were not significant.[49]

Ultimately, the patient and the individuality of the fracture determine the course of treatment. A thorough understanding of the anatomy of the condylar region is paramount for facial trauma surgeons. Understanding this along with the biomechanics of the injury helps to guide surgeons in therapy.

CLASSIFICATION OF CONDYLAR FRACTURE

Various classification systems describing mandibular condylar fractures have been developed and published, essentially since the development of treatment protocols for these injuries. The universal application of a single classification system is highly controversial, if not impossible, because of variability in terminology, grammatical differences, native language challenges, and regional preferences for a specific system.[50]

A clinically relevant classification system should comprise several key elements specifically: the anatomic position of the fracture, the degree of displacement and/or dislocation, and a simple classification scale construction that allows for ease of recall and comprehensibility. The anatomic position of the fracture is a critical component of any useful classification system. Any structural reference site should be easily identifiable, even within significant fracture patterns, and have applicability over a wide variety of treatment protocols. Considerable variability exists between the use of the terms "displacement" and "dislocation." The term displacement with the understanding there remains some degree of bony contact between the fractured and dislodged bony fragments while the condylar head remains within the articulating fossa. Dislocation refers to fractures where the condylar head is totally dislodged from the articulating fossa.

The anatomic position of the fracture is the most critical component of any classification system. The most widely referenced are discussed next, with a description of each of the relevant components associated with each one. In 1927, Wassmund[51] distinguished between fractures of the condylar head and the condylar neck. The condylar head fractures were identified as either comminuted head fractures or "chip fractures" not affecting continuity. The condylar neck fractures were further isolated to:-

- Vertical neck fractures secondary to shearing
- Transverse neck fractures secondary to bending

- Oblique neck fractures caused by a combination of shearing/bending

Wassmund[52] continued his work and in 1934 described dislocated fractures into three categories:

Wassumund(1927)

- Base fracture
- Neck fracture
- Head fracture (diacapitular)

Wassmund's classification (1934)

1. **Type I-** The angle between the head and the long axis of the ramus :10 to 45 degrees.
2. **Type II-** angle of 45 to 90 degrees, resulting in tearing of the medial portion of the capsule.
3. **Type III-** the fragments are not in contact, and the head is displaced mesially and forward owing to traction of the lateral pterygoid muscle. confined to within the glenoid fossa.
4. **Type IV-** fractures where the condylar head articulates in an anterior position to the articular eminence.
5. **Type V-** vertical or oblique fractures through the head of the condyle.

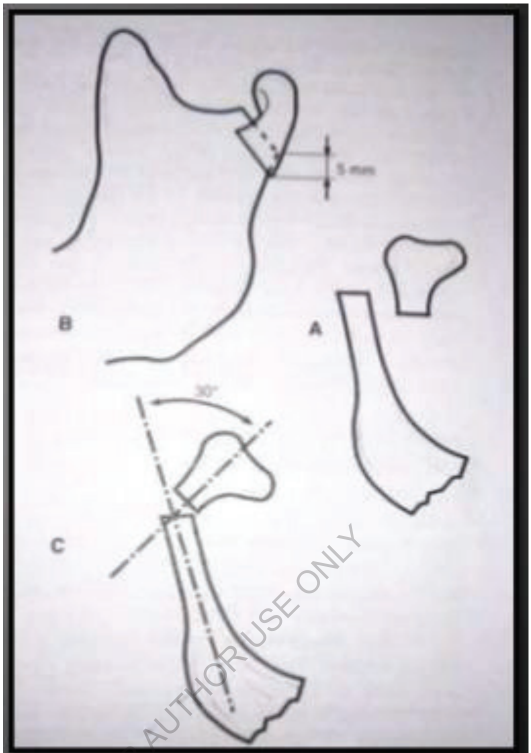

Fig.18. Wassmund's classification (1934)

The classification systems continued to become more descriptive when in 1952 MacLennan divided condylar fractures into sections according to anatomic location, the position of the condylar head within the articulating fossa, and the association between larger and smaller fracture segment:-

- Lower condylar neck fracture line starts at the sigmoid notch and extends caudally and obliquely to the posterior border of ramus.
- High condylar neck fracture begins above the sigmoid notch with involvement of the condylar neck.

- Subcondylar fractures consist of posterior oblique fractures of the mandibular ramus.
- Complete luxation fractures have avulsion of the condylar process.

MacLennan[53] further described the differences among simple “bending” of the condylar process, displacement fractures, and dislocation fractures:

- <u>Class I</u>: no deviation (bending)
- <u>Class II</u>: deviation (bending) at the fracture level
- <u>Class III</u>: displacement (condylar head remains within fossa)
- <u>Class IV</u>: dislocation (condylar head outside of fossa)

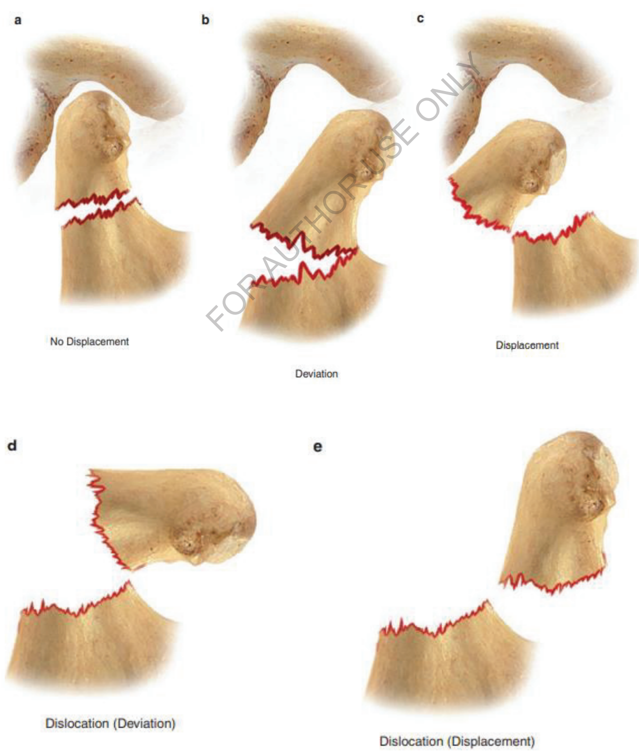

Fig.19. Maclennan classification (1952)

Rowe and Killey[54] described in 1955 a more simplified classification system based on the anatomic dimensions of the TMJ capsule and the surrounding structures of the TMJ:

- Intracapsular fractures
- Extracapsular fractures
- Fractures associated with the TMJ capsule, TMJ ligaments, articulating disk, and bony structures surrounding the TMJ

Dingman and Natvig[55] proposed a classification system in 1964 that incorporates the insertion of the lateral pterygoid muscle at the condylar neck:

- High condylar neck fracture: fracture line is at or above the level of the lateral pterygoid attachment on the fovea of the condylar apparatus.
- Intermediate condylar neck fracture: fracture line is below the level of insertion of the lateral pterygoid.
- Low condylar neck fracture: fracture begins at or below the sigmoid notch and extends to the posterior border of the mandibular ramus.

In 1972, Spiessl and Schroll[56] gave their classification on the location of the condylar neck fractures. They differentiated between fractures of the condylar base and neck, noting the degree of angulation associated with deviation, displacement, or dislocation:

- Type I: condylar neck fracture without deviation/ displacement.
- Type II: low condylar neck fracture with deviation/ displacement
- Type III: high condylar neck fracture with deviation/ displacement
    - IIIa: ventral
    - IIIb: medial
    - IIIc: lateral
    - IIId: dorsal

- Type IV: low condylar neck fracture with dislocation
- Type V: high condylar neck fracture with dislocation
- Type VI: intracapsular fracture of the condylar head

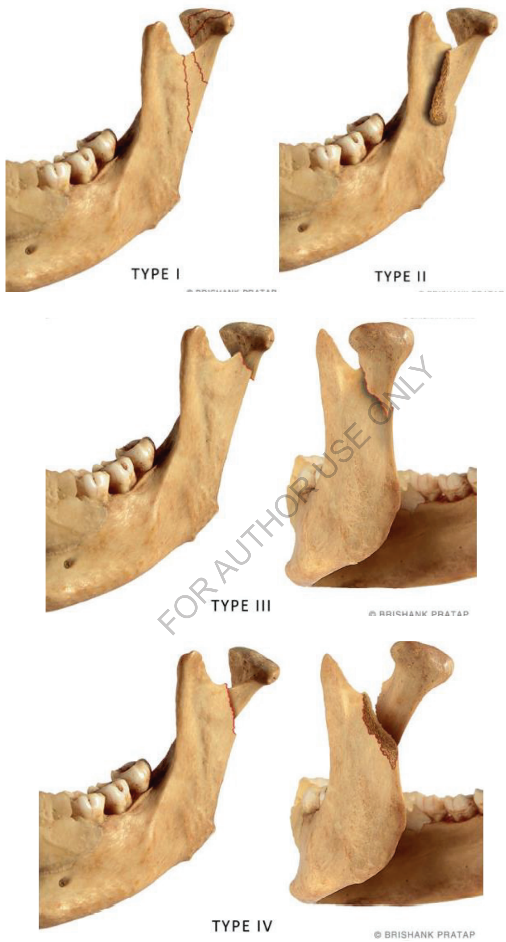

Fig.20. Spiessl and schroll classification (1972)

SPIESSL AND SCHROLL (1972)- modification : Rasse, Neff et al., Hlawitschka and Eckelt, and Loukota et al.

1. **Type A**: There is a continuous bony contact within the glenoid fossa, with a component of the remaining condylar head and the fracture supported with no loss of ramal height
2. **Type B**: Loss of support within the articulating fossa and with the loss of mandibular ramal height
3. **Type C**: The highest portion of the fracture is below the level of the lateral ligament, as a result there in a loss of ramal height

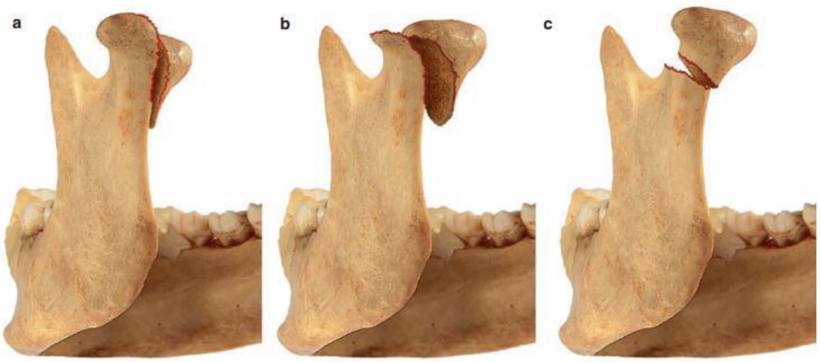

Fig.21. SPIESSL AND SCHROLL (1972)- modification : Rasse, Neff et al., Hlawitschka and Eckelt, and Loukota et al.

Lindahl[57] in 1977 published the most comprehensive description of mandibular condylar head fractures to date within the literature. This classification system, although highly descriptive, is also complicated because it describes the location of the fracture, deviation, and/or displacement and position of the condylar head within the articulating fossa.

1:Fracture level

1a: condylar head

1b: condylar neck

1c: subcondylar/condylar base

2: Deviation and displacement

2a: bending/deviation with medial overlapping segments

2b: bending/deviation with lateral overlapping segments

2c: bending/displacement without overlapping

2d: nondisplaced fracture without deviation

3: Relation between condylar head and fossa

3a: no dislocation

3b: slight dislocation

3c: moderate dislocation

3d: severe and/or complete dislocation

4: Condylar head fracture

4a: horizontal

4b: vertical

4c: compression fracture

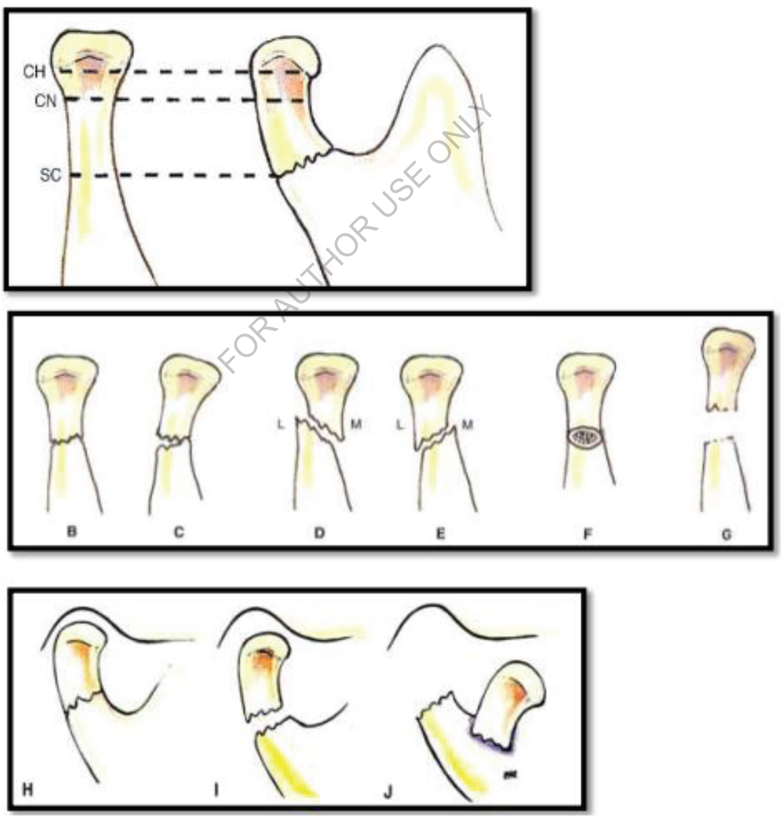

Fig.22.lindahl classification (1977)

Lindahl[57] describes the subcondylar fracture line beginning at the sigmoid notch and passing till the posterior border of the mandible. A condylar neck fracture is observed at the condylar process below the level of the condylar head. A condylar head fracture essentially has most of its fracture components, the entirety of the fracture, containing within the TMJ capsule.[57]

Lindahl's classification system remains highly accurate in the description of the fracture location, but is unwieldy and difficult to recall because of the multiple subsections involved in a complete description of the fracture site.

Modifications to the descriptions of Spiessl and Schroll were conducted by numerous authors adding the component of condylar head integrity (diacapitular fracture) for type V and type VI fractures. These included Rasse[58] in 1993, Neff and coworkers[59] in 1999, Hlawitschka and Eckelt[60] in 2002, and Loukota and coworkers[61] in 2010. In total, the changes evolved into the following clarifications of the Spiessl and Schroll system:

- Type A: continuous bony contact within the articular fossa, with a component of the condylar head remaining and the fracture supported without loss of ramus height
- Type B: loss of support within the articulating fossa and subsequent loss of mandibular ramus height
- Type C: the uppermost portion of the fracture is below the level of the lateral ligament, resulting in a loss of ramus height

Ellis and coworkers[62] in 1999 described a more simplified classification system, which dealt with the location of the fracture and the degree of dislocation and/or displacement:

- Condylar head fracture: intracapsular fracture

- Condylar neck fracture: fracture below the condylar head, but on or above the lowest point of the sigmoid notch
- Condylar base fracture: fracture in which the fracture line is located below the lowest point of the sigmoid notch

Radiographic interpretations of the Ellis classification system included[62]

- No detectable dislocation and correct positioning of the condylar head
- Slight dislocation: most of the condylar head remains within the articulating fossa and the degree of angulation/bending of the condylar process is less than 20º
- Severe dislocation: the condylar head is either on the articulating eminence or even further anteriorly, and the degree of angulation/bending of the condylar process is greater than 20º

In 2005, Loukota and coworkers[63] proposed a classification system for fractures of the condylar process of the mandible, which was subsequently adopted by the Strausbourg Osteosynthesis Research Group. This protocol described "Line A," which is a perpendicular line that extends through the lowest extension of the sigmoid notch to the mandibular ramus. The purpose of the line is to identify a component of the structural anatomy of the mandible that is easily reproducible even in cases of significant condylar trauma. Additionally, clarification of the condylar head fracture (diacapitular fracture) was noted, and presented a definition for the term "minimal displacement"

- Diacapitular fracture: the fracture line starts in the articular surface and may extend outside the TMJ capsule
- Condylar neck: the fracture line starts somewhere above Line A and runs above Line A for more than half of its length

- Condylar base: the fracture line extends behind the mandibular foramen and runs below Line A for more than half of its length
- Minimal displacement: displacement of less than 10 or overlap of the bone edges by less than 2 mm, or both

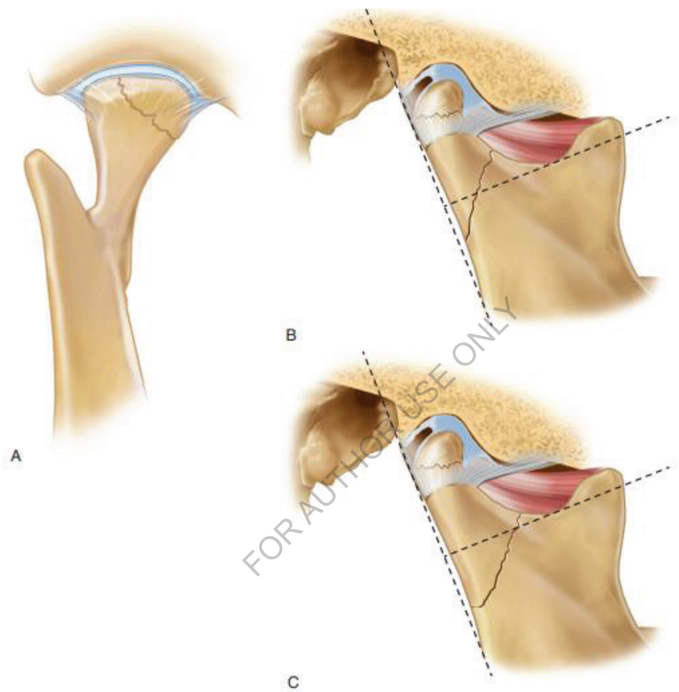

Fig.23. Strasbourg osteosynthesis research group classification (2005)

The AO Foundation[64] expanded on Ellis' classification with the determination of "high-neck" and "low-neck" fractures within the online AO Surgery Reference in 2010, providing greater detail to the location of "high and low" as theorized by Loukota:

- The first line parallels the posterior border of the mandible

- The sigmoid notch line runs perpendicular to the first line at the deepest portion of the sigmoid notch
- There is a line below the lateral pole of the condylar head that is also perpendicular to the first line
    - A line is drawn half way between the lateral pole line and the sigmoid notch line
    - A "high-neck" fracture is above this line, whereas a "low-neck" fracture is below

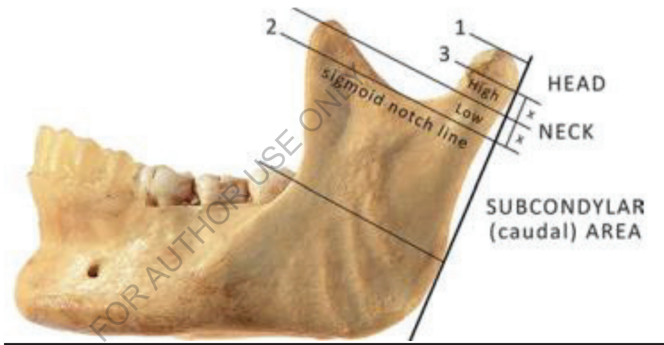

Fig.24. AO Foundation classification (2010)

In 2014, Neff and coworkers[65] published the Comprehensive AOCMF Classification System: Condylar Process Fractures. This system highlights numerous avenues of fracture location, identification, displacement, comminution, and dislocation. There is an attempt at clarity in identifying the location of the condylar fracture:

- Condylar head: the condylar head reference line runs perpendicular to the posterior ramus below the lateral pole of the condylar head

- Condylar neck: the sigmoid notch line running through the deepest point of the sigmoid notch perpendicular to the ramus line extending superiorly to the condylar head
- Base of the condylar process: the sigmoid notch line running through the deepest point of the sigmoid notch perpendicular to the ramus line extending inferiorly

This protocol addresses each section of the mandibular condylar process fracture independently, with unique classifications for the degree of displacement, comminution, dislocation, and angulation noted. A representative diagnostic chart of the classification system is noted in Table 1. The accuracy, but inherent complexity, of this classification system is easily noted by reviewing Table 1. As such, the clinical usefulness of this classification system may be somewhat limited, because recall by the surgeon is hampered by having to remember multiple subsections and scaling protocols.

Table 1 Comprehensive AOCMF classification system: condylar process fractures

	Specific Level-3 Condylar Process System		Subregions		
Parameters	Code and Description	Process	Head	Neck	Base
Location	M = medial to the pole zone/P = within or lateral to the pole zone	—	x	—	—
Fragmentation	0 = none/1 = fragmented minor/2 = fragmented major	—	x	x	x
Vertical apposition	0 = complete/1 = partial/2 = lost	—	x	—	—
Sideward displacement	0 = none/1 = partial/2 = full	—	—	x	x
	Direction a = anterior/p = posterior and m = medial/l = lateral	—	—	x	x
Angulation	0 = none (up to 5°)/1 = > 5°–45°/2 = > 45°	—	—	x	x
	Direction a = anterior/p = posterior and m = medial/l = lateral	—	—	x	x
Displacement head fragment/fossa	0 = no displacement/1 = displacement/2 = dislocation	x	—	—	—
	Direction a = anterior/p = posterior and m = medial/l = lateral	x	—	—	—
Displacement caudal fragment/fossa	0 = no displacement/1 = displacement	x[a]	—	—	—
	Direction a = anterior/p = posterior and l = lateral	x[a]	—	—	—
Distortion of condylar head	0 = orthotopic/1 = dystopic	x	—	—	—
Overall loss of ramus height	0 = no change of height/1 = loss of height/2 = increase of height	x	—	—	—

Adapted from Neff A, Cornelius CP, Rasse M, et al. The Comprehensive AOCMF classification system: condylar process fractures: level 3 tutorial. Craniomaxillofac Trauma Reconstr 2014;7(Suppl 1):S46; with permission.

An overview of the various classification systems for mandibular condylar fractures has been conducted throughout this article. The creation of the consensus mandibular condylar classification system will continue to be a source of debate, and frustration, because of the many valid points brought forward by operative surgeons as to how their preferred classification system highlights individual criteria they find important. For the purposes of the remainder of this text, the description of Line A as presented by Loukota is the preferred method to describe the location of the condylar fractures. The term dislocation refers to the luxation status of the condylar head within the articulating fossa. Displacement refers to the fracture line status. The degree of displacement is considered as

- Minimal displacement: displacement of less than 10 or overlap of the bone edges by less than 2 mm, or both
- Moderate displacement: displacement between 10 and 45 or overlap of the bone edges by greater than 2 mm, or both
- Severe displacement: displacement greater than 45 or loss of overlap of the bone edges, or both

The operative surgeon should feel comfortable using the classification system that best delineates the location and description of the condylar fracture in a manner that affords the clearest understanding of the injury sustained by the patient. Once the determination has been made regarding the location and anatomic components of the injury, the surgeon can then appropriately discuss the inherent risks/benefits of open versus closed operative management with the patient and decide on a course of action.

CLINICAL SIGNS AND SYMPTOMS

- **UNILATERAL MANDIBULAR CONDYLE FRACTURE:-**[66]

1. Swelling and tenderness over TMJ area.

Fig.25. Swelling unilaterally

2. Hemorrhage from the ear on that side (results from laceration on the anterior wall of the external auditory meatus).

Fig.26. Hemorrhage from the ear

3. Ecchymosis of the skin just below the mastoid process on the same side. This particular sign also occurs with fractures of the base of the skull when it is known as 'Battle's sign'

Fig.27. Ecchymosis

4. If the condylar head is dislocated, medially and all edema has

subsided due to passage of time, a characteristic hollow over the region of the condylar head is observed.

5. Deviation of the mandible on opening towards the side of the fracture.

Fig.28. Deviation of the mandible on opening towards the side of the fracture.

6. Unilateral posterior crossbite and retrognathic occlusion.

Fig.29. Posterior crossbite

7. Paresthesia of the lower lip on the fracture side.
8. Gagging of the occlusion on the ipsilateral molar teeth.
9. Painful limitation of protrusion and lateral excursion to the opposite side.
10. Mandible will be locked.

BILATERAL MANDIBULAR CONDYLE FRACTURE:- [66]

1. Swelling and tenderness over TMJ area bilaterally.

Fig.30. Bilateral swelling

2. Hemorrhage from the ear on both sides (results from laceration on the anterior wall of the external auditory meatus).

3. Ecchymosis of the skin just below the mastoid process on both sides. This particular sign also occurs with fractures of the base of the skull when it is known as 'Battle's sign'.
4. If the condylar head is dislocated, medially and all edema has subsided due to passage of time, a characteristic hollow over the region of the condylar head is observed.
5. Overall mandibular movement is usually more restricted than in unilateral fracture.
6. Bilateral posterior crossbite and retrognathic occlusion.
7. Paresthesia of the lower lip on both sides.
8. Gagging of the occlusion on both sides molar teeth.
9. Painful limitation of protrusion and lateral excursion bilaterally.

DIFFERENTIAL DIAGNOSIS[67]

The differential diagnosis of condylar fracture can be listed as follows:

1. Muscular Torticollis
2. Condylar Hyperplasia
3. Juvenile Condylar Arthritis
4. Hemifacial Microsomia
5. Unilateral Coronal Craniosynostosis
6. Hemifacial Hypertrophy

1.Muscular torticollis:

Muscular torticollis is a fairly common congenital condition, with an estimated incidence ranging from 0.3 to 1.3 percent in the newborn population.[68] Muscular torticollis is caused by a shortened, tight, or dysfunctional sternocleidomastoid muscle on one side. It is commonly attributed to intrauterine or birth trauma that causes injury to the sternocleidomastoid muscle and hematoma formation and eventual scar contracture on the affected side. Up to 62 percent of muscular torticollis patients were born in the setting of difficult labor, breech presentation, forceps delivery, and cesarean section.[69-71] Muscular torticollis may lead to cranial base asymmetry and skull (deformational plagiocephaly) and face asymmetry (facial scoliosis).[72]

Fig.31. Muscular torticollis

A tight, restricted sternocleidomastoid muscle may cause cranial base distortion and lead to a favored sleeping position because of the slight head tilt. This constant posterior pressure of the malleable skull contributes to deformational plagiocephaly. Lower facial asymmetry is typically a slow, gradual progression with increasing mandibular distortion that may lead to an occlusal cant or mandibular deviation.[72]The asymmetry usually becomes evident during or after the growth phase in early adolescence. Occlusal patterns may vary, but there is often development of a mandibular shift to the contralateral side with a relative ipsilateral class II dental relationship and a relative contralateral class III dental relationship.[73]Therefore, in cases of mild and untreated muscular torticollis, malocclusion may be the first clinically presenting complaint. The eventual finding of asymmetry with a laterally deviated mandible is made on orthognathic evaluation. Occlusion may vary, with an occlusal cant or a more involved anterior and lateral cross-bite.

Patients with moderate to severe congenital muscular torticollis are diagnosed in infancy or early childhood, based on head tilt, tightness or tumor of the sternocleidomastoid muscle on palpation, or plagiocephaly. In the milder forms, it can go unnoticed until the development of the lower face asymmetry. These patients appear to be otherwise unaffected by the condition; therefore, the orthognathic surgeon may be the first physician to properly diagnose the condition. Although it is useful to obtain a thorough gestational and obstetric history, the diagnosis of mild to moderate torticollis is made largely on the basis of clinical examination. On examination, the sternocleidomastoid muscle fibrosis may not be palpable. Because the torticollis is mild, the sternocleidomastoid muscle shortening may be indiscernible by simple observation. However, on lateral flexion and lateral rotation of the head, there is often a measurable discrepancy between the angle of tilt and the degree of rotation between the two sides. In addition, there is tightness of the affected sternocleidomastoid muscle on lateral flexion or rotation, compared with the other side. With the patient looking up in the worm's-eye view, a head tilt is noticed, with the ipsilateral ear and cranial base in lower position. Torticollis, which means "twisted neck," more commonly has muscular causes than nonmuscular causes. However, these nonmuscular causes should be considered, including vertebral (cervical spine) abnormalities and ocular abnormalities (orbital dystopia or strabismus). Orthopedic abnormalities, such as vertebral dysplasias, can be identified by means of cervical spine radiographs or computed tomographic scanning. Strabismus, most often caused by an imbalance of the superior oblique extraocular muscles, is a less common cause of head tilt and is diagnosed largely on clinical examination. Vertical orbital dystopia may be seen in more severe cases, in which a horizontal torsional shift creates facial scoliosis.[74,75] With this situation, the patient has more comfortable vision in a tilted head position.[72-76]

2. Condylar hyperplasia:

Condylar hyperplasia is an idiopathic disease of the temporomandibular condyle that usually presents during puberty. It is usually unilateral and is thought to be etiologically heterogeneous. There have been many causes proposed, such as trauma, circulatory problems, infections, arthrosis, and others.[77]Condylar hyperplasia leads to increased ipsilateral mandibular growth, triggering a compensatory growth of the maxilla in the vertical dimension. This often occurs during the growth phase of puberty but can sometimes occur sporadically in adulthood. The overgrowth of the mandible, coupled with the vertical maxillary hyperplasia, may lead to an unstable or wobbly occlusal plane, which limits mouth opening. The mandibular overgrowth usually stops at the end of puberty, as the germinal centers become less active.

Fig.32. Condylar hyperplasia

This condition can be diagnosed by combining radiographic and clinical data. Patients usually present because of malocclusion or because of temporomandibular joint symptoms, including pain, limited range of motion of the mandible, and joint noise.[77] Patients may also report pain on palpation of the temporomandibular joint area. Clinical signs consist of chin deviation to the contralateral (unaffected) side, ipsilateral class III occlusion, and contralateral cross-bite. A classic radiographic sign is the presence of increased vertical dimension of the condyle, which may be seen on the standard cranial radiographs (laterolateral, posteroanterior, and axial views) or three-dimensional reconstructed computed tomographic scan. During active growth, one can visualize the active growth center of the affected hyperplastic condyle by means of technetium-99 scintigraphy. Scintigraphy thus has the additional role of informing the surgeon that mandibular stability has not been reached, thereby helping with the timing and planning of the reconstructive orthognathic procedure. However, it can only elucidate the abnormality of the condyle during the time when the germinal center is active; it sheds no insight about the cause of the asymmetric mandible once the growth has stopped.

3. Juvenile Condylar Arthritis:

Juvenile rheumatoid arthritis is characterized by arthritis persisting for greater than 6 weeks and is diagnosed before 16 years of age. The temporomandibular joint is often involved in the disease process. Juvenile rheumatoid arthritis causes inflammation of the synovial membrane, leading to erosion and eventual flattening of the condyle. Damage of the temporomandibular joint therefore leads to a smaller mandible on the affected side, retrognathia, and a steeper mandibular plane. The chin deviates to the affected side in unilateral temporomandibular joint arthritis, or toward the severely affected side in bilateral cases. Many patients are asymptomatic and may not exhibit symptoms, but may have involvement of the temporomandibular joint nonetheless and may suffer its inflammatory sequelae.

Fig.33. Juvenile Condylar Arthritis

Conventional radiographs often miss the early inflammatory changes of the condyle. Active temporomandibular joint involvement may not be seen, depending on the timing of radiography, because of the relapsing/ remitting nature of the disease. Dentofacial dysmorphology occurs more commonly in the polyarticular subtypes of juvenile rheumatoid arthritis patients. Early onset of juvenile rheumatoid arthritis, long duration, and severity of disease are positively associated with temporomandibular joint abnormalities and with reduced mandibular growth. Factors that most correlate with temporomandibular joint abnormality are radiographically visible condylar abnormalities; early onset, aggressiveness, and long duration of disease; and long-term corticosteroid use.[78-81] The occlusion pattern most frequently encountered is class II. The mandibular abnormalities seen in juvenile rheumatoid arthritis are akin to what one sees with condylar destruction, which consist of a steeper mandibular plane, overall smaller mandibular dimensions, and an increase in anterior facial height. It is not uncommon to have condylar destruction in patients who deny temporomandibular joint symptoms and who have had negative radiographs in the past. On physical examination, posterior rotation of the mandible is seen in patients with juvenile rheumatoid arthritis.

The diagnosis is made mostly on the basis of patient history. Fifty percent of juvenile rheumatoid arthritis patients experience full remission of the disease after 5 to 10 years.[78] Therefore, patients and physicians may not correlate the asymmetric mandible with the childhood disease, as patients usually present in the latter part of the second decade or even in adulthood. Patients with radiographically abnormal condyles are the patients who are most predisposed to facial asymmetry.[82,83]Standard radiographs often show narrowing of the joint space and an anterior displacement of the condyle in the glenoid fossa. Other radiographic features include osteophyte formation, subchondral cysts, diminished condylar volume, and sclerosis of the glenoid fossa.[78]A magnetic resonance imaging scan may further delineate erosion of the condylar cartilage.

4. Hemifacial Microsomia:

Hemifacial (craniofacial) microsomia is the most common congenital malformation of the head and neck, second only to the cleft lip and/or palate.[84] The estimated incidence is believed to be one in 5600.[85] There is a huge range of phenotypical severity, which explains the constellation of descriptive names, such as otomandibular dysostosis, auriculobranchiogenic dysplasia, lateral facial dysplasia, and hemignathia and microtia syndrome. Hemifacial microsomia involves the structures of the first and second pharyngeal arches. Therefore, it can affect the maxilla, mandible, external and middle ear, facial and trigeminal nerves, muscles of mastication, and overlying soft tissue to varying degrees. It is most often unilateral, but can be bilateral in approximately 20 percent of cases.[86] Despite this, there is always asymmetry of disease severity.[87] Jaw asymmetry may not be apparent among infants because of the prominence of buccal fat pads; it later becomes apparent in the middle of the first decade during active mandibular growth or during puberty.[88]

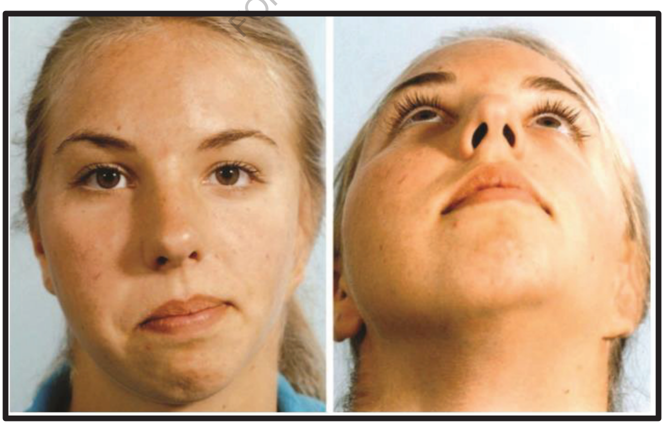

Fig.34. Hemifacial microsomia

Hemifacial microsomia is largely diagnosed clinically. Craniofacial or hemifacial microsomia may consist of a spectrum of deformities ranging from mild to moderate to severe, typically with unilateral mandibular hypoplasia (Fig. 5). The mandibular defect results in variable degrees of hypoplasia (or even absence, in severe cases) of the mandibular ramus, condyle, temporomandibular joint, and/or glenoid fossa. In addition, the maxillary zygomatic bones and other facial structures are affected to a lesser degree. With hemifacial microsomia, lateral mandibular deviation is accompanied by an occlusal cant and, at times, external manifestations of microtia, macrostomia, or ocular anomalies. A Panorex image and a computed tomographic scan are helpful in elucidating the extent of asymmetry in bony and soft tissues of the face and can also be useful in surgical planning. Early diagnosis is crucial for optimal treatment timing. Severe mandibular hypoplasia may be treated during growth with distraction osteogenesis ramal lengthening. Underrecognition of the mandibular abnormality and suboptimal orthodontic treatment will lead to occlusal problems and delay in final orthognathic care.

5. Unilateral Coronal Craniosynostosis:

Patients with unilateral coronal synostosis have a deviated mandible away from the synostosis and a nasal root deviated toward the synostosis. The unique cranial dysmorphology caused by abnormal head growth from premature suture fusion causes these facial findings. The specific findings include a shortened anterior cranial base, ipsilateral deviation of the ethmoid, cranial displacement of the lesser wing of the sphenoid, an increased volume of the sphe notemporal fossa, and anterior displacement of the petrous temporal bone.[88]In the setting of these cranial deformities, mandibular asymmetry arises because of malpositioning of the glenoid fossa on the synostotic side. On the side of the synostosis, the characteristic finding of the hemimandible is a diminution of volume, body length, and gonial angle.[83] The laterally deviated mandible may not be fully appreciated or relevant until skeletal maturity in these patients. Patients with unicoronal synostosis have unique characteristics seen on clinical examination. In contrast to the clinical examination of the torticollis patient, the eyes and ears are not parallel in the case of unilateral coronal synostosis.[74]

Fig.35. Unilateral Coronal Craniosynostosis

Other signs associated with unilateral coronal synostosis are unilateral frontal bone flattening, contralateral fullness of the temporal and occipital bones, and a positive Bielschowsky test (head tilt test to detect damage to the IVth cranial nerve and palsy of the superior oblique rectus muscle so that with the head tilted toward the unaffected shoulder, diplopia resolves).[85] A skull radiograph and head computed tomographic scan will confirm the characteristic resultant plagiocephaly.

6.Hemifacial Hypertrophy:

Hemifacial hyperplasia is a rare and interesting congenital disease that manifests as overgrowth of both soft tissue and bony structures of the hemiface, resulting in overt facial asymmetry. This unilateral overgrowth may be demonstrated on Panorex or computed tomographic scan. Similarly, hemimandibular hyperplasia is a three-dimensional overgrowth of the hemimandible, which ends abruptly at the symphysis.

Parry-Romberg syndrome is a progressive hemifacial atrophy of the soft tissue, involving the underlying bony structures in severe cases. Nonmuscular causes of torticollis (head tilt) can be caused by vertebral, central nervous system, or ocular disturbances. Vertebral abnormalities include spondyloepiphyseal dysplasia, Klippel-Feil malformation, subluxation of the vertebral joints, or hemivertebra.

Fig.36. Hemifacial Hypertrophy

Central nervous system abnormalities include cortical dysplasias or tumors. Ocular abnormalities include strabismus or vertical orbital dystopia in which a patient acquires a head tilt for improved ocular perception.[89]Each of these abnormalities is a rare occurrence, but together they constitute up to 18 percent of all causes of torticollis.

CLINICAL EXAMINATION[90]

Ask specific questions regarding the facial injury.

- Does patient have epistaxis or clear fluid running from nares or ears?
- Did patient lose consciousness? If so, for how long?
- Has patient had any hearing problems, such as decreased hearing or tinnitus?
- Does patient have any malocclusion, and is patient able to bite down without pain?
- Does moving the jaw cause pain or spasm?
- When the jaw moves, is a grinding sound produced?
- Does the patient have areas of numbness or tingling on the face?
- In women, ask if the injury was from a partner or if they feel threatened by anyone.
- In children, ask questions to determine if child abuse is an issue.

Physical

Complete examination of the face is necessary because multiple injuries can easily occur.

- Inspect face for asymmetry, performed while looking down from head of bed.
- Inspect open wounds for foreign bodies and palpate for bony injury.
- Test teeth for stability and inspect for bleeding at gum line, a sign of fracture through the alveolar bone.
- Check teeth for malocclusion and step-off.
- Palpate mandible for tenderness, swelling, and step-off in condylar region.
- Check for localized oedema or ecchymosis in the floor of the mouth.
- Evaluate distributions of the supraorbital, infraorbital, inferior alveolar, and mental nerves for anaesthesia.
- If teeth are missing, account for them to ensure they have not been aspirated.
- Inspect area just anterior to the meatus of the ear for ecchymosis and palpate for tenderness. This is the condyle of the mandible and site of an often-missed fracture.

Plain radiographs are not good at visualizing the condyle, thus maintain a high level of suspicion if physical exam is suggestive.

- Mandibular fracture is suggested by inability to open mouth, trismus, malocclusion of teeth, or palpable step-offs of bone along symphysis, angles, or body. Gingival bleeding at the base of a tooth suggests fracture, especially if teeth are maligned. Oedema or ecchymosis may be present in the floor of the mouth. Neurologic findings may include hypesthesia in distribution of inferior alveolar or mental nerves.
- A sublingual haematoma is not always a consistent finding, but when present is strongly suggestive of a mandibular fracture.[90]

RADIOGRAPHIC EXAMINATION:- [91]

Radiographs help confirm ant clinical findings. Most common radiographs which are advised to confirm mandibular condyle fracture are:-

1. Panoramic radiograph (OPG or Orthopantomogram)
2. PA view of mandible
3. Reverse Town's view
4. Lateral Cephalography
5. Computed Tomography Scan
6. Magnetic Resonance Imaging

For the measurement of condylar process displacement[92,93] coronal displacement is evaluated with Towne's radiograph (Fig 15-5A) and sagittal displacement with a panoramic radiograph. To evaluate the loss of ramus height,[92,93,94] a panoramic radiograph is used.

The measurement technique is as follows (see Fig. 15-5B):

• Line drawn between gonial angles across Panorex

• Perpendicular lines to most superior aspect of condylar heads

• The difference between the nonfractured and fractured side equals the change in ramus height.

OPG (ORTHOPANTOMOGRAM):-

Fig.37. Orthopantomogram

PA VIEW OF MANDIBLE

Fig.38. PA view of mandible

REVERSE TOWN'S VIEW

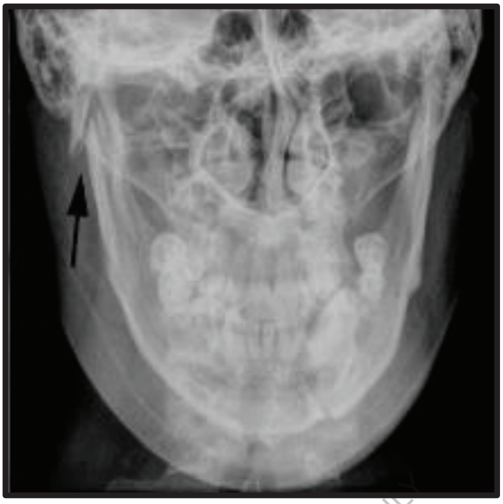

Fig.39. Reverse town's view

LATERAL CEPHALOGRAPHY

Fig.40. Lateral cephalography

COMPUTED TOMOGRAPHY SCAN

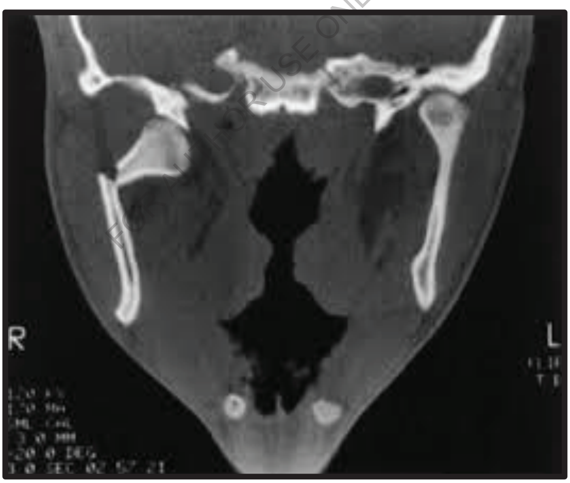

Fig.41.3D CT scan

MAGNETIC RESONANCE IMAGING

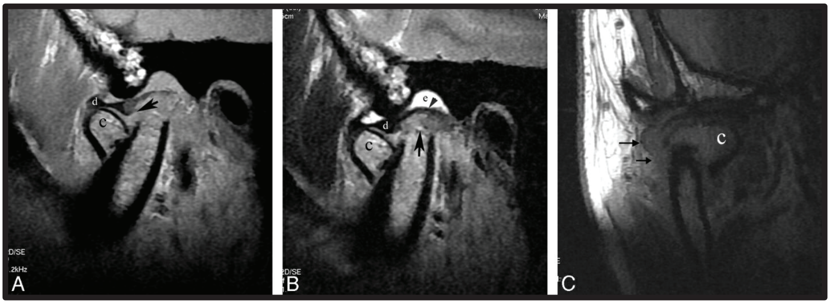

Fig.42. Magnetic resonance imaging

MANAGEMENT OF MANDIBULAR CONDYLE FRACTURE

The goals of treatment of condylar fractures are to restore function to the pre-injury state and to do so with undisturbed healing of the injured site. An understanding of the pre-injury state is important in assessing the results of the treatment of condylar fractures. On evaluation pain, deviation, other jaw excursion problems, and joint noise are frequently present.

There are two types of treatment options for treatment of condylar fractures- [95]

1) **Closed reduction and functional therapy:**
2) **Open reduction and internal fixation**

1) Closed reduction and functional therapy:

For closed reduction, intermaxillary fixation is conducted using arch bar and wire, followed by maintaining of the fixation of the maxilla and mandible for 2 to 4 weeks. After achieving stable union of the fractured site, a wire for intermaxillary fixation is removed. Then, normal occlusion is induced after fixation using rubber elastics, and soft diet is maintained for 2 weeks. Functional therapy that consists of passive mandibular movement exercise and mouth opening exercise is conducted and then clinical outcomes are observed. For mouth opening exercise, the physician holds the molar and mandibular border of the fracture side after standing behind the patient, and induces normal occlusion and normal mandibular movement by traction to the anterior inner inferior several times. At the same time, the patient opens his/her mouth for him/herself, and applies counter-force using hands to avoid mandibular deviation. The authors conduct initial intermaxillary fixation in intracapsular fracture patients aged less than 5 years for 2 weeks, in those aged 5 years or higher for 4 weeks, and in extracapsular fracture patients aged less than 8 years for 2 weeks. [95]

Fig.43.Closed reduction

ADVANTAGES:- Closed reduction with functional therapy is a relatively safe treatment. No injury of nerves and blood vessels occur during the treatment, and no postoperative complications such as infection or scar occurs.

DISADVANTAGES:- Long-term intermaxillary fixation has disadvantages of the injury of the periodontal tissue and buccal mucosa, poor oral hygiene, pronunciation disorder, imbalanced nutrition, mouth opening disorder, and respiration disorder. In the case of conservative treatment using closed reduction, the growth disorder and excessive growth of the injured mandible may occur due to inappropriate reduction of bone fragments and the right and left displacement of the mandibular ramus or mandibular deviation upon opening may occur after conservative treatment. Many studies reported that facial asymmetry or TMJ disease may occur in pediatric patients aged 10 to 15 years due to growth disorder or functional disorder, and that in particular, the growth and functional disorders of the TMJ may occur in 20% to 25% of pediatric patients aged 7 to 10 years.

2. **OPEN REDUCTION AND INTERNAL FIXATION:-**

METHOD:- There are various operation methods of open reduction for mandibular condyle fracture depending on fracture site and degree of bone fragment displacement. In general, they include preauricular approach, postauricular approach, submandibular approach, Risdon approach, combined approach, and retromandibular approach. Treatment type should be selected considering patient's age, preference, fracture type, fracture of other sites, and teeth status.[96]

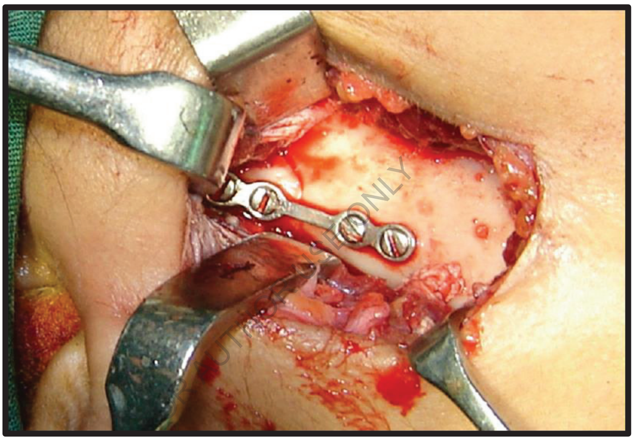

Fig.44. Open reduction

ADVANTAGES:- Open reduction has advantages of the reduction of the displaced bony fragment to the most ideal anatomical site by a direct approach to the facture site. In addition, it can prevent complications such as respiration disorder, pronunciation disorder, and severe nutritional imbalance by shortening intermaxillary fixation period via rigid fixation.

DISADVANTAGES:- Open reduction is an invasive treatment, which may cause injury of nerves or blood vessels during operation, and postoperative complications including infection. In addition, it has permanent scar though the surgery is conducted after designing the incision line.

OPERATIVE PROCEDURES:-

- **PREAURICULAR APPROACH:-** Preauricular approach reduces condyle fracture by incising 3 to 4 cm from the inferior border of the tragus toward external auditory canal along the skin crease of the anterior part of the external ear. It provides an easier approach to high condylar fracture such as intercapsular fracture, easy reduction of the injured soft tissues of the TMJ, and reduction via a direct inspection of the appropriate relationship among the condyle, disc, and joint with eyes. In particular, preauricular approach is very useful for the case of the condyle fragment anteromedially displaced by the pulling of the medial pterygoid. Furthermore, as the amount of exposing the mandibular ramus is very limited, rigid fixation using mini-plate is hard to be conducted if fracture site is positioned inferiorly to the mandibular condyle neck.[97]

Fig.45. Preauricular approach

* **POSTAURICULAR APPROACH**:- The postauricular approach is a method that reduces the condyle fracture by incising from a site 3 mm posterior to the postauricular curved region, and by incising the mastoid process inferiorly and the upper ear-attached region superiorly. It can be used for the reduction of high condyle fracture. This method has advantages of excellent aesthesis due to the approach from the posterior side of the ear, avoiding injuries of the facial nerve branch and superficial temporal artery, low risk of parotid injury, and securing the surgical field for the TMJ region. Meanwhile, it has disadvantages of a narrow surgical field for mandibular condyle neck fracture, difficulty in using surgical devices, complications such as external auditory canal stenosis, tinnitus, infection and necrosis of auricular cartilage, permanent auricular paresthesia due to injury of the external auditory canal, and longer wound closure time compared to the preauricular approach.[97]

Fig.46. Post auricular approach

* **SUBMANDIBULAR APPROACH:-** The submandibular approach reduces condyle fracture by conducting incision from a site 2 to 3 cm inferior to the mandibular inferior border, parallelly to the mandibular inferior border or along with the skin crease. Due to its easier approach to the mandibular ramus, inferior mandibular condyle, and coronoid notch, it is commonly used for mandibular

condyle fracture. However, it has disadvantages of requiring excessive traction for reducing mandibular condyle fracture, requiring rigid fixation using percutaneous trocar for reducing high condyle fracture due to difficulty in a direct approach to the site of the fracture line formed, and requiring deep tunneling for mandibular condyle fracture due to a long distance from the incision line to the fixation site, and requiring the use of mini-plate due to poorly secured surgery field. Furthermore, it has disadvantages of the possible risk of the injury of marginal mandibular branch of the facial nerve, submandibular scar formation, difficulty in approaching the high condyle fracture site, and difficulty in examining the internal structure of the TMJ.

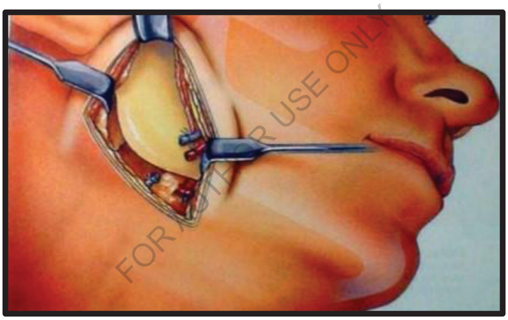

Fig.47. Submandibular approach

<u>RISDON APPROACH:</u>- Risdon approach is a method similar to submandibular approach. It can easily approach to the inferior region, ramus, gonial angle and posterior body of the mandibular condyle. If the upper flap is intensively retracted, even mandibular condyle inferior and neck fractures can be exposed. Reduction of bone fragments can be easily conducted by traction the mandibular gonial angle inferiorly. Meanwhile, like submandibular approach, Risdon approach requires excessive traction for high condyle fracture. [98]

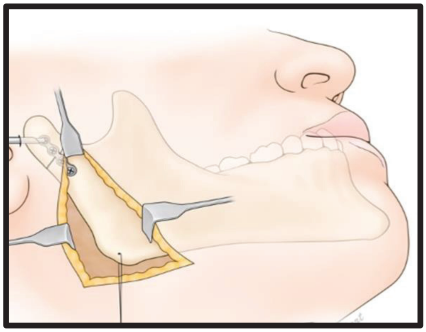

Fig.48. Risdon's approach

- **<u>COMBINED APPROACH:</u>**- This method reduces both inferior and superior fractures of the mandibular condyle by applying preauricular approach and submandibular approach simultaneously. This method is very useful as mandibular subcondyle fracture is reduced using submandibular approach, and the superior fractures of the TMJ or mandibular condyle neck is approached via preauricular approach and bone fragments are reduced while putting in traction the mandible inferiorly. Meanwhile, due to the use of two approaches, combined approach has disadvantages of relatively longer operation time, large scar formation, high risk of the injury of facial nerve, and risk of secondary TMJ disease due to scar formation on the TMJ capsule by preauricular approach.

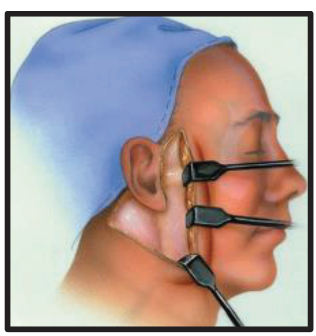

Fig.49. Combined approach

- **<u>INTRAORAL APPROACH:-</u>** Intraoral approach reaches the mandibular condyle in a way similar to vertical ramus osteotomy. The incision line is formed along the anterior mandibular ramus and buccal sulcus. For the achievement of surgery field and device approach, the temporalis muscle attached to the mandibular ramus and the periosteum of the buccinator located at the body should be completely dissected to elevate them. This method has advantages of no scar formation and the minimum injury of facial nerves. Meanwhile, an approach using devices is difficult though operation field is secured using an endoscope. Furthermore, percutaneous trocar should be used for rigid fixation using metal plate after reduction. It has disadvantages of difficulties in the maintaining of bone fragment stability and in the observation of the internal structure of the TMJ for mandibular subcondyle fracture.

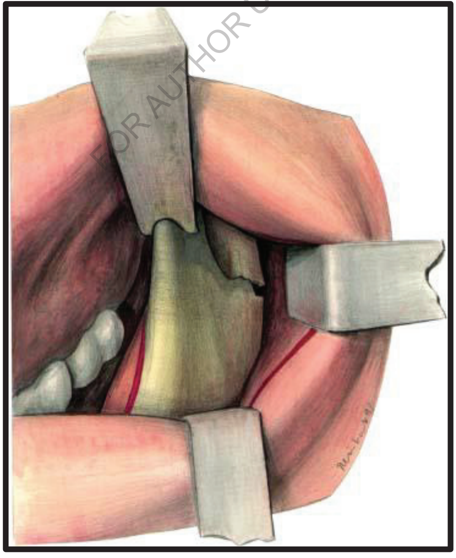

Fig.50. Intraoral approach

- **RETROMANDIBULAR APPROACH:**- Retromandibular approach reduces condyle fracture by dissecting the skin and subcutaneous tissue vertically to the mandibular angle using the 3-cm incision line to the 5 mm inferior to the auricular lobe. This method provides easy reduction and rigid fixation for mandibular subcondyle fracture. Percutaneous trocar is not required as the method can tract the tissues anteriorly and superiorly at the sigmoid notch. It also provides reduction and rigid fixation for high condyle fracture, where incision length is small. Furthermore, this method has advantages of insignificant scar formation due to the incision made at the posterior mandibular ramus, and the sufficient exposure of bone fragments to the upper part of the mandibular ramus. However, it has disadvantages of risk of the injury of facial nerves and bleeding caused by the injury of blood vessels.[97]

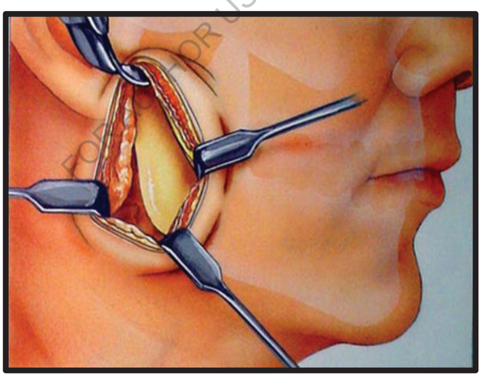

Fig.51. Retromandibular approach

FACTORS AFFECTING OUTCOME OF CONDYLAR FRACTURE TREATMENT

Minimal morbidity with open reduction is essential to offering it as a common option, and therefore, outcomes must be assessed in order to guide appropriate treatment decisions.

All surgical approaches to the condyle, including preauricular, postauricular, retromandibular, transoral and Risdon incisions, place both cranial nerves V and VII at risk for iatrogenic injury. For retromandibular and Risdon approaches, the marginal branch of VII is at greater risk, whereas the preauricular approach places temporal and zygomatic branches of VII at highest risk.[98]

Independent of the method of condylar fracture treatment, many known variables will affect the outcome. The relationship of these variables results in a complex interaction that shows that the ability of small cohort studies to make meaningful statements about treatment remains problematic. The relative weight, or importance, that each of these variables carries in an individual case will vary. These variables include:[99]

1. **Patient Age:** It is generally understood that condylar fractures can inhibit the vertical growth of the face according to Moss's theory of functional matrices whereby associated parts will not grow if condylar growth is inhibited by injury. Younger children upto the age 11 had better results owing to the potential for considerably more adaptation and remodeling of the bone than teenagers or adults. This makes sense when considering that the greatest vertical growth of the condyle occurs during adolescence. Condylar fractures in the elderly and edentulous patient are known to result in poor adaptation and less compensation and remodeling than in younger adults.
2. **Patient gender:** Adolescent female appears to demonstrate more functional derangement than males. Because TMJ disorders occur with a frequency far greater in female patients, internal derangement, idiopathic condylar resorption, and myofascial pain dysfunction may be related to issues separate from, or in addition to, the acute trauma of a condylar fracture.

3. **Systemic diseases:** The effects of specific systemic diseases have not been well studied relative to condylar fractures. However, diabetes mellitus, osteoarthritis, smoking, alcoholism, bisphosphonate use, and steroid use may play an adverse role in outcomes of condylar fracture treatment.
4. **Patient compliance:** There should be good patient doctor rapport in order to gain compliance in a path to rehabilitation in many patients.
5. **Risk of infection:** There remains a substantial risk of infection after open reduction of condylar fractures. This may be associated with avascular necrosis of the condylar head owing to periosteal reflection and possible muscular detachment. Fractures that extend into the external auditory canal, delayed treatment, and multiple injury patient may be at higher risk of infection.
6. **Risk of operative site injury:** Whereas immunocompromise may predispose to poor wound healing such as with diabetes mellitus, obese patients offer special challenges for open reduction condylar fractures. Cranial nerve traction injuries and pressure necrosis are more likely when access is difficult owing to excessive overlying soft tissue.
7. **Risk of scaring:** Scar is the most frequent complaint of patient who underwent open reduction of condylar fractures. Developing the skill for transoral endoscopy assisted fracture treatment may mitigate this complaint. For older patients, an extended face lift incision, if indicated has been performed to minimize the appearance of scar and offer improved aesthetic outcomes.
8. **Risk for chronic pain:** The investigation of postoperative pain is very important in assessing the most appropriate treatment for a patient. Surprisingly, open reduction appears to offer a relatively lower impact on chronic pain.

9. **Comminution:** Intracapsular comminution with loss of blood supply to the segments is particularly associated with pain, limitation in opening, infection, and malunion. When treated with open reduction, fixation failure is more likely to occur in the comminuted fracture patient.

10. **Hemarthrosis:** It is bleeding into joint spaces. It usually follows injury but occurs mainly in patients with a predisposition to hemorrhage such as those being treated with warfarin (or other anticoagulants) and patients with hemophilia.

11. **Disc injury:** In condylar fractures with displacement and the disk typically follows the condylar head due to the attachments of the medial and lateral collateral ligaments as well as the anteromedial influence of the lateral pterygoid muscle.

12. **Osteoarthrosis:** Adaptive changes of the condyle fossae complex occurs after both open and closed treatment. Osteoarthrosis are typically noted on imaging e.g., osteophyte formation, flattening of the condylar head and joint space narrowing.

13. **Presence of other facial fractures:** The mandibular corpus fractures, particularly those of the symphysis, if allowed to be fixated in a position that results in mandibular widening, are associated with a higher rate of temporomandibular joint ankylosis due to the lateral impingement of the condylar head. It has been understood that posterior facial height is dependent on establishing proper ramus height via operative management of condylar fractures in patients with panfacial fractures.

14. **Glenoid fossa fractures:** A condyle displaced into the middle cranial fossa is an indication for reduction of the fracture as well as fossa reconstruction with an appropriate bone graft and alloplast.

15. **Occlusal consideration:** High mandibular plane angle patients and those with shallow intercuspal relationships due to bruxism are more prone to post treatment malocclusion and open bite after closed treatment. High mandibular plane angles allow for fulcrum changes after condylar fracture that promote the development of an open bite occlusion. Patients with a deep bite and a low mandibular plane angle are less prone to open bites even with an anatomically shortened ramus due to a subcondylar fracture. Those without posterior bite support owing to loss of molars are more likely to sustain loss of vertical dimension.

16. **Bruxism and masseteric hypertrophy:** Patients may fracture a bone plate after open reduction and displace the bony segments if they suffer from bruxism. Masseteric hypertrophy is often present in these cases.

17. **Functionally shortened ramus:** Whereas an anatomically shortened ramus can be measured as a decrease in the distance from condylion to gonion, a functionally shortened ramus is one in which the condyle ramus unit does not support the vertical dimension requirements for adequate occlusion and mastication. This is an important indication for open reduction.

18. **Surgeon experience:** Experienced surgeon need to obtain procedure specific training to properly treat subcondylar fractures surgically. Those who are well trained and experienced are more able to achieve anatomic reduction and fixation of fractures with minimal morbidity.

19. **Economic constraints:** In the present economic climate, medicine is only supporting treatment based upon proven benefit at reasonable cost. Without a cogent means to support one method over another, the less expensive method will be chosen. Although condylar fractures are not a significant component of trauma

care, they will be looked at in the context of another maxillofacial trauma treatment.[99]

OPEN VERSUS CLOSED TREATMENT OF MANDIBULAR CONDYLE FRACTURE : A CONTROVERSY

More and more debate has occurred in published studies about which condylar fractures would be better treated open rather than closed. The choice of surgical versus non-surgical treatment for fractures of the condylar process remains a controversial issue. Several factors are usually offered as reason to perform open treatment, including the loss of posterior facial height, the position of the fractured condylar process, and the degrees of displacement and dislocation. The availability of plate screws fixation and other technological developments that can potentially minimize complications, such as use of the endoscope have fueled this debate.[100]

Although it is likely that this debate will continue for years, what has been less often discussed is which condylar process fractures do not require open treatment and how they can be identified.

In the past, most surgeons have seemed to favor non-operative treatment of condylar process fractures. However, 2 innovations have caused an increase in the open treatment of such fractures: stable internal fixation devices and safer surgical approaches. Plate and/ or screw fixation allows the stabilization of condylar fractures – something that was not possible with wire fixation. Surgical approaches that minimize operative complications, such as injuries to the facial nerve, have also changed the indications for open treatment. Also, extraoral approaches inevitably also associated with visible scar.[101]

Zide and Kent's classic report regarding the indications for open reduction of mandibular condyle fractures has been the "gold standard" for the past decade and a half. The introduction of better materials for osteosynthesis, such as Kirschner wires, miniplates and lag screws have made open surgical treatment more advantageous. These advantages are based on exact fragment repositioning; the need for disk repair and, in the case of rigid fixation, MMF thus has been rendered superfluous.

The development of stable osteosynthesis modalities with miniplates, lag screws and further development of the surgical approaches have made surgical treatment safer and have the functional advantage of earlier mobilization of the traumatized tissues.

Zide and Kent's indication of open reduction (1983) For indications of open reduction on mandibular condyle fracture, Zide and Kent suggested that absolute indications should include displacement into middle cranial fossa, inappropriate occlusal restoration by closed reduction, lateral extracapsular displacement, and foreign material of the fracture site, and that relative indications should include bilateral mandibular condyle fracture of edentulous patients who cannot have splint, impossible intermaxillary fixation and physical therapy due to internal diseases, bilateral mandibular condyle fracture with comminuted fracture of other facial bone, and bilateral mandibular condyle fracture with jaw deformities. They also suggested that factors involved in the selection of open reduction include the location of the displaced mandibular condyle, fracture site, time delayed after fracture, patient's individual characteristics, edema severity, selection of incision line, and fixation type.[102]

ABSOLUTE INDICATIONS:-

- Displacement into middle cranial fossa.
- Impossibility of obtaining adequate occlusion by closed reduction.
- Lateral extracapsular displacement.
- Invasion by foreign body.

RELATIVE INDICATIONS:-

- Bilateral condylar fractures in an edentulous patient without a splint.

- Unilateral or bilateral condylar fractures where splinting cannot be accomplished for medical reasons or because physiotherapy is impossible.
- Bilateral condylar fractures with communited midfacial fractures, prognathisim or retroprognathism.
- Periodontal problems.
- Loss of teeth.
- Unilateral condylar fracture with unstable base.

Mathes (1983) Klotch and Lundy and Choi et al. suggested that angulation between the fractured fragments in excess of 30 degrees and fracture gap between the bone ends exceeding 4 or 5 mm, lateral override, and lack of contact of the fractured fragments should be considered before justifying open reduction.[103]

OPEN REDUCTION INDICATIONS:-

- Malocclusion with closed reduction.
- Fragment angulation: more 30°.
- Bone gap: more 4-5 mm.
- Lateral override
- Lack of contact of the fracture fragment.

PREFFERED FOR OPEN REDUCTIONS:-

- Any low, dislocated subcondylar fracture.
- Low condylar fracture with multiple fractured mandible or maxillary or Le Fort fracture.
- Low condylar fracture with displacement of condylar head out of the glenoid fossa.
- Condylar fragment 14°- medial tilt Ramus shortening - 5%.
- Bilateral fracture with open bite.

- Gross fracture end malalignment.
- Fracture – dislocation.
- Abnormal function, malocclusion.

AAOMS (2003) In 2003, American Association of Oral and Maxillofacial Surgery suggested an international guideline on the treatment of mandibular condyle fracture. According to the guideline, open reduction is recommended for the cases of mandibular condyle fracture suspected in clinical and radiologic examinations to prevent complications such as functional or growth disorders.[104]

PARAMETERS OF CARE INDICATIONS FOR OPEN REDUCTION:-

- Physical evidence of fracture.
- Imaging evidence of fracture.
- Malocclusion Mandibular dysfunction.
- Abnormal relationship of jaw.
- Presence of foreign bodies.
- Lacerations and/or hemorrhage in external auditory canal.
- Hemotympanum
- Cerebrospinal fluid otorrhea.
- Effusion
- Hemarthrosis

MANAGEMENT OF CONDYLAR FRACTURE IN ATROPHIC EDENTULOUS MANDIBLE

Management of mandibular condylar fractures represents a controversial issue in maxillofacial trauma. In particular, treatment of condylar fractures in edentulous patients with atrophic mandibles is a peculiar field that has been little considered in the literature.[105] Minimally displaced condylar fractures in the edentulous atrophic mandible are generally treated conservatively and minor occulsal changes are corrected by fabrication of new prostheses.[106] Moreover, small deviations in mandibular motion and aesthetics are commonly of minor importance for elderly edentulous patients. However, open reduction and rigid fixation of displaced and unstable mandibular condylar fractures in the edentulous atrophic mandible is frequently necessary to maintain the posterior vertical height of the mandibular ramus. Moreover, the provoked loss of vertical mandibular ramus height due to condylar fractures may cause altered jaw mechanics with either deviation to toward the fractured side or, in the case of bilateral fractures, open bite deformity. [107]Therefore, open reduction and rigid fixation has been suggested for displaced mandibular condylar (neck and subcondylar) fractures in edentulous patients with loss of vertical ramus height.[108] Previously, only few studies have evaluated the treatment outcome after the management of mandibular condylar fractures in edentulous patients. However, small patient samples, different treatment modalities and short-term observation period diminish the possibility of providing evidence-based treatment guidelines of mandibular condylar fractures in edentulous patients. Consequently, several European centers that had already shown research experience in maxillofacial trauma decided to collaborate on a multicenter research project about the management of mandibular condylar fractures in edentulous patients, in order to obtain a wide study population and to reduce bias.

Management of mandibular condylar fractures in edentulous patients with atrophic mandibles is a controversial topic, which has not received much attention in the literature.[105,106] According to a study done by Brucoli M et al. on 52 patients with fractures of the atrophic edentulous mandible from the involved maxillofacial surgical units across Europe between January 1, 2008, and December 31, 2017, it was concluded that no strict rules of indications can be applied to edentulous patients with mandibular condylar fractures, but clinical decision has to be taken, in agreement with the patient, on a case by case basis. As for the etiopathogenesis of condylar fractures in edentulous patients, it has been seen that the distribution of condylar fracture subtypes does not change according to Luhr classes of atrophy. Therefore, the decrease of height and thickness of atrophic mandibles does not seem to contribute to different types of condylar fractures. [107-109]

RECENT ADVANCES

Recently, there have been an increased number of enhanced study designs with randomised prospective reports, comparative clinical analysis, and novel techniques reporting not only clinically relevant interpretations to be applied in daily clinical practice but also broadened management strategies.[110] Significant improvement in diagnostic modalities, adequate surgical access and operative concepts for complex and difficult fractures has been achieved. Accordingly operative indications have expanded to include some conditions previously thought to be inoperable condylar fractures in children are commonly managed by closed reduction: however technical improvements have enabled a change in managing such cases. Contrary to other joints of the body involvement of the capsular and diskoligamentous soft tissue of the TMJ restricted operative indications of condylar fractures in the past. Taken together, newer medical technologies and devices and enhanced operative expertise added to the fact that anatomic alignment is rarely achievable, have all encouraged surgeons to perform open, reconstructive, anatomic reduction and internal fixation.[111]

Recent advancements in the management:

1) Enhanced imaging modalities/interpretations

a) Detection of soft tissue injuries

b) Detection of fracture line in relation to capsule

c) Assessment of precise location, angulation comminution

d) Assessment of hardware placement, alignment, and interferences

2) Surgical anatomic studies/revisited technique/innovation and modified surgical approaches

3) Intracapsular fracture

4) Soft tissue injury management

5) Early and effective post-operative physiotherapy

6) Improved fixation techniques

Goals and functional importance

The main goals of managements are:

1) To restore premorbid occlusion

2) Painless normal range of movements

3) To correct and avoid functional, esthetic and developmental complications

Supportive and closed treatment options:

1) Dietary restrictions

2) Medication (pain)

3) Partial immobilization

4) Total immobilization (not exceeding 20 days)

5) Continuous passive motion

6) Orthodontic therapy

7) Physical therapy

Advances in open reduction:

The earlier the trauma the greater the potential of disturbance to development of facial growth if an improper treatment is delivered or if injury goes unnoticed without any form of treatment.[112]

Relative operative indications in children:

1) Dislodgement of the condyle segment out of the fossa

2) Dislocation into - tympanic wall, external auditory meatus

3) Presence of foreign bodies

4) Bilateral fracture with occlusal disturbances

5) Open wounds

Operative approaches

1) **Transcutaneous**

- Existing lacerations
- Transmassetric
- Anteparotid
- Transparotid
- Retromandibular
- Extended temporal
- Preauricular
- Bicoronal

2) **Transoral**

- Posterior vestibular
- Endoscopic

Challenges in surgical approaches

1) **Access and exposure**

- Diminutive cutaneous incision
- Overly extended incision ‘distant from fracture site
- Excessive retraction forces
- Scar formation
- Postoperative complications

❖ Facial nerve damage

❖ Auriculotemporal dysfunction

❖ Parotid fistula

❖ Excessive scar

❖ Infection

2) Reduction and fixation

- Indirect open reduction
- Invisibility of final condylar reduction
- Complexity in checking fixation
- Undesirable placement
- Increased manipulation

Advances in internal fixation:

Osteosynthesis materials and techniques have dramatically facilitated implementation of open reduction and internal fixation.[113] Titanium screws are considered the most reliable materials, Few materials are

❖ One plate mini plate

❖ Two plate mini plate

❖ Lag screws

❖ Delta plates

❖ Trapezoid plates

❖ Resorbable systems

Recently using 24 hole plates were proposed to be biomechanically stable dual plates can be executed at the condylar neck or lower base of condyle neck fractures can be used to overcome tension and compression trajectories and if warranted should be applied on the anterior and posterior borders of condyle neck.[114] If one plate is chosen 2 screws on each side must be placed. Resorbable plates with lesser manipulation were introduced to combat the disadvantages of titanium as well as those of resorbable that need tapping particularly in a location in which the area may require managements with strong retractions and difficult or restricted operative angulations.[115]Ultrasonic welding and smelting of resorbable pins are used. The pin is inserted into the drilled holland melts laterally with the cancellous bone and therefore, anchorage is enhanced for improved fixation .These screws have fewer complications than metal screws.[116-119]

ENDOSCOPY ASSISTED MANAGEMENT OF CONDYLAR FRACTURE:[120]

Closed treatment of mandibular fractures with maxillomandibular fixation (MMF) has a long and successful history, but it is not without significant morbidity. The best results have been achieved in skeletally immature children, where condylar remodeling often can restore condylar anatomy to near normal, even in the face of little or no fracture reduction.[120] Despite almost miraculous condylar remodeling in children, the outcomes in adults have not been uniform, and a significant percentage suffers long-term aesthetic and functional problems.[121-125] Few studies exist comparing similar fractures treated by open versus closed methods. Most show equal or better outcomes after open treatment despite the fact that more severely injured patients tended to undergo open treatment.[126-135]Patients treated with an open approach had better restoration of facial symmetry, faster recovery of jaw motion, and less chronic pain. The most important long-term complications of closed treatment are internal derangement and persistent malocclusion, the latter reported in up to 28% of patients.[135-137] The reluctance to use open reduction and internal fixation of condylar fractures stemmed from the belief that these injuries do well with closed treatment using MMF and because the open technique was challenging and associated with significant morbidity. All surgical approaches for the open treatment of condylar fractures require a facial incision, and nearly all will result in a perceptible scar[130], with up to 4% reporting an unsightly scar.[127] Close proximity of the facial nerve to the condyle compromises access to the fracture segment and makes the dissection tedious. Efforts to improve surgical access may result in either direct facial nerve injury or a traction injury during retraction. The risk of permanent facial nerve injury reported in 21 different series of open approaches, comprising 455 patients, averages 1%, while the risk of transient palsy ranges from 0% to 46% (mean 12%)[131,134,135,138-147]. An open intraoral approach, designed to circumvent these drawbacks, has been described, but it rarely is used because of very poor visualization and difficult hardware fixation.[148] The use of the endoscope to treat condylar injuries was a natural extension of minimally invasive techniques for managing craniomaxillofacial trauma. Most surgeons accept, on an intellectual level, that fracture reduction and rigid fixation with restoration of anatomy are laudable goals if that can be achieved without undue morbidity. Endoscopic assistance allows the surgeon to produce anatomic fracture alignment, and to avoid the negative sequelae of condylar malunion. The endoscopic approach described here has the potential to reduce morbidity by limiting scars, reducing the risk to the facial nerve, and eliminating the need for MMF, all while embracing the accepted advantages of anatomic reduction and rigid fixation. The decrease in morbidity associated with the endoscopic approach may expand the indications for reduction and rigid fixation in the future.

Regional anatomy and the effect of maxillomandibular fixation:

Regional anatomy and the effect of maxillomandibular fixation exacerbated by the normal resting tone of masticatory, suprahyoid, and infrahyoid musculature. As the fragments overlap, the mandible rotates such that there is premature posterior occlusal contact and an anterior open bite. In addition, this causes an unappealing loss of chin projection at the pogonion. Only with effort, as during chewing, are proper occlusion and chin position forcefully restored.[150] Furthermore, ramal shortening causes a decreased radius of mandibular rotation that is visible as ipsilateral jaw deviation during motion.[149] Attachments of the lateral pterygoid muscle usually place the condylar fragment into a flexed posture. This has been the case in 80% of adult condylar fractures in the authors' experience. In addition, the lateral ptygeroid often will cause inclination of the condylar head medially, further shortening the ramal height. This results in premature contact with the anterior wall of the glenoid fossa, limiting interincisal opening to initial hingetype motion only. The additional 15 to 20 mm of opening available through translational movement never is achieved fully. The complex relationships of the temporomandibular articulation allow only minimal imprecisions. A malunited condyle alters these precise relationships, resulting in significant aberrations in joint dynamics that have a marked potential to produce late internal derangement. In addition, because of the bilateral interdependence of the craniomandibular articulation, the contralateral condyle sustains excessive biomechanical loads and similarly is predisposed to early degenerative changes.[151] Extended experience and careful analysis of closed treatment of condylar injuries using MMF have shown that fracture reduction rarely occurs. Instead, centric occlusion is forced through neuromuscular adaptation to the condylar malunion at the temporomandibular joint. Malunion often results in shortening of the posterior ramus because of interfragmentary overlap, abnormal orientation of the condylar fragment, and alteration of temporomandibular joint biomechanics, all of which carry significant functional and aesthetic consequences. When assessing the shortcomings of closed treatment, the significant independent morbidities associated with MMF often are overlooked because of the surgical simplicity of its application. The prolonged period of immobilization using MMF necessitates a lengthy postoperative regimen of muscular and occlusal rehabilitation to improve muscle function, condylar movement, and range of motion. Studies in rhesus monkeys have demonstrated loss of interincisal opening and maximal stimulated bite force after MMF.[152,153] Additionally, comparisons of patients with condylar neck fractures randomized to open versus MMF treatment have demonstrated that patients after MMF have decreased range of motion necessitating long periods of physiotherapy to regain their premorbid function.[127,135] Many patients find MMF uncomfortable, and who have dementia or psychiatric diagnosis simply may not tolerate the procedure. It is difficult to maintain good oral hygiene with MMF; orthodontic treatment must be delayed during the period of MMF, and those who have seizure disorders or alcoholism are at risk for aspiration and death.

Role of the endoscope—treatment indications:

The goals of condylar fracture treatment are: painfree mouth opening with interincisal distance beyond 40 mm, good excursion of the jaw in all directions, restoration of preinjury occlusion, stable temporomandibular joints, and good symmetry.[150] In most circumstances, anatomic reduction and rigid fixation of the condyle are required to satisfy these objectives by restoring preinjury ramal height, upright posture of the condylar head ,and complex anatomical relationships of the temporomandibular articulation. Patients with condylar process fractures are selected for endoscopic-assisted reduction and fixation based on age, location of fracture, degree of comminution, direction of proximal fragment displacement, dislocation of condylar head, concomitant medical or surgical illness, and patient choice. Condylar fractures in prepubertal patients do not require anatomic reduction because of the great potential for rehabilitation through growth and remodeling. Fractures of the condylar head generally do not demonstrate significant loss of posterior ramal height and can be expected to do relatively well with traditional methods. Fractures that do not allow for the application of at least two holes of a 2.0 mm plate are likewise not amenable to endoscopic repair. Finally, open treatment is not advocated for nondisplaced, nondislocated fractures, as normal biomechanical relationships are unaltered.

Preoperative planning:

Fracture anatomy

The endoscopic technique of condylar fracture repair relies on visual confirmation of fracture fragment reduction and sufficient length of the extracapsular segment for the placement of fixation hardware. Endoscopic approaches by their very nature have a limited optical cavity, distorted perspective, and geometric constraints for instruments. Consequently, determination of the precise fracture geometry preoperatively is mandatory so that a decision can be reached whether an endoscopic approach is feasible. There are four specific fracture attributes that will help to make the decision: location, displacement, comminution, and relationship of the condylar head to the fossa.

Fracture location

Condylar fractures are classified as head (intracapsular), neck (below the head and above the sigmoid notch), and subcondylar.[154] Intracapsular fractures and high neck fractures are not treated using the endoscopic approach, because there is no possibility of applying fixation. In addition, surgical exposure may lead to devascularization of the condylar head. Fractures of the condylar neck are suitable for endoscopic treatment if sufficient bone stock is present proximally to accept two screws for miniplate fixation. Endoscopic repair of subcondylar fractures is generally the easiest.

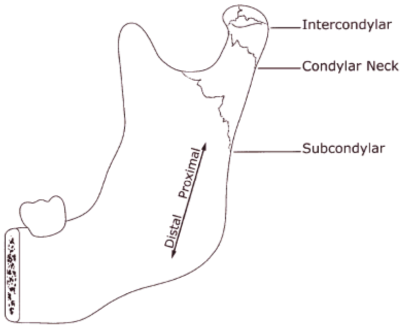

Fig.52. Condylar fractures can be classified as head (intracapsular), neck (below the capsular attachment and above the sigmoid notch), and subcondylar (passing through the nadir of the sigmoid notch)

Fracture displacement

Displacement refers to the position of the condylar fragment relative to the ascending ramus. Fractures where the condylar segment is located medially are termed medial override, those where it is lateral, lateral override]. The latter group forms the vast majority of adult condylar injuries treated at the authors' centers. Displacement is an important variable guiding the initial approach to endoscopic treatment. Lateral override fractures are especially amenable to repair because of easier fragment visualization, manipulation, and hardware fixation.[121] In contrast, medial override injuries are more difficult to reduce endoscopically, as the telescoped ascending ramus obscures visual access to the lateral surface of the condylar fragment and greatly impairs manipulation because of physical obstruction. The authors simplify the treatment of medial override injuries by first reducing them to the lateral override category. Nondisplaced, nondislocated fractures signify the presence of sufficient periosteal support for stability and do not require open treatment.

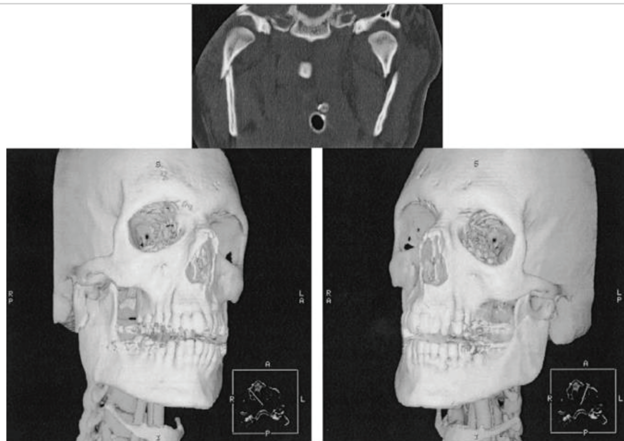

Fig.53. Coronal (above) and three-dimensional (below) CT reconstructions of a patient who sustained bilateral condylar fractures. The fracture of the right condyle demonstrates lateral override, that of the left, medial override. Generally lateral override fractures are the easiest to approach endoscopically, whereas medial override injuries are first reduced to lateral override to facilitate rep

Fracture comminution

Significant comminution is a relative contraindication to endoscopic repair as this technique relies largely on visualization of the fracture line for anatomic reduction and some degree of interfragmentary opposition for solid fixation. During reduction, the anterior and posterior borders of the fracture line are used as anatomic landmarks to assess accurate reduction. Comminuted fractures often will have fracture fragments that involve the border and thereby obscure these landmarks. Microcomminution will obscure the interdigitation of small irregularities along the fracture line that ordinarily assist in precise reduction. Unfortunately, the visual limitations of endoscopy make reliable assessment of reduction deceptively challenging in the face of comminutionA minor degree of comminution is not considered a contraindication.

Condyle–fossa relationship

Fractures associated with nondislocated condylar heads are the most favorable for endoscopic repair. A displaced condylar head without true dislocation usually can be relocated into anatomic position easily; however, those fractures with true dislocation of the condylar head are significantly more challenging.

Radiographic imaging:

Accurate radiographic imaging is necessary to reliably assess the feasibility of endoscopic repair and to formulate a precise treatment strategy by identifying fracture location, direction of displacement, and degree of comminution. The accuracy of modern helical CT scans has surpassed panoramic tomography for detecting mandibular fractures. Using 1 mm collimated images (with a pitch of two) and 1 mm axial images reconstructed on every second image, in 2001, Wilson and colleagues compared helical CT scanning with panoramic tomography in detecting 73 mandibular fractures in 42 consecutive patients and correlated the results with known surgical findings.

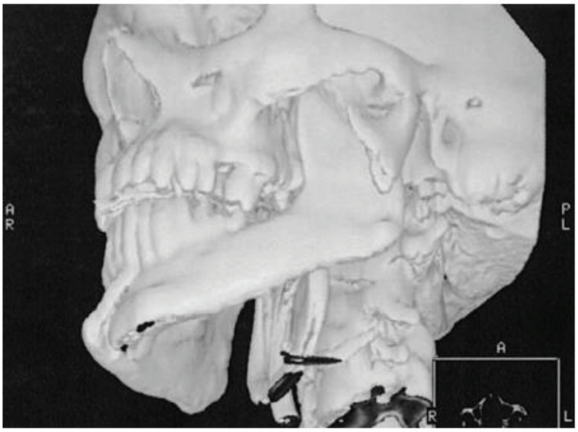

Fig.54. Three-dimensional CT scan of a left condylar fracture demonstrating characteristics amenable to the endoscopic repair technique: adequate proximal bone stock, no comminution, lateral override, and no dislocation out of the condylar fossa

Helical CT scan detected 100% of the fractures, while panoramic tomography detected only 86%. In six missed fractures, the surgical management was altered by the additional information provided from the CT scan. In one patient, the nature of a dental root fracture was seen better on panoramic tomography.[155] In the authors' experience, fine cut axial computed tomography scans with three-dimensional reformatting provide the most precise illustration of these variables. The three-dimensional reformatting is not accurate for detecting fracture detail but rather used to aid in the visualization of the fracture, and forming a clear mental picture of what will be required for reduction.

Operative technique:

Endoscopic equipment

A 4 mm diameter 30o angle endoscope, a 4 mm endoscopic brow lift sheath (Isse Dissector Retractor, Karl Storz, Germany) that maintains the optical cavity, and a video system can be used. Standard mandible fracture repair instruments are used in addition to the Subcondylar Ramus fixation set from Synthes (Paoli, Pennsylvania), which provides many specialized instruments facilitating the endoscopic technique.[121]

Repair sequence

If present, extracondylar fractures are addressed first using standard open reduction and internal fixation techniques to restore an intact mandibular arch. The rigid arch is then helpful in manipulating fracture fragments to achieve adequate reduction. Injection at the intraoral incision site and along the lateral aspect of the ascending ramus with 1:200,000 epinephrine solution will decrease bleeding into the optical cavity

Maxillomandibular fixation

If MMF was used for repair of an extracondylar fracture, it is removed. The use of tight wire maxillomandibular fixation will prevent distraction of the fracture and lock the displaced condyle in a malreduced position. The authors routinely employ rubber band anterior MMF that facilitates fracture repair by maintaining occlusion but permitting realignment of fracture fragments. Remember that the reduction of the fracture is a visual reduction and not based on occlusion.

Exposure

An intraoral incision along the oblique line of the mandible is made. The endoscopic cavity is created by elevating the periosteum off the lateral aspect of the ascending ramus. The assistant may hold the endoscope while the surgeon uses the periosteal elevator and suction to continue the dissection proximally to reveal the condylar fragment. A common mistake is to inadvertently dissect under (or medial to) the proximal fragment. This occurs because of a failure to appreciate the degree of lateral override and coronal plane angulation of the proximal fragment. Once the proximal fragment is identified, the subperiosteal dissection continues on the lateral surface up to the joint capsule, or a sufficient distance to place the fixation hardware. Transcutaneous stab incisions for screw placement are made directly over the palpated fracture line at the posterior border of the mandible. Gentle, blunt hemostat dissection through the parotid gland and masseter muscle is performed to avoid injury to the facial nerve.[121]

Reduction

To facilitate repair, medial override injuries are reduced initially into lateral override by placing a curved elevator medial to the proximal fragment while strongly distracting the fracture so as to allow the proximal fragment to be displaced to the lateral surface of the ascending ramus. If the fracture already is a lateral override, then interfragmentary realignment is achieved by distracting the distal segment through mechanical traction at the mandibular angle or placement of a 3 mm posterior occlusal spacer. The proximal segment can be reduced by bringing the condylar fragment out if its flexed position and applying medially directed pressure using a trocar inserted through the stab incisions. Removal of traction or posterior occlusal wedge then will permit the rubber band fixation to temporarily impact the fracture interfaces together and often maintain reduction while fixation is applied.[121]

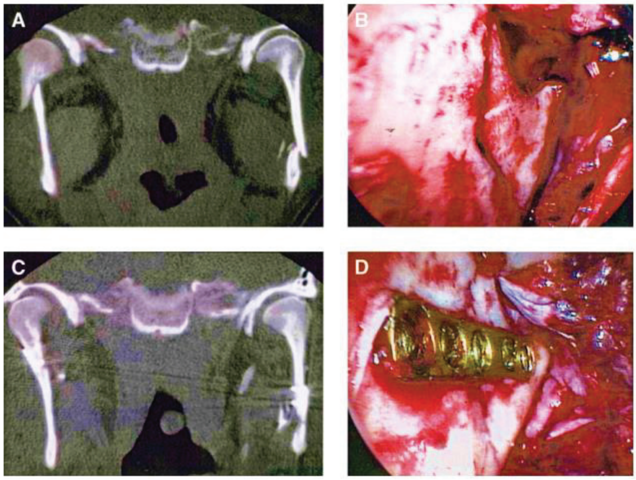

Fig.55. Fig. 4. (A,B) Preoperative coronal CT scan of a patient with bilateral condylar fractures and an endoscopic view of the left condylar fracture after reduction. (C,D) Postoperative coronal CT and a view of the anatomically reduced and rigidly fixated left condylar fracture using the endoscopic technique.

Fixation

Screws are introduced through the transcutaneous trocar. A miniplate is fixated along the posterior border of the ascending ramus, taking advantage of its thick cortical bone and flat surface. At least two screws are placed in each fracture segment to ensure solid fixation. Self-drilling screws have not been useful and often are a significant liability. Several authors have reported fracture of single miniplates; the authors advocate placement of two miniplates whenever possible. In general, the fixation plate is attached to the condylar fragment first. This allows the plate to act as a handle to position the condylar fragment into reduction. After reduction is achieved, the screws are placed into the mandibular portion. Some groups have found that placing a plate near the sigmoid notch or anterior portion of the fracture first simplifies placement of the posterior border plate.[121]Ultimately, each fracture will dictate the best approach. No matter the method, a meticulous inspection of the visual landmarks of anatomic reduction is imperative. The sigmoid notch and posterior border of the mandible must be visualized to ensure that reduction has occurred. If the reduction is not correct, then the distal screws should be removed and the condylar fragment repositioned. Following hardware placement, rubber band MMF is released and the mandible ranged in all excursions to ensure reproducible preinjury occlusion and stability of fixation.

Bailout

In a small number of attempted cases the endoscopic repair will not be possible because of inadequate proximal bone stock, excessive comminution, or inability to place fixation. In this circumstance, surgeons should resort to the method of condylar repair that they would use if the endoscopic technique was not available.[121]

Postoperative regime

All patients leave the operating room without MMF and are kept on a soft diet for 6 weeks.

In the treatment of condylar injuries, the endoscope is not only an aid; it alters the treatment philosophy, from the conservative MMF to anatomic repair. Each surgeon will have to decide on his or her indications for endoscopic repair, and indeed this may depend heavily on his or her experience and patient preference. The anatomic reduction and fixation are the best way to restore preinjury facial aesthetics and mandibular motion dynamics and to prevent late sequelae of internal derangement. It has been strongly advocated to do endoscopic repair of adult condylar neck and subcondylar fractures that demonstrate displacement or dislocation

PEDIATRIC CONDYLAR FRACTURES

The management of mandibular condyle fractures in the pediatric and adolescent population presents the surgeon with unique challenges. The distribution and fracture patterns of the mandibular condyle at various stages of development predictably follow the developmental anatomy of the lower jaw. The anatomy of a child's (age 2-5) mandible predisposes itself to intracapsular comminuted fracture patterns in the regenerative setting of a thin cortex with periosteum in a very active osteogenic phase. Although anatomic reduction using wide exposure and rigid internal fixation has gained increasing support for mandibular condylar process fractures in adults, this method of treatment is seldom useful in children. Conservative closed treatment of the condyle fracture in children without open reduction and internal fixation remains the standard today for most injuries. Despite encountered postsurgical radiographic abnormalities, conservative management of condylar fractures in children usually yields satisfactory to excellent clinical results.[156]

The condyle as a subunit is an important area of growth in the developing mandible. As a result, any trauma to the pediatric or adolescent condyle has the potential to disrupt growth and has long-term adverse effects. Possible traumatic fracture complications include pain, malocclusion, masticatory dysfunction, facial asymmetry, restricted mandibular movements, and temporomandibular joint disorders or ankylosis. It is therefore imperative for the surgeon to be able to properly identify and diagnose mandibular condyle fractures and provide appropriate treatment to help avoid these potential complications. The overall goal of treating mandibular condyle fractures in the growing patient is to reduce these risks and restore function, symmetry, and occlusion, while not interfering with mandibular growth.[157]

In general terms, a patient is considered to be a pediatric patient from birth until the age of 18, whereas the World Health Organization defines adolescence as the period in human growth and development that occurs after childhood and before adulthood, from ages 10 to 19. It is important to note that in terms of treating maxillofacial trauma, including condylar fractures, there is no clear delineation between a pediatric patient and an adolescent patient in terms of treatment.[158]

Craniofacial growth and development

For surgeons who treat pediatric facial fractures, an understanding of craniofacial growth and development can guide clinical treatment. It is the anatomy of the pediatric mandible that determines its response to trauma. The general pattern of normal facial growth occurs in a downward and forward motion along with concurrent lateral expansion, depending on the amount and location of apposition and resorption of bone. Differences in the rate and location of apposition and resorption of bone are responsible for characterizing the typical growth pattern of the face, and any disturbance can cause skeletal and/or dental malocclusions. The mandible follows the downward and forward growth pattern of the face with the addition of upward and backward growth of the condyles to maintain contact with the glenoid fossa. Vertical height is gained at the condyle through endochondral replacement, and height is added via remodelling of the ramus.[158]

Ages 0 to 2

- The condylar neck is short and thick and engages a shallow glenoid fossa.
- Extensive vascular channels are found in the condylar head that make it vulnerable to a crush-type injury.
- Unlike older age groups, the short stocky nature of the condylar neck makes it relatively resistant to fracture, whereas the regenerative capacity is significant.

Ages 3 to 12

- A more adultlike configuration of the condylar process and glenoid fossa begins to develop.
- Although unlike adults, there still remains an enormous potential for regeneration and remodelling in this age group.

Ages 13 to 18

- Although the capacity for extensive new bone formation is equivalent to that of children, teenagers lack the corresponding capacity for condylar remodelling that is found in the younger groups.

CLINICAL FEATURES:-

- Submental ecchymosis or laceration.
- Malocclusion
- Preauricular oedema or tenderness to palpation.
- Chin deviation toward the affected side (unilateral fracture)
- Shortening of the ramus on the affected side (unilateral fracture)
- Posterior displacement of the mandible (bilateral fracture)
- Anterior open bite (bilateral fracture)

DIAGNOSIS:-

A clinical and radiographic examination is necessary to obtain an accurate diagnosis for facial fractures, including those of the mandible. The diagnosis of pediatric mandible fractures is often difficult due to the limited ability to obtain accurate subjective complaints, such as pain, malocclusion, or inferior alveolar nerve dysfunction from the patient. The ability to elicit subjective findings from a patient increases with age, but imaging often remains the best method for the diagnosis of fractures in younger patients.

Plain films of children are often difficult to obtain secondary to patient cooperation, and short condyle – ramus complex fractures can be often missed due to overlap. Computed tomography is often necessary to adequately diagnosis this area.[159]

Closed vs Open Treatment

The optimal treatment of mandibular condylar fractures continues to be controversial, with both surgical and nonsurgical treatment options being debated. In adults, there are well-documented absolute indications, as well as relative indications, for open reduction and internal fixation of condylar fractures. In children, closed treatment is most commonly the treatment of choice for condylar fractures given that the condylar complex rapidly remodels. The use of functional appliances has been shown to be a successful closed treatment option for condylar fractures by reestablishing the vertical dimension and encouraging the remodeling of the hard and soft tissues of the temporomandibular joint. The design of a functional appliance must be determined based on specific treatment objectives with the overall goal of establishing a balanced and functional occlusion. A retrospective study demonstrated that a removable occlusal splint worn for 1 to 3 months had satisfactory clinical outcomes. The thickness of the splint and the duration of wear were determined according to the age, the developmental stage of the dentition, the level of the fracture, and the degree of dislocation. Open reduction and internal fixation of condylar fractures is often reserved for adult patients; however, in certain situations open reduction of pediatric condylar fractures may be considered. The age at which the decision to treat closed versus open is not always apparent. Multiple studies have been completed to evaluate the outcome of pediatric condylar fractures depending on the treatment modality chosen.[160]

For closed treatment of mandibular condyle fractures, a period of maxillomandibular fixation may be used. The time period for maxillomandibular fixation has traditionally been 7 to 10 days. The most common maxillomandibular fixation methods include the following: [161]

1. Erich arch bars
2. Risdon cable
3. Ivy loops

COMPLICATIONS

The debate on which is the best way to treat condylar fractures is an ongoing one. Outcomes of both open and closed treatments have been critically reviewed (Rozeboom et al., 2016, 2017).[162] The major drawback of open treatment remains the surgery-related complications. A better definition of the most appropriate approach and knowledge of the exact risks for specific complications are essential in the decision-making process.

The most serious complication is probably damage to the facial nerve. Fortunately, this is transient in most cases, with a reported incidence of between 12% and 48% (Ellis et al., 2000; Manisali et al., 2003; Vesnaver et al., 2005; Downie et al., 2009; Choi et al., 2012), when the most commonly used incision (the retromandibular transparotid approach) is used. Based on literature, the incidence of temporary weakness is higher with transparotid dissection than with non transparotid dissection.[163-166] The recovery rate is significantly higher with the transparotid approach compared with the anterior or posterior parotid approach. A possible explanation might be the necessity for less traction of the nerve. Differences in the subcutaneous approaches, i.e. with or without retrograde nerve dissection with identification of the nerve, could have biased these outcomes.

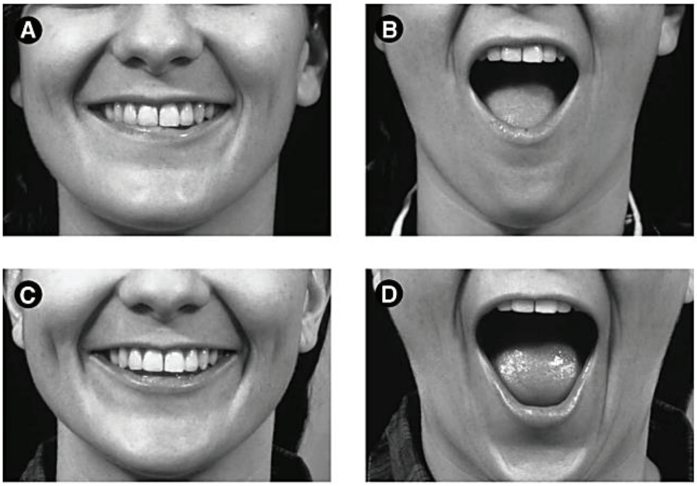

Fig.56. Patient who underwent open treatment of right condylar process fracture. Slight "weakness" of the right lower lip was noted by both observers in the 6-week smiling (A) and open mouth (B) photographs. However, by 6 months, the observers no longer recorded any remaining asymmetry in the smiling (C) or open mouth (D) photographs.

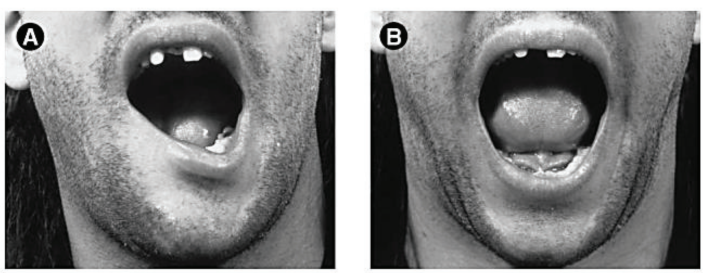

Fig.57. Patient who underwent open treatment of right condylar process fractures showing gross "weakness" of right lower lip at 6 weeks (A), and complete resolution at 6 months (B).

Recently a comprehensive systematic review and meta-analysis was published on facial nerve injuries (Al-Moraissi et al., 2017)[167] related to surgical approaches for treating mandibular condylar fractures. With respect to the condylar neck and base fractures, no differences between the non-transparotid and transparotid approach were found.

Though Al-Moraissi et al. did emphasize the importance of traction on the nerve and the risk of damaging the nerve by either approach, it was stated that the choice of approach was highly related to the level of the fracture and therefore different approaches were recommended for different condyle fractures.

In addition to this, Al-Moraissi et al. (Al-Moraissi et al., 2017), concluded that for condylar head fractures the retro-auricular approach or deep subfascial perauricular approach was the safest in terms of protecting the facial nerve, for condylar neck fractures the safest was the transmassetric anteroparotid approach with retromandibular and preauricular extension, and for condylar base fractures they suggested high submandibular incisions with a transmassetric anteroparotid approach with retromandibular or transmassetric subparotid approach.[167]

Every incision creates a scar. Hiding the scar is an important step in facial reconstruction. It has been noted that signs of poor preauricular incision planning include visible preauricular incision lines, an unnatural tragal appearance, and loss of earlobe definition with a 'pixie-ear' configuration (Kridel and Liu, 2003).[168] A rhytidectomy (or facelift incision) produced no unsatisfactory result and, could therefore be the incision of preference. An alternative could be the retro-auricular incision, where the incision is hidden behind the earlobe. Although the complication rates seem to be low (Benech et al., 2011)[169], strictures of the external auditory canal have been described.

The focus of the debate is most likely not the choice of skin incision, but rather the choice of subcutaneous dissection. Based on the literature, use of the transparotid approach has gained popularity as a more straightforward approach, with direct visibility of the fracture and the shortest distance between the skin and the mandibular condyle. Because of the shorter working distance, there is less need to forcefully retract the soft tissues, implying a limited complication rate, in particular with reference to facial nerve weakness (Dalla Torre et al., 2015). [170]

If sialoceles or fistulas occur, these are managed in most studies by aspiration or the collection and placement of a compression dressing (Saikrishna et al., 2009; Bhutia et al., 2014; Kanno et al., 2014).[171-173] It is believed that this complication can be avoided in most cases by careful closure of the parotid capsule with running sutures (Bindra et al., 2010; Bouchard and Perreault, 2014; Colletti et al., 2014). [174-176]

Currently, surgeons are using more minimally invasive surgery (MIS) (Hou et al., 2014).[177] The suggested advantages of small incisions include: less surgical trauma, less bleeding, fewer and smaller scars, reduction in infection risk, and shorter hospital stays (Hou et al., 2014).[177] Some (Biglioli and Colletti, 2009; Rao et al., 2014)[178.179] use the mini retromandibular approach, limited to 20 mm, for fractures at every level, from high-neck to low-subcondylar fracturees. Colletti et al. (Colletti et al., 2014)[176] stated that this broad application is possible because the view is limited by the deeper part of the access, not by the skin incision.

Nevertheless, Biglioli et al. (Biglioli and Colletti, 2009)[178-179] described difficulty with the use of this limited incision in overweight patients with redundant soft tissues of the cheek.

Transient facial nerve weakness was explained by the relatively greater stretching of the soft tissues resulting from a small incision, and increased likelihood of excessive stretching of the nerve fibers and therefore of transient facial nerve weakness (Rao et al., 2014). [179]

Hou et al. (Hou et al., 2014)[177] designed the minor parotid anterior approach to treat medial and low condylar fractures. They describe three advantages of this approach: first, there is a lower risk of injuring the facial nerve; second, the length of the incision used is short (2–2.5 cm, compared with, for example, 3–3.5 cm in the retromandibular approach), and therefore scarring is reduced; and third, because the location of the incision overlies the fracture site, it provides excellent visual exposure of the fracture fragments and makes the procedure quick and simple.

The great diversity of fractures, approaches, and surgical techniques makes it difficult to generate an objective, clear, and usable comparison of surgical techniques for condylar fractures and their complications (Manisali et al., 2003; Klatt et al., 2010).[164,180] To establish more evidence for the best approach to an open treatment, more research will be needed on, for example, different extraoral approaches and their comparisons, the use of antibiotics, the development of advanced and less technically demanding endoscopic techniques, the role of nerve integrity monitoring during surgery (e.g. the NIM stimulator; Medtronic, Minneapolis, MN) (Bindra et al., 2010),[174] and perhaps in the future, the use of intraoperative surgical navigation. In this way, an evidence-based protocol for the treatment of this complex fracture will be accomplished (Bouchard and Perreault, 2014).[175]

A clear treatment protocol is needed to attain predictable clinical practice. In cases of open treatment of condylar fractures, such a protocol should be interpreted and implemented by taking the skills of the surgeon into consideration.

Concerning the skin incision, no real preference exists, although the submandibular and periangular skin incision showed the best results. Subcutaneously, a transparotid approach is recommended, because, it is straightforward, with direct visibility of the fracture and the shortest distance between the skin and the mandibular condyle and therefore results in less traction on the facial nerve.

Most important for the surgeon is a sufficient view of the fracture site. With regard to the skin incision, one could argue for using the preauricular, retroauricular, or perilobular approach for high condylar fractures (Nam et al., 2013),[181] the retromandibular or preauricular approach for middle-height fractures (Ellis et al., 2000; Manisali et al., 2003; Vesnaver et al., 2005; Nam et al., 2013),[163, 164, 165, 181] and the retromandibular, high submandibular, or periangular approach, or rhytidectomy modifications, for low condylar fractures (Ellis et al., 2000; Manisali et al., 2003; Vesnaver et al., 2005; Nam et al., 2013; Zide and Kent, 1983;).[163, 164, 165,181,182]

After the open reduction and fixation, the parotid capsule is sutured with care. When there is a high level of experience, MIS could be used. On the other hand, especially for surgeons with limited experience, it is prudent to discourage approaching the fracture with a small incision and forcible opening of the dissected tissues (Yabe et al., 2013).[183] Furthermore, the use of a neurostimulator during surgery is advised.

REVIEW OF LITERATURE

A controlled, parallel group randomized trial was done in total 50 patients having fractures of the mandibular condylar processes. All fractures were displaced with degree of deviation between the condylar fragment and the ascending ramus of 10° to 45° (medio-laterally). Patients were randomly divided into two groups with group 1 subjected to open reduction internal fixation and group 2 closed reduction. The follow-up was done over the period of 6 months. Statistically significant improvement was seen in group 1 as compared to group 2 in terms of anatomic reduction of condyle, shortening of ascending ramus, occlusal status and deviation on mouth opening. A statistically significant difference was seen in the patients treated with open method have improved TMJ functions and fewer short and long-term complications compared to closed method of treatment.[1]

Nine routine preoperative CT scans of patients with bilateral mandibular fractures were acquired and post-processed using a mean model of the mandible and Amira software extended by custom-made scripting and programming modules. A computerized technique was developed that allowed three-dimensional modeling, separation of the mandible from the cranium, distinction of the fracture fragments, and virtual fracture reduction. User interaction was required to label the mandibular fragments by landmarks. Virtual fracture reduction was achieved by optionally using the landmarks or the contralateral unaffected side as anatomical references. It offered expanded planning options for osteosynthesis construction or the manufacturing of personalized rapid prototyping guides in fracture reduction procedures. CAPP is justified in complex mandibular fractures and may be adopted in addition to routine preoperative CT assessment.[2]

A retrospective study was conducted of mandibular fracture morbidity associated with treatment by the oral and maxillofacial surgery service between 1996 and 2000. A total of 721 fractures were recorded, with 594 fractures available for review. Perioperative and postoperative complications were assessed by reviewing patient charts, operative reports, and radiographs. Complications were classified by location, type of complication, and treatment modality. Standard statistical tests were used to assess differences between the groups. Of the 594 fractures available for review, a total of 79 fractures were noted to have had a complication (13.3%). One hundred five complications were observed in the group of 79 fractures due to more than one complication being associated with a specific fracture (15.8%). Closed reductions accounted for the largest treatment group, representing 341 fractures with 26 complications (7.6%). Miniplate fixation was used in 97 cases, with 23 complications (23.7%). Mandibular plates with or without a superior border miniplate were used in 140 fractures, with 28 complications (20%). The most common complication was wound infection, which occurred in 35 fracture sites, followed by nonunion, which occurred at 30 sites. It was concluded that in an urban area with a high prevalence of poor living conditions, substance abuse, and poor patient compliance, the treatment of mandibular fractures by closed reduction resulted in the least number of postoperative complications in all anatomic regions of the mandible. The mandibular angle fracture had the highest overall morbidity rate.[7]

A total of 28 patients with a condylar fracture were selected and were classified with the help of orthopantomogram and reverse Towne view radiographs. Of the 28 patients, 22 had unilateral fractures of the mandibular condyle process and 6 had bilateral fractures. They were treated with no invasive treatment, closed reduction with maxillo-mandibular fixation, or open reduction with internal semirigid fixation. No significant difference was observed in the occlusion, maintenance of fixation of anatomically reduced fractured bony segments, trismus index, movements of the mandible (i.e, opening, protrusion, and lateral excursions), or masticatory efficiency. The only significant difference was the subjective discomfort of the surgically treated patients in terms of pain on movement and mastication, swelling, neurologic deficit, and parotid fistula formation. It was concluded that patients with a condylar fracture with no displacement, dislocation, or derangement of occlusion seem best treated with medication only for symptomatic relief without any invasive treatment. Patients with derangement of occlusion or displacement of fractured fragments, especially in unilateral cases, seem best treated with closed reduction and maxillo-mandibular fixation, with medication for symptomatic relief and postoperative physiotherapy. Patients with deranged occlusion, displaced bony fractured fragments, and a dislocated condylar process out of the glenoid fossa, especially bilateral cases, seem best treated with open reduction with internal semi-rigid fixation.[8]

After recalling Michelet's principles of mandibular osteosynthesis, the authors relate their experiences after 18 months of biomechanical analysis. They define the best locations for osteosyntheses according to calculations of when flexion and torsion occur, taking anatomical conditions into account. Details are given of the position of the plate or plates according to the location of the fracture or osteotomy (horizontal branch, symphysal and para-symphysal region and angle). Analysis of stresses within the osteosynthesized mandible has resulted in the development of what seems to be a reliable medium. One hundred anf forty facial osteosyntheses they have carried out confirm their faith in the safety of the method.[31]

Ten patients (20 to 49 years old) with isolated anterior mandibular parasymphyseal fractures were treated by means of open reduction and internal fixation using SR-P(L/DL)LA 70/30 bioresorbable plates and screws. During the minimum of 6 months of follow-up, no problems were encountered except for 1 case where a plate became exposed intraorally and infected. This required debridement and later excision of the exposed part of the plate. Despite this setback the fractured bone healed well. The authors concluded that SR-P(L/DL)LA 70/30 plates and screws are reliable for internal fixation of anterior mandibular fractures in adults.[38]

Eighty-seven patients with symptoms and indications of TMD in one or both TMJs were referred for MRI. Cone-beam CT (3DX) was used to measure the thickness of the RGF at its thinnest point. Linear measurements were made three times on the monitor by three separate investigators and the mean values obtained were used for the statistical analyses. The joints were categorised as normal (70 joints), anterior disc displacement with reduction (ADWR; 53 joints) or anterior disc displacement without reduction (ADWOR; 51 joints). The joint disorders were also categorised into the following subgroups: with osteoarthritis (OA) (21 joints), without OA (153 joints), with disc deformation (33 joints), without disc deformation (141 joints), with joint effusion (JE) (61 joints) and without JE (113 joints). The average minimum thickness of the RGF was 0.85 mm for normal joints, 0.90 mm with ADWR, 0.93 mm with ADWOR, 0.99 mm with OA, 0.87 mm without OA, 0.87 mm with disc deformation and 0.89 mm without disc deformation. There was no significant difference between these figures. There was a significant difference in the thickness of the RGF with (0.97 mm) and without (0.84 mm) JE. These results suggest that RGF thickness is influenced by JE, but is unaffected by disc position and configuration.[47]

In total, 49 patients with unilateral condylar fractures were treated non-surgically in 1972-1976. Of these, 23 patients were available for follow-up, 17 were dead, 7 were not found and 2 did not answer letters or phone calls. The follow-up was a telephone interview according to a standardized questionnaire concerning occurrence of pain and headache, function of the jaw and joint sounds. Information from original records, radiographic reports and the standardized trauma charts revealed fracture site, type of fracture and intermaxillary fixation if any. Eighty-seven percent of the patients reported no pain from the jaws, 83% had no problems chewing and 91% reported no impact of the fracture on daily activities. Neck and shoulder symptoms were reported by 39% and back pain by 30%. The 31-year results of non-surgical treatment of unilateral non-dislocated and minor dislocated condylar fractures seem favourable concerning function, occurrence of pain and impact on daily life.[66]

Twenty-four patients less than 14 years of age were included from 2000 to 2005. Classes II to V after Spiessl and Schroll, eg, displaced or dislocated fractures were surgically treated; Class I and VI nondisplaced, nondislocated fractures were treated closed. At yearly intervals, facial symmetry, pain, nerve function, bone repositioning, scarring, and reossification were evaluated. Incisal opening, protrusion, laterotrusion and sonographic condylar translation were measured in mm. Nineteen (79%) patients presented for follow-up: Class I, 8; Class II, 3; Class III, 0; Class IV, 2; Class V, 5; and Class VI, 1. After 1 year, 11 patients (58%) presented for follow-up; after 2 years, 4 (21%) patients, and after 5 years, 4 (21%) patients presented for follow-up. The reasons for not presenting for follow-up given by the parents upon telephone interview were no symptoms and absent motivation. All patients exhibited sufficient opening; 1 Class IV patient had insufficient translation; 3 patients had opening deflection; 2 patients' partial facial nerve paresis subsided after 1 year; in 2 cases broken osteosyntheses were removed. Vertical and horizontal condyle support was successfully reconstructed; considerable bone resorption occurred in Class V; failure rate was 4 (17%). Of 5 Class V, 3 were failures (60%). The evaluated treatment rationale attained 83% treatment success; Class V should be repositioned with careful mobilization to not risk impaired perfusion and considerable remodeling.[91]

Clinical, radiologic, and axiographic follow-up of 40 patients with 50 intracapsular fractures of the mandibular condyle was carried out after closed treatment. The examinations were performed an average of 22 weeks after treatment. Three types of intracapsular fractures were distinguished: type A, or fractures through the medial condylar pole; type B, or fractures through the lateral condylar pole with loss of vertical height of mandibular ramus, and type M, multiple fragments, comminuted fractures. Moderate to serious dysfunction was observed in 33% of the cases. Radiologic examination of fracture types B and M revealed a reduction in the height of the mandibular ramus of up to 13% compared with the contralateral side. These 2 fracture types also resulted in the most prominent deformations of the condylar head. Axiography revealed irregular excursions and a limitation of condylar movement in comminuted fractures of up to 74% compared with the nonfractured side. lesions to the osseodiscoligamentous complex of the temporomandibular joint caused by intracapsular fractures of the mandibular condyle can be severe. The poor functional and radiologic results encountered in the fracture types B and M showed the limitations of closed functional treatment.[95]

Sixty-six patients with 79 displaced fractures (deviation of 10 degrees to 45 degrees, or shortening of the ascending ramus >or=2 mm) of the condylar process of the mandible at 7 clinical centers were enrolled. Patients were randomly allocated to CRMMF (n = 30 patients) or ORIF (n = 36 patients) treatment. The following parameters were measured 6 months after the trauma. Clinical parameters included mouth opening, protrusion, and laterotrusion. Radiographic parameters included level of the fracture, deviation of the fragment, and shortening of the ascending ramus. Subjective parameters included pain (according to a visual analogue scale), discomfort, and subjective functional impairment with a mandibular functional impairment questionnaire. The difference in average mouth opening was 12 mm (P <or= .001) between both treatment groups. The average pain level (visual analogue scale from 0 to 100) was 25 after CRMMF, and 1 after ORIF (P <or= .001). In 53 unilateral fractures, better functional results were observed for ORIF compared with CRMMF, irrespective of fracture level (condylar base, neck, or intracapsular head). Unexpectedly, the subjective discomfort level decreased with ascending level of the fracture. In patients with bilateral condylar fractures, ORIF was especially advantageous. Fractures with a deviation of 10 degrees to 45 degrees, or a shortening of the ascending ramus >or=2 mm, should be treated with ORIF, irrespective of level of the fracture.[96]

A total of 332 patients with unilateral extracapsular fractures of the mandibular condylar process were retrospectively studied. After any other mandibular fractures had undergone open reduction and internal fixation, the maxillomandibular fixation was released and the occlusion checked to determine whether deviation of the mandible was present toward the side of the condylar fracture. In addition, digital posteriorly directed force was applied to the chin to determine how easily the mandible would deviate. Those cases in which the mandible dropped posteriorly toward the side of fracture, creating a malocclusion ("drop-back"), were treated either closed or by open reduction, according to several factors. Those whose mandibles either did not deviate toward the side of fracture or those in whom the mandible could be pushed posteriorly on the side of fracture but readily regained a midline position on release of pressure (nondrop-back) were treated closed. Displacement of the condylar process was examined using pretreatment Towne's and panoramic radiographs. The relationship between the intraoperative drop-back results and the pretreatment level and displacement of the condylar process fractures was statistically assessed. Of the 332 fractures, 105 were in the nondrop-back group and 227 were in the drop-back group. The only demographic difference between the 2 groups was the displacement of the condylar process, which was greater in the drop-back group. All patients in the nondrop-back group, except for 1, had good occlusal and functional outcomes, with minimal need for interarch elastic guidance. Determining which patients would not benefit from open reduction and internal fixation can be assessed clinically during surgery more reliably than using preoperative imaging studies.[100]

Thirty patients with mandibular fractures associated with no other facial fractures were selected. They were randomly assigned into 2 groups for treatment with conventional MMF (group A) and MMF for a short period of 2 weeks followed by an arch bar splint wired to the lower jaw (group B). Complications were recorded and post-treatment maximum interincisal mouth opening was measured at 1 week and 3 and 6 months. Age and gender-matched control groups were randomly selected. Groups were then compared for significant differences. A value of $P < .05$ was considered significant. he 2 patient groups were not significantly different in relation to site and cause of fracture ($P = .995$ and $P = .682$, respectively), the mean time from injury to MMF ($P = .234$), and the mean time required for fracture healing ($P = .315$). Delayed union and nonunion were not encountered, and there were no significant differences in relation to postoperative infection ($P = 1$) and malocclusion ($P = .598$). When compared with group A patients, group B patients had an early significantly greater degree in mouth opening ($P = .001$); at no time was there a significant difference in the degree of mouth opening between group B patients and the control group (1 week, $P = .079$; 3 months, $P = .166$; 6 months, $P = .378$). In selected cases, a short period of MMF followed by an arch bar splint wired to the lower jaw is a suitable alternative to conventional MMF for treatment of fractures of the mandibular tooth-bearing area. The method is effective and significantly reduces the potential adverse effects of long-term MMF.[102]

A total of 32 patients with displaced unilateral condylar fractures were included in the present study. Of the 32 patients, 27 were men and 5 were women. The patients were divided into 2 groups. The group I patients were treated with closed treatment and rigid maxillomandibular fixation, and group II patients were treated with open reduction and internal fixation. The patients were assessed for maximal interincisal opening, protrusive movements, lateral excursion movements on the fractured and nonfractured sides, anatomic reduction of the condyle on radiography, pain in the temporomandibular joint, and malocclusion. Parameters such as the maximal interincisal opening, protrusive movements, and lateral excursion movements on the fractured and nonfractured sides between the 2 groups were compared statistically using an independent t test. Parameters such as anatomic reduction of the condyle, pain in the temporomandibular joint, and malocclusion between the 2 groups were compared statistically using the chi(2) test. No significant difference was found between the 2 groups in the maximal interincisal opening, protrusion, lateral excursion movement, malocclusion, and temporomandibular joint pain; however, a statistically significant difference was seen in the anatomic reduction of the condyle. The results of the present study have shown that no significant clinical difference exists between patients undergoing closed treatment and rigid maxillomandibular fixation or open reduction and internal fixation. However, a radiographically better anatomic reduction of the condylar process was seen in the patients treated with open reduction and internal fixation.[104]

The data of all patients with fractures of the atrophic edentulous mandible from the involved maxillofacial surgical units across Europe between January 1, 2008, and December 31, 2017 were collected. Only patients that were diagnosed with condylar fractures of the edentulous atrophic mandible were included. A total of 52 patients met the inclusion criteria and were included in the study: 79% of patients reported one or more comorbidities. Thirty-four unilateral neck or subcondylar fractures, 9 bilateral neck or subcondylar condylar fractures, 7 unilateral head condylar fractures, and 2 bilateral head condylar fractures were diagnosed. No treatment was performed in 37 cases, whereas in 4 patients a closed treatment was decided, and 11 patients underwent open reduction and internal fixation. Outcome was considered to be satisfying in 48 patients, with no complications. The golden rule still remains that the diagnosis of a subcondylar or neck fracture in an edentulous patient should constitute an indication for open reduction and internal fixation. However, an appropriate choice of management options has to be individualized on a case by case basis, also depending on the patient consent.[105]

Thirty patients with 40 fractures of atrophic mandibles were treated by open reduction and internal fixation at our department between 1994 and 2001. Twelve fractures occurred in Class I (between 15- and 20-mm bone height), 10 fractures in Class II (between 10 and 15 mm), and 18 fractures in Class III atrophy (<10 mm). The profile heights of plating systems used for stabilization varied from 0.5 to 2.2 mm and were applied with an intraoral (n = 37) and extraoral (n = 3) approach. In 36 fractures, bone healing was uneventful. Major complications (loose hardware or nonunion) occurred in 4 fractures: 2 in Class II and 2 in Class III atrophy. Major complications were observed with 1.4-mm (n = 3) and 2.2-mm (n = 1) plates. Minor complications (infections or dehiscence) were observed in 6 fractures: 3 in Class II and 3 in Class III atrophy. Hypesthesia of the inferior alveolar nerve was present 1 week and 1 year postoperatively in 39 and 16 fractures, respectively. Treatment of atrophic mandible fractures should be based on the degree of atrophy. More rigid fixation may be necessary in mandibles with less than 15 mm bone height.[106]

The retrospective analysis was performed on all patients treated for low subcondylar fractures (below the sigmoid notch) between 2006 and 2011. Patients were divided into two groups: the closed reduction group (maxillomandibular fixation, MMF) and the open reduction group (anteroparotid transmasseteric (APTM) approach). Out of 129 condylar fractures, a total of 37 patients met the inclusion criterion of a fracture below the sigmoid notch (low subcondylar). Ten patients (seven males and three females) were treated using the APTM approach, and 27 patients were treated conservatively by MMF. In the open reduction group, two patients (20%) had limited mouth opening that resolved following physiotherapy; the closed reduction group had a similar percentage (18.5%) of mouth opening limitation (below 35 mm). No facial nerve damage was noted. Adult patients suffering from low subcondylar fractures can be treated by open reduction and internal fixation using the APTM approach, which was found to be a safe and reproducible procedure with no facial nerve damage; however this is a surgical procedure with a shallow learning curve.[109]

Sixty patient files were analyzed and 28 patients were seen for re-examination and a x-orthopantomogram was taken. Functionality was graded with the Helkimo index at an average of 3.0 years follow-up. The clinical dysfunction index showed: severe symptoms in 11%, moderate symptoms in 39%, mild symptoms in 39% and 11% had no symptoms. Index for occlusal state showed: 21% severe occusal disturbances, 61% moderate occlusal disturbances and 18% no occlusal disturbances. According to the anamnestic dysfunction index 89% of the patients were symptom-free. The clinical outcome group showed a significant left/right ramus length difference compared with a 20-person control group. The re-examined group did not significantly differ from the control group. Conservative treatment for condylar fractures was successful in only 46% according to the 1999 consensus criteria described by Bos et al.[113]

Out of a total of 88 randomized patients from 7 centres, 66 patients with 79 fractures of the mandibular condylar process completed the study and were evaluated. All fractures were displaced, being either angulated between 10 degrees and 45 degrees or the ascending ramus was shortened by more than 2mm. The follow-up examinations 6 weeks and 6 months following treatment included evaluation of radiographic measurements, clinical, functional and subjective parameters including visual analogue scale for pain and the Mandibular Function Impairment Questionnaire index for dysfunction. Correct anatomical position of the fragments was achieved significantly more often in the operative group in contrast to the closed treatment group. Regarding mouth opening/lateral excursion/protrusion, significant (p=0.01) differences were observed between both groups (open 47/16/7mm versus closed 41/13/5mm). The visual analogue scoring revealed significant (p=0.03) differences with less pain in the operative treatment group (2.9 open versus 13.5 closed). The Mandibular Function Impairment Questionnaire index recorded a significant (p=0.001) difference with less pain and discomfort in the open treatment group (10.5 versus 2.4 points). Both treatment options for condylar fractures of the mandible yielded acceptable results. However, operative treatment, irrespective of the method of internal fixation used, was superior in all objective and subjective functional parameters.[115]

Fifteen cases of condylar fracture were selected and thermoforming plates were applied. The patient's recover was uneventful in all 15 cases, and the period of IMF ranged from 7 to 17 days, (mean 12) for the following 7 days IMF was used only at night together with functional jaw training during the day. The outcome was good. IMF using a thermoforming plate may be a useful technique for selected condylar fractures.[116]

A clinical, radiographic and computer-assisted axiographic follow-up was carried out on 60 patients who had been treated for unilateral subcondylar fractures. These were patients of the Department of oral, maxillofacial and facial plastic surgery of the Medical Faculty of the University of Technology in Aachen, Germany. After surgical reduction of the condyle with fixation by osteosynthesis where results were positive, 27 patients exhibited a shortening of the condyle paths on the side operated on by up to 16.4%. Although conservative therapy produced slighter straightening of the condyle with more or less strongly marked condylar deformations in two-thirds of the cases, functionally more positive results were obtained by markedly slighter limitation of the condyle paths on the traumatized side. These results would appear to indicate operative therapy of unilateral subcondylar fractures in the case of luxation fractures, condylar dislocation in excess of 50 degrees, and in those cases where intermaxillary immobilization is not feasible. In the remaining cases, conservative treatment is preferred, due to it showing functionally more positive results.[121]

Fifty-five children aged between 2 1/2 and 9 3/4 years, presenting with a singular unilateral fracture of the mandibular condyle, were treated in a nonsurgical-functional way using an intraoral myofunctional appliance. In the follow-up period, patients were investigated by standardized clinical examination and by evaluation of panoramic radiographs taken immediately post-traumatically, after 6, 12, 24, 48 and 72 weeks, and then yearly through the period of growth. With a satisfactory clinical course in all patients, there was no instance of functional disturbance or mandibular asymmetry after the respective follow-up periods. The radiographs showed a fairly good shape of the condyle (no or only slight condylar deformity) in the 47 patients of the 2-6 year age group. In the eight patients of the 7-10 year age group presenting with a class II or III condylar fracture, healing was characterized by incomplete condylar regeneration, resulting in a moderate condylar deformity in two cases, a definite reduction in condylar neck height in two cases, and a hypertrophic condylar deformity in four cases. The positive results of this study confirm the concept of a nonsurgical-functional approach in children presenting with various types of unilateral fractures of the mandibular condyle. Condylar remodeling was the mode of fracture healing in instances of displaced and dislocated condylar fractures.[125]

A total of 137 patients with unilateral fractures of the mandibular condylar process (neck or subcondylar), 77 treated closed and 65 treated open, were included in this study. Standardized occlusal photographs obtained at several postsurgical time intervals were examined and scored by a surgeon and an orthodontist. Standard statistical methods were used to assess differences between groups. Patients treated by closed techniques had a significantly greater percentage of malocclusion compared with patients treated by open reduction, in spite of the fact that the initial displacement of the fractures was greater in patients treated by open reduction. Based on this study, more consistent occlusal results can be expected when fractures of the mandibular condylar process are treated by open reduction.[127]

Sixty-one patients treated by open reduction and internal fixation for unilateral condylar process fractures were studied prospectively using Towne's and panoramic radiographs. The radiographs were made before surgery, and immediately, 6 weeks, and 6 months postoperatively. The images were traced and digitized, and the position of the fractured condylar process was statistically compared with the position of the nonfractured condylar process in both the coronal and sagittal planes. Additionally, 2 observers examined the images and assessed these same 2 factors. After surgery, the difference in position between the fractured and non-fractured sides averaged less than 2 degrees (not significantly different), indicating good reduction of the fractures. However, subsequently, between 10% and 20% of condylar processes had postsurgical changes in position of more than 10 degrees. This study showed that it is possible to anatomically reduce the fractured condylar process, but changes in position of the condylar fragment may then result from a loss of fixation.[129]

CONCLUSION

The treatment of fractures of the jaw has a long history, from ancient Egypt to the present. Today's oral and maxillofacial surgeons are recipients of knowledge acquired from many surgeons through the ages, including Hippocrates, Kazanjian, and Lane. In the 18th and 19th centuries, fractures were treated quite successfully in outpatients. During that period the potential for sepsis was ever-present and access to anaesthesia limited, so treatment was conservative; the teeth were simply repositioned (without anaesthetic) using bandages and dental splints to hold them in alignment. Today, this work is undertaken in a more sophisticated way under general anaesthesia. The ability to control infection together with the advent of new biomaterials has revolutionized treatment. Now open reduction is the norm and tiny titanium plates are used to immobilize fragments of the jaw. Morbidity of the procedure is low with the advantage that the patient returns to normal function within days of treatment. But low morbidity comes at a price of expensive materials and the need for inpatient hospital facilities.

Ultimately, the patient and the individuality of the fracture determine the course of treatment. A thorough understanding of the anatomy of the condylar region is paramount for facial trauma surgeons. Understanding this along with the biomechanics of the injury, helps to guide surgeons in therapy.

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