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Current views on the treatment of condylar fractures

Aktualne poglądy na temat leczenia złamań wyrostka kłykciowego żuchwy

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ABSTRACT
The aim of this review was to present and discuss current views on the treatment of condylar fractures (CFs). The authors addressed the following issues: the etiology, epidemiology and mechanisms of CFs; strategies and methods for the treatment of CFs. Moreover, the choice of surgical approach for the open treatment of CFs as well as techniques and materials used for fixation of CF are discussed.
The PubMed database was used to search for relevant articles published between 2000 and 2018. The analysis referred to both original and review papers (including meta-analyses) that concerned adult patients. There are still differences in opinions among researchers regarding the choice of appropriate treatment – closed or open. There is no consensus among open treatment supporters in choosing the right surgical approach. The important question is which material to choose for osteosynthesis of the condylar fracture.
Recent studies show satisfactory results in terms of stability of condylar osteosynthesis with the use of 3D plates. Further discussion is required on the choice of material for fixation of the condylar fracture and, in particular, on the possibility of using resorbable materials.
Keywords: condylar fractures; etiology; mechanism; treatment methods.

ABSTRAKT
Celem niniejszego przeglądu piśmiennictwa było przedstawienie i omówienie obecnych poglądów na temat leczenia złamań wyrostka kłykciowego żuchwy. Autorzy omówili etiologię, epidemiologię, mechanizmy, jak również zasady i metody leczenia złamań wyrostka kłykciowego żuchwy. Ponadto przedstawiono zagadnienie wyboru dostępu chirurgicznego oraz technik i materiałów do otwartej osteosyntezy złamań wyrostka kłykciowego żuchwy. Do wyszukiwania odpowiednich artykułów opublikowanych w okresie 2000–2018 r. wykorzystano bazę PubMed. Analiza obejmowała zarówno prace oryginalne, jak i poglądowe (w tym metaanalizy) dotyczące dorosłych pacjentów.
Wciąż istnieją różnice w opiniach badaczy co do wyboru odpowiedniego leczenia chirurgicznego – zamkniętego czy otwartego. Wśród zwolenników leczenia otwartego nie ma jednomyślności co do wyboru właściwego dostępu chirurgicznego. Istotnym pytaniem jest, jakie materiały wybrać do osteosyntezy złamań wyrostka kłykciowego żuchwy.
Ostatnie badania wykazują zadowalające wyniki stabilności osteosyntezy złamań wyrostka kłykciowego żuchwy za pomocą płytek 3D. W przyszłości konieczna jest dalsza dyskusja nad wyborem rodzaju materiału do osteosyntezy złamań wyrostka kłykciowego żuchwy, a w szczególności na temat możliwości zastosowania materiałów wchłanialnych.
Słowa kluczowe: złamania wyrostka kłykciowego żuchwy; etiologia; mechanizm; metody leczenia.

INTRODUCTION

Studies on the method of treatment of condylar fractures (CFs) are still timely and important. Despite many articles published in this area there are many controversies about how to treat these fractures [1, 2, 3, 4, 5].

The aim of this review was to present and discuss the current views on the treatment of CFs. The following issues are addressed in this review: the etiology, epidemiology and mechanisms of CFs; the strategies and methods for the treatment of CFs. Moreover, the choice of surgical approach for the open treatment of CFs as well as techniques and materials used for fixation of CF are discussed.

SURVEY METHODOLOGY

The PubMed database was used to search for relevant articles published between 2000 and 2018. The following search terms were used: "Mandibular condylar fractures", "Mandibular condylar process", "Mandibular trauma", "Mandibular condyle fracture treatment". The analysis included both original and review papers (including meta-analyses) that concerned adult patients. Case reports and conference proceedings were excluded from the analysis.

ETIOLOGY AND EPIDEMIOLOGY OF CONDYLAR FRACTURES

The most important causes of CFs are traumas received as a result of beatings, falls, traffic accidents and injuries associated with sports [6, 7, 8, 9, 10]. The hierarchy of these causes varies depending on the geographical region. In Germany, England, and Denmark CFs are mostly a consequence of injuries sustained in traffic accidents, while in France, the US, and Poland they are mainly caused by beatings [8, 9, 11, 12, 13, 14]. It is believed that the increase in the frequency of CFs is due to the increasing number of traffic accidents and injuries sustained during the performance of certain sports [12, 15, 16, 17], but it may also be associated with the ever-greater precision of diagnostic radiology, especially in multislice computed tomography [18].

Scientific reports show that the CFs is approx. 4 times more common in men than in women [7, 12, 14]. According to Marker et al., these proportions are smaller; 66% vs 34%, respectively [11]. In turn, Wong [19] indicates 8 times and Al Ahmed et al. 11 times higher incidence of CFs in men [20]. According to some authors CFs occur most often in people between 20–30 years of age [13, 16, 20]. Research by Marker et al. shows that the age group of 20–40 years represents 48–59% of all CFs [11]. Ellis et al., in turn, indicates that CFs in men occur most often between 20–30 years of age, while among women in the 4th decade of life. They also argue that the most common cause of this type of fracture in men are beatings, while CFs in women are mostly a result of falls [21].

Reports vary significantly in their estimation of CF incidence against other mandibular fractures. Oikarinen et al. indicate that fractures of this region constitute approx. 60% of all mandibular fractures [22], while Li et al. estimate this proportion to be approx. 3 times smaller [23]. The prevalent opinion in the literature is that CFs constitute approx. 25–35% of mandibular fractures [8, 13, 22, 24]. There is no doubt that this high incidence is the main cause of intense interest in CFs among researchers.

CLASSIFICATION OF CONDYLAR FRACTURES

Various classification systems have been proposed in the field of CFs. An ideal classification should take anatomical aspects of fracture and also should be clinically useful and support surgeon in making adequate decision about treatment method. During ages many various classifications have been described [25, 26, 27, 28, 29, 30, 31, 32, 33, 34]. Different classification systems of CFs proposed by many authors used different criteria. We cannot definitely state which classification is the most useful. Now some of them probably have only a historical importance: Wassmund, MacLennan, Rowe and Killey, Dingman and Natvig. Nowadays one of the most commonly used classification of CFs is that one described by Spiessl and Schroll [26]. These authors divide the CFs into 6 types:

- 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; subtypes according to direction of deviation/displacement: type IIIa (ventral), type IIIb (medial), type IIIc (lateral), type IIId (dorsal),
- type IV – low condylar fracture with dislocation,
- type V – high condylar fracture with dislocation,
- type VI – intracapsular fracture of condylar head.

Neff et al. modified above classification system by discriminating type V and type VI into other types of condylar head fractures [30]:

- type A – displacement of the medial condylar head pole with preservation of the vertical dimension,
- type B – displacement involving the lateral parts of the condyle with loss of vertical dimension,
- type C – dislocation of the entire condylar head; this type is identical to type V by Spiessl and Schroll classification.

In 2002 Hlawitschka and Eckelt extended this classification by adding Type M – comminuted fracture with loss of vertical dimension and contraction without restraint [31].

Lindahl proposed own classification based on criteria mentioned below [27]:

1. Fracture level:
1a. Condylar head.
1b. Condylar neck.
1c. Subcondylar.
2. Deviation and displacement:
2a. Deviation with medial overlapping.
2b. Deviation with lateral overlapping.
2c. Displacement without overlapping.
2d. Undisplaced fissural fracture without deviation.
3. Relation between condylar head and fossa:
3a. No dislocation.
3b. Slight dislocation.
3c. Moderate dislocation.
3d. Complete dislocation.
4. Condylar head fractures:
4a. Horizontal.
4b. Vertical.
4c. Impacted fracture.

Ellis et al. proposed own simple classification system of CFs including [29]:

- condylar head fracture,
- condylar neck fracture,
- condylar base fracture,

In 2005 Loukota et al. suggested new classification of CFs and divided fractures into the following 3 types [32]:

1. Diacapitular fracture through the head of the condyle; the line of the fracture starts in the auricular part of the head and may extend outside the capsule fracture of the condylar neck; the line of the fracture starts above line "A" (the perpendicular line that extends through the semilunar incision to the tangent of the mandibular ramus) in the lateral view for more than half of its lengths.
2. Fracture of the condylar neck; the line of the fracture starts above line A (the perpendicular line that extends through the semilunar incision to the tangent of the mandibular ramus) in the lateral view for more than half of its lengths.
3. Fracture of the condylar base; the line of the fracture runs behind the mandibular foramen and for more than half of its length below line "A".

Despite the fact that there is a great number of classification systems of CFs none of them become a gold standard. This topic is still discussed and authors did not desist to seek out a decisive consensus [33, 34].

MECHANISMS OF CONDYLAR FRACTURES

CFs occur most often on the basis of the indirect mechanism. According to Lindahl, there are 3 basic types of interactions, which result in CFs [27]:

1. The first type consists in the action of kinetic energy transferred from the moving object to the fixed mandible. This mechanism is characteristic for punches or blows with a blunt instrument in the area of the body of the mandible. Most frequently, it results in the fractures of the mandibular body at the site of force application (direct trauma) and CFs on the opposite side (indirect trauma).
2. Type 2 is associated with the operation of the kinetic energy of a person hitting a resting object. This pathomechanism of CFs is usually a result of tripping and falling, or during physical exercise, when the area of the chin hits a hard surface. Most frequently, fracture occurs at the site of force application, i.e. in the area of the chin, accompanied by bilateral CFs in an indirect mechanism.
3. Type 3 defines the mechanism of injury resulting from the forces acting in opposite directions. An example of this is the head-on collision of vehicles, a consequence of which is a severe impact of the driver's or passenger's chin into the dashboard. The result is both bilateral mandibular fracture and bilateral CF, which may be accompanied by the fracture of the mandibular fossa of the temporomandibular joint, fracture of the external auditory canal, and even fracture of the skull base with the middle cranial fossa penetration by the fractured condyle.

STRATEGIES AND METHODS FOR THE TREATMENT OF CONDYLAR FRACTURES

Methods of CFs treatment are the most controversial among all facial fractures. There are 2 major therapeutic strategies: conservative (closed) and surgical (open) [1, 2, 3, 4, 5]. The conservative treatment involves passive (painkillers, soft diet, functional therapy) or active procedures (flexible tractions, braces, functional therapy) [35, 36, 37]. Surgical treatment includes the open fracture reduction and stable osteosynthesis, followed by functional therapy [38, 39, 40].

There is an ongoing discussion aimed to determine the most effective treatment of CFs and specialists apply and propose different criteria for choosing the best method of treatment. Factors taken into account include the patient's age, location of the fracture gap, the range of displacement of bone fragments, the degree of motion abnormalities of the jaw, the severity of occlusal disorders, individual experience of the surgeon, and the patient's decision. However, an objective comparison of these criteria, and in particular the results of treatments based on these criteria, is very complicated. The difficulty is caused by the adoption of different CF classifications by various authors. However, regardless of the type of fracture and accepted therapeutic strategy, treatment of patients with CFs should have the following goals:

1. Restoration of the correct shape of the mandible and its activities (movements in horizontal, frontal, and sagittal planes).
2. The prevention of acute and chronic pain.
3. Restoration of the pre-injury occlusal conditions.
4. Prevention of ankylosis of the temporomandibular joint.

The supporters of conservative treatment propose 2 different tactics. The first group of researchers believe that the early initiation of functional therapy is most crucial in the conservative treatment of CFs, involving the early implementation of mandible exercises [41]. In contrast, other authors advocate starting with the intermaxillary fixation (IMF) using splints or bicortical screws, with the functional treatment started only after their removal [36]. There is no agreement on the duration of the fixation, and the differences of opinion are quite significant. Some authors argue that the IMF should continue until resolution of pain, and therefore for no more than a few days [42]. According to others, the optimal duration is 2 weeks [1]. There are also some who recommend IMF for 5 or even 6 weeks [36, 43], arguing that such action will facilitate the adjustment of bone fragments under the control of occlusion and create the right conditions for osteosynthesis and contribute to the improvement in the well-being of the patient. Quite a different view on this issue is presented by Palmieri et al. who associate motion abnormalities of the mandible directly with the duration of IMF, not recommending this procedure in the conservative treatment of CFs [44].

The supporters of conservative treatment in CFs believe it is sufficiently effective and at the same time allows to avoid the complications associated with surgery performed under general anaesthesia, such as postoperative scar, poor fracture fixation, fracture of the stabilizing plate, loosening of screws, infection and paralysis of the facial nerve. It is emphasized, however, that non-surgical treatment requires constant and long-term monitoring of the patient, which inevitably requires the time-consuming involvement of a physician and requires good cooperation from the patient [45].

The proponents of surgical treatment of CFs express the belief that the condition for the effective functional treatment is the correct fracture reduction and stable fixation of fracture [36]. Open treatment helps to avoid inconveniences or complications related to IMF, such as the need of liquid diet, weight loss, risk of respiratory problems, insufficient oral hygiene, discomfort associated with the inability of mandibular opening, dysfunction of the temporomandibular joint, especially the ankylosis of temporomandibular joint [46, 47]. Analyzing the effectiveness of treatment of CFs in their own material, Kotrashetti et al. conclude that the open method allowed better results both in the clinical picture as well as in imaging tests [4]. The supporters of the open method also argue that the use of a proper surgical technique eliminates the risk of significant complications associated with surgery, including the damage to the facial nerve [14].

Some authors believe that conservative and surgical treatment of CFs do not differ significantly in terms of effectiveness [5, 48, 49]. In a study by Leiser et al. on patients treated conservatively and surgically for the low fracture of the condylar base, both strategies had similar effectiveness in terms of results and related complications [49]. Similar conclusions were formulated by Sforza et al. after verifying the efficacy of CFs treatment with a 3D mandibular mobility analyzer [48]. The confirmation of these observations can also be found in the work of Liu et al., a meta-analysis of randomized studies on the choice of treatment strategy in unilateral CF with displacement [5]. On the other hand, Bruckmoser and Undt, after reviewing a number of references dealing with CFs, expressed a belief that conservative treatment gives better results in children, while surgical therapy seems more favorable in adults [50]. Those authors also recommend conducting a prospective, multicenter randomized study to determine from which age it is advisable to use the surgical treatment of CFs.

Functional therapy is an undisputed step in treating patients with CFs, both in the context of conservative and surgical treatment [1, 43, 51]. Its key premise is ensuring the biological adaptation of the condylar process [52]. Stimulation of muscles (especially pterygoid muscles) and increasing the periosteal activity during functional therapy are most crucial here, as they lead to the stimulation of bone formation and allow the reconstruction of the newly formed bone. This in turn determines the final shape of the reconstructed condylar process [52, 53]. Functional therapy is the foundation of the passive phase of the closed treatment, although it is also advised even after the removal of IMF in the active phase or as a continuation of surgical treatment [1, 43, 51]. The literature emphasizes that all forms of this therapy are justified, starting from the simplest exercises recommended by the surgeon, such as opening of the jaws in front of a mirror, chewing gum on the non-fractured side, lateral movements, protrusive movements, or closing mouths aiming at maximum occlusion. These exercises can be performed by the patient or in a professional manual therapy carried out by a physiotherapist. These may be either active or passive exercises [44, 45, 54]. Besides the exercises, many authors recommend the use of functional instruments such as flexible tractions, screws, or splints [44, 46, 55, 56]. Many authors recommend the use of functional orthodontic appliances, usually referred to as activators [54, 55, 57, 58]. These devices include Andresen-Häupl activator, Klammt activator, myofunctional activator, bionator, monoblock and the Frankl regulator. These appliances are designed in the constructive occlusion intended for an individual patient. Their effects include the stimulation of muscles, restoration of the normal function of the ligaments of the temporomandibular joint, stimulation of bone remodeling in the fractured condylar process, prevention of the shortening of the mandibular branch by offloading the fracture area, prevention of the restricted mandible mobility, ensuring the correct occlusion, as well as ensuring comfort for the patient. The most frequently recommended duration of functional treatment is 2–3 months. However, some do recommend longer treatment, 4–6 months, 6–12 months, and even over a year [44, 46, 55, 57, 59].

The divergence of views on the selection and efficacy of optimal treatment of CFs has prompted investigators to conduct prospective randomized research. Unfortunately, the results of these studies, though generally indicating that surgery is more effective, are quite ambiguous.

Eckelt et al., based on the results of the first prospective randomized study comparing the 2 main treatment strategies, argue that a more favorable anatomical position of bone fragments is obtained significantly more frequently in patients treated with surgery [1]. That group of patients experiences significantly improved mobility and significantly lower mandible pain, as shown on the analog pain scale. Eckelt et al. conclude that both closed and open treatment give acceptable results, but surgical procedures (regardless of method of fixation) give better subjective and objective functional characteristics. Similar results were obtained by Singh et al., confirming the advantage of surgical treatment [60]. However, they consider open and closed strategies to be equally effective with regard to the occlusion after treatment.

Schneider et al., in turn, indicate that patients with fractures with displacements in the range 10–45 degrees, and patients with CFs accompanied by the ramus shortening by 2 mm or more, should be treated with surgery regardless of the location of fracture. They also argue that open treatment is particularly justified in bilateral CFs [61]. Both Eckelt et al. and Schneider et al. consider the shortening of the ramus of the mandible by about 2 millimeters and more to be one of the main criteria for selecting the open method of treating CF. However, Kommers et al., in their measurements of the mandibular branch in panoramic radiographs of patients with unilateral CF, observed that 34% had a shorter ramus of the mandible on the non-fractured side. Therefore, they recommend extreme caution when qualifying a patient for surgery and discourage the use of this criterion as an absolute indication for surgical intervention [62].

Danda et al., based on the results of a prospective randomized research, and comparative analysis applied for maximum jaw opening, protrusive and lateral movements, and pain in the area of the temporomandibular joint, argue that there are no clinically relevant differences between the groups of patients with CFs treated conservatively (including the step of therapy involving the use of IMF) and surgically [2]. Nevertheless, they emphasize that a better fixation of bone fragments (as seen in radiographs) is achieved in surgically treated patients. Finally, Park et al., after reviewing the literature, express the conviction that the surgical treatment of CFs should be chosen "as often as possible" [63].

As noted by Kommers et al., literature lacks comparisons between the quality of life of patients with CFs after surgery and those treated with conservative methods. The results of such analysis would be useful not only for the general knowledge. They could be useful in choosing the appropriate therapeutic strategy, at least for some patients [62].

THE CHOICE OF SURGICAL APPROACH FOR THE OPEN TREATMENT OF CONDYLAR FRACTURES

In surgical treatment for CFs, the most problematic is the selection of the most favorable surgical approach, because none of the known and currently used methods gives a complete access to all types of fractures. For this reason, the literature provides many descriptions of techniques that allow optimal access to the fracture site and to efficiently perform a surgical intervention [64, 65, 66, 67, 68, 69, 70, 71, 72]. These include the following approaches: preauricular (Blair), temporo-auricular (Rasse), retroauricular (Bockenheimer and Axhausen), transparotid (Ellis et al.), retromandibular (Hinds and Girotti), low submandibular (Perthes), perimandibular (Eckelt), submandibular (Risdon), high perimandibular (modified Risdon–Strasbourg), and endoscopic-assisted intraoral approach (Mokros and Erle). The most important criterion for the selection of the appropriate surgical approach seems to be the location of the fracture gap. Therefore, it is believed that the treatment of fractures of the condylar base (subcondylar) and the condylar neck should apply the retromandibular, transparotid, submandibular in various modifications, perimandibular in various modifications, and the endoscopic-assisted intraoral approach [67, 68, 69, 70, 72]. However, in cases of intraarticular (head) fractures, more appropriate are preauricular, anteauricular, and temporo-auricular approaches [64, 65, 71]. Some authors introduce additional rules for the selection of appropriate surgical approach; e.g. the direction of the displacement of fractures, as mentioned by Mohan et al. who use preauricular approach in patients with fractures with the medial displacement, while the retromandibular approach in patients with lateral displacement [73].

The use of the extraoral approaches to the condylar access is associated with the risk of damage to the facial skin and a scar. According to most authors, these complications can be avoided by using the endoscopic-assisted intraoral approach [74, 75, 76]. However, Choi and Lee report the emergence of the transient paralysis of the facial nerve in a patient treated with this method [77]. Similar results are presented by Arcuri et al. [78] and Domanski et al. [79]. Regardless of dubious effectiveness, the use of the endoscopic-assisted intraoral approach requires expensive instrumentation, not always available in every center offering treatment of CFs [80]. Besides, some authors emphasize that it can only be applied in the cases of low subcondylar fractures with slight displacement [36]. It also seems that it should not be used in the treatment of fractures with medial displacement [81].

TECHNIQUES AND MATERIALS USED FOR THE FIXATION OF CONDYLAR FRACTURE

Among the many controversies associated with the treatment of CFs, special attention should be paid to the choice of the proper method of fracture fixation. For decades views have been changing as to how to immobilize the fragments of the mandible, starting with the surgical suture (Perthes), through the Kirschner wire (Stephenson and Graham) or "anchor screws" (Krenkel) and "lag screws" (Eckelt and Gerber), to miniplate osteosynthesis (Koberg and Momma). Currently, the most popular materials used in condylar base and neck osteosynthesis are screwed miniplates. In cases of head CFs the most popular are titanium compression screws.

Almost all standard plates dedicated to base and neck CFs osteosynthesis are made from 1 mm thick titanium alloys. The holes in these plates have 2.0 mm diameter for adequate screws. There is a great number of various standard 2.0 plates for stabilizing of CFs – for example 4 holes plates, 6 holes plates, straight plates, L-plates, X-plates, Y-plates, plates with different kind of bar (6 to 17 mm), rigid plates, semi-rigid plates. Screws dedicated to plates can be both self-tapping and self-drilling and they are produced in great variety of length (4 to 23 mm). Some manufacturers provide beside standard plates and standard screws also locking plates and locking screws. Locking plates are also made from titanium but they are thicker (1.2 to 1.5 mm) than standard plates. Some authors decided to compare standard (non-locking) plates and screws with locking plates and screws [82, 83, 84, 85]. Glória et al. in their meta-analysis in the field of locking and non-locking plates and screws argue that although a better bite force result with the locking plates, there is still no sufficient evidence to support this information safely [85]. Wusiman et al. claim that mandible fractures treated with 2.0 mm locking miniplates and standard 2.0 mm miniplates present similar short-term complication rates [83].

In cases of condylar head fractures there is inappropriate to use plates for osteosynthesis. In such small and gentle intracapsular space bulky materials induced postoperative scarring of the capsule and ligaments, thus limiting the movement of disc and condylar head [86, 87, 88, 89].

Anatomical restoration of condylar head with preservation of disc and condylar mobility and biomechanical stability are a prerequisite for successful outcome. This goal can be achieved by using 2 or 3 titanium compression screws. These screws are 1.5 mm to 1.8 mm diameter and 9–20 mm length. These kinds of screws ensure high load resistance, high retention and low trauma to head and periarticular soft tissues [89, 90, 91, 92].

Many authors recommend the fixation of condylar base and neck fractures with a single plate with minimum 4 screws (at least 2 screws on each side of the fracture), positioned vertically along the rear edge of the neck of the condylar process [93, 94, 95]. Other researchers believe, however, that the use of a single plate technique is often followed by complications such as the fracture of the plate or loosening of screws, which leads to the secondary displacement of the fracture [43, 96, 97].

According to many authors, the application of the 2 plates for condylar base and neck fractures fixation gives better results by increasing the stability of fixation [96, 98, 99, 100, 101]. The first plate is mounted along the posterior margin of the condylar process (similar to the single plate technique), responsible for maintaining the proper (anatomical) orientation of the condylar process, and thus the correct height of the ramus. The second plate is placed somewhat obliquely below the semilunar incision to effectively counteract the forces of chewing, particularly the tensile strength in the sagittal plane (in the case of the single plate technique, this force can cause the displacement of bone fragments). This plate may be fastened with 2 screws, one on each side of the fracture. Parascandolo et al. argue that the additional advantage of the 2 plates technique is a statistically significant reduction in the gap between the bone fragments, which in turn significantly improves the primary stability of the fracture [102]. Similar results are presented by Kang [103]. On the other hand, the use of at least 2 plates and 6 screws and their correct positioning on a really small area remains a major technical challenge. To avoid operational difficulties, attempts have been made to place plates one above the other. In the absence of the desired results, this approach has not gained popularity and has eventually been forsaken [104].

It is well known that the higher the location of the fracture gap, the more difficult it is to access it intraoperatively, reduce it and properly fixate, which in turn significantly affects the functional stability of fixation after surgery. According to the observations by Pilling et al., the biomechanical stability of fixation seems to be particularly important in the treatment of condylar fractures [105]. However, the execution of functionally stable fixation in such a difficult anatomic area is not easy. In order to avoid such difficulties, manufacturers launched plates with smaller dimensions to facilitate their positioning and make it possible to use only 2 screws in the proximal bone fragment. At the same time, it was important to place a plate along the line of ideal osteosynthesis. This resulted in the emergence of the so-called 3D plates, which include a trapezoid condyle plate (TCP), Delta plate, Rhombic 3D condylar fracture plate, Strut plate, Lambda plate, Trapezoidal plate, and the A-shape condylar plate. Due to the shape and positioning of these plates, functionally stable fixation of CFs can now be achieved only with one plate. Almost all of these plates are produced with 2 different kinds. Compression (standard) 3D plates which are stabilized with compression screws and locking 3D plates which are stabilized with locking screws.

The literature presents results in both experimental and clinical studies using 3D plates [97, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118]. Their advantage over conventional 2D plates is reported, for example, by Sadhwani and Anchlia, who argue that the use of 3D plates results in correct 3-dimensional stability of the fracture and enhances the resistance to undesirable forces [119]. They also report that better stabilization of bone fragments with the 3-dimensional plates reduces the number of infectious complications in the postoperative period. Similar benefits of 3D plates are mentioned by Hakim et al. [109].

Meyer et al. show the results of treatment of CFs using TCP, indicating that none of them was broken the 6-month period of postoperative control [120]. They do admit, however, that 6.6% of the surveyed patients experienced secondary displacement of bone fragments. Yet they do not associate that complication with the plate's faults, but emphasize the poor quality of bones and the presence of additional fracture gaps. They also emphasize the effect of their own mistakes related to the lack of experience in applying TCPs.

In their study on the use of Delta plates in the treatment of CFs, Lauer et al. [106] reported that during the annual follow-up of 19 patients they did not observe any fracture of the plates, which significantly contrasts with the results of Choi et al. [121], Seemann et al. [122] and Schön et al. [123] who broke other types of plates in 3–12% of cases. Although Lauer et al. did observe the loosening of screws stabilizing the Delta plate, it did not affect fracture healing in any case.

Haim et al. conducted experimental studies in which they compared the stability of fixation using the 2 plates technique (Delta plate and Delta locking plate) [107]. It turned out that all 3 techniques of fixation met the requirements of stable and functional osteosynthesis, with Delta locking plate showing the highest primary stability and the lowest susceptibility to the loosening of screws.

Another notable works verifying the value of the materials used for stable osteosynthesis in the treatment of CFs include the research by Aquilina et al., demonstrating the efficacy of the 1.5 mm X-shaped plate 1.5 [124], and the report by de Jesus et al., highlighting the effectiveness of the use of the 7-hole Lambda plate in cases where it was possible to use only one plate [125].

Traditionally, titanium plates and screws have several disadvantages, particularly in the growing patients. Following that some authors try to use for CFs osteosynthesis resorbable sheets and pins [126, 127, 128, 129].

Resorbable fixation for maxillofacial fractures has not gained widespread acceptance because of technical difficulties with the materials and concern about inflammatory reactions during their resorption. However resorbable fixation materials can be useful to fix fractures of the condylar neck. McLeod and Van Gijn presented patients in whom ultrasound-activated resorbable sheets and pins were used to fix condylar fractures in which the fracture pattern did not permit the use of stable metal fixation, or the age of the patient precluded the use of metal fixation. They observed no perioperative complications and no problems related to the stability of the fixation. Only slight disadvantages were minor swelling relating to the resorption of the material in one case did not require any management [129].

Also Kim et al. argue that using biodegradable plates is a stable and reliable method for the management of mandibular subcondylar fractures and eliminates the need for secondary surgery for plate removal [128].

CONCLUSIONS

There are still differences in opinions among researchers regarding the choice of appropriate treatment – closed or open. There is no consensus among open treatment supporters in the context of choosing the right surgical approach. Important question is which material to choose for fixation of condylar fracture. The recent studies show satisfactory results in terms of stability of condylar base and neck osteosynthesis with the use of 3D condylar plates. When seeking an optimal technique of condylar osteosynthesis, one should take into consideration not only the biomechanical aspects, but also the effects of implants on organism, in particular on cellular, humoral and vascular mechanisms responsible for the inflammatory response [130]. In the future, further discussion is required on the choice of the type of material for fixation of condylar fracture and, in particular, on the possibility of using new resorbable materials. With the development of virtual surgical planning techniques as well as the increasing use of individual implants, it is possible to use these methods in the future for surgical treatment of condylar fractures.

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