

# Clavicle Fractures – Is there a Standard Treatment?

## Zlomeniny klíční kosti – Existuje standardní léčba?

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### SUMMARY

Clavicle fractures, especially of the mid third, are an injury commonly seen in clinical practice, therefore, there is constant earnest discussion of the optimal approach to therapy.

Until recently clavicle fractures were solely the domain of non surgical management. Even displaced fractures have been successfully managed without surgery. However, complications have been reported after non surgical treatment, the most frequent being post-traumatic shortening of the clavicle with varying functional consequences for the shoulder joint and range of arm motion as well as pseudarthrosis, especially after more severely displaced fractures.

Recent studies have now shown that outcomes after non surgical management of displaced fractures or shortening of the clavicle are worse than had been previously assumed. Surgical techniques for the stable fixation of clavicle fractures have been improved and a wider selection of implants for osteosynthesis of these fractures has become available. Although there is widespread consensus that undisplaced or minimally displaced clavicle fractures respond well to non surgical management, optimal treatment of displaced fractures or severe shortening is under scrutiny with regard to both the basic choice between non surgical or surgical management and implant selection. According to current research findings, surgical management of displaced clavicle fractures has advantages and appears to be superior to non surgical management. Intramedullary nailing has proven suitable for simple straight fractures, and plate fixation for multifragmentary fractures.

### EPIDEMIOLOGY

Fracture of the clavicle is the most frequently seen fracture in clinical routine. Its incidence ranges from 29 to 64 per 100 000 p.a. (18, 31). Men are affected two to three times more often than women, whereby the highest incidence is in young men between the ages of 13–20 years. The age peak for all clavicle fractures lies between 32 and 34 years (32, 35). Given the rising number of sports injuries and road traffic accidents, which particularly affect younger patients, the number of clavicle fractures and their clinical significance is likely to increase in the future (10). Even now, clavicle fractures are the second most frequent fracture in human after distal radius fracture (41).

Fractures of the clavicle shaft (clavicle fractures in the mid third) account for about 70–80% of all such fractures. About 15% of all clavicle fractures affect the lateral clavicle and only about 2–5% occur in the medial third (7, 34).

### AETIOLOGY

The clavicle is the only bone that connects the shoulder girdle with the trunk. Its function lies in the precise positioning and abduction of the arm. The entire length of the clavicle lies directly below the skin. Frequent injury to the mid third reflects the anatomy, position and specific construction of the clavicle. The human clavicle is S-shaped, medially compact but becoming thinner and

flatter to form an oval cross section towards the mid third. This means that the forces of oscillation and resistance are low, especially in the horizontal plane, which explains frequent injuries due to the impact of axial force (12, 13).

For a long time a fall onto the outstretched arm was propagated as the most frequent cause of injury (1). Based on a better understanding of the biomechanics involved as well as a larger number of case studies, it has been possible to identify a fall directly onto the shoulder or direct force applied to the shoulder as the most frequent cause of clavicle fracture (32, 37). Those most vulnerable are young men who frequently sustain their injuries during sports activities or in road accidents.

In particular, injuries caused by high velocity trauma are often associated with a range of concomitant disorders requiring attention. Haemo- or pneumothorax can be expected in up to 3% of cases (19). Additional injuries to the ribs, acromioclavicular joint, scapula or the cervical spine, injuries to the arteries or subclavian vein and lesion of the brachial plexus are conditions associated with clavicle fracture.

In the absence of adequate trauma it is important to consider the possibility of a pathological fracture. Furthermore, an incidence of 3–7 per 1000 births is reported for perinatal fractures of the clavicle, which must be differentiated from congenital pseudarthroses (41). Current opinion holds that the latter are not the result of birth trauma but due to an intrauterine developmental disorder.

## CLASSIFICATION

Numerous attempts have been made to compile a suitable classification for clavicle fractures. Taking the anatomical site as a quick guide to the necessary diagnostic procedures and an indicator of possible concomitant injuries, Neer and Allman classified clavicle fractures according to their position in the medial, mid or lateral thirds (1, 30) (Fig. 1).

- Allman Group I: Fractures of the mid third
- Allman Group II: Fractures of the lateral third
- Allman Group III: Fractures of the medial third

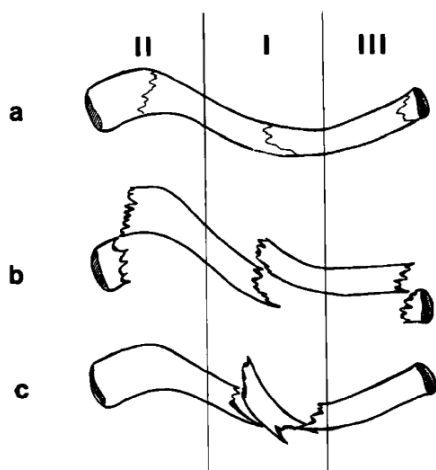


Fig. 1a–c showing schematic drawings of fractures of the clavicle classified according to the Allman and Neer classification depending on fracture localization and kind of fracture into Allman Group I, II and III, respectively Neer Type I, II and III. (a) Undisplaced, (b) displaced and (c) comminuted clavicular fractures. Neer also classified lateral clavicle fractures. Further classifications for medial clavicle injuries exist according to Allman. (From Nordqvist et al. (31)).

- Neer Type I: Fractures of the mid third
- Neer Type II: distal or interligamentous fractures
- Neer Type III: Fractures of the inner third

In the widely accepted classifications of Allman or Neer, fracture patterns are subdivided into (a) non displaced fractures, (b) displaced fractures, and (c) multi-fragmentary fractures.

Assessment of fractures of the lateral and medial thirds must include close inspection for around the joint or intra-articular fractures. In these cases, special attention should be paid to ligamentous and articular involvement in addition to fragment displacement.

The Neer classification is generally used in the English-speaking world to classify all types of clavicle fracture.

Another tool widely accepted in the English-speaking world that also subdivides into three broad regions and has good predictive value in terms of clinical outcome is the Edinburgh classification introduced by Robinson based on an analysis of about 1000 clavicle fractures (35). It takes into account not only the anatomical site of the fracture but also the extent of displacement, comminution, articular extension as well as the number of fragments and their positions.

The most widely accepted classification in the German-speaking world was introduced by Jäger and Breitner and is based on the different relationships of lateral clavicle fractures to the coracoclavicular ligaments (Fig. 2).

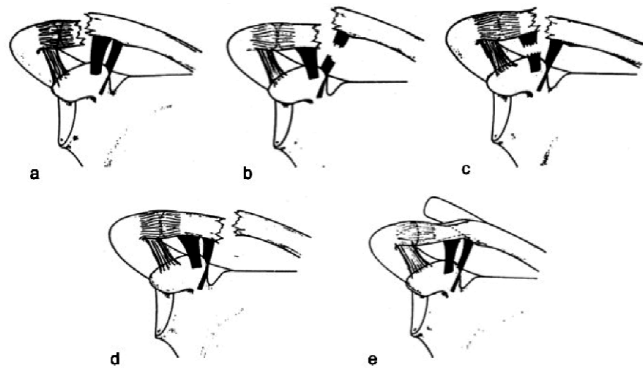


Fig. 2. Classification of lateral clavicular fractures according to Jäger and Breitner. Type I (a), Type IIa (b), Type IIb (c), Type III (d), Type IV (e) (16).

Type I according to Jäger and Breitner refers to a stable lateral fracture without injury to the coracoclavicular ligaments with or without involvement of the acromioclavicular joint.

Type IIa is an unstable fracture of the clavicle with rupture of the pars coronoidea of the coracoclavicular ligament. Since the trapezoid ligament is intact, the medial fragment displaces upwards and backwards, and the lateral fragment tends to descend under the weight of the arm.

Type IIb injuries are stable or moderately unstable fractures with rupture of the stronger, peripheral pars trapezoidea while the pars coronoidea of the coracoclavicular ligaments remains intact. The lateral fragment displaces cranially due to the pull of the trapezoid muscle.

Type III refers to a lateral clavicle fracture located medial to the intact coracoclavicular ligaments.

Type IV refers to injuries in children and adolescents that manifest with a pull out of the acromial extremity of the periosteal sheath and cranial displacement. The ligamentous structures, which fuse with the periosteum caudally, are intact and remain in anatomical position.

Fractures of the mid third can be differentiated according to fracture pattern and number of fragments as they are described in the AO classification of diaphyseal fractures of the long bones (29). Interestingly, current literature offers few publications on the AO classification of clavicle fractures. It was only in 2007 that the “Classification, Database and Outcomes Committee” of the “Orthopedic Trauma Association” published a contribution to the Classification Compendium on the standardization of the AO and OTA classifications of fractures of the clavicular diaphysis (26). The clavicular diaphysis is given the number 15. In accordance with the AO classification, fractures are subdivided into simple, wedge, and complex patterns. However, medial and lateral clavicle fractures have not yet been included in the AO classification system (Fig. 3).

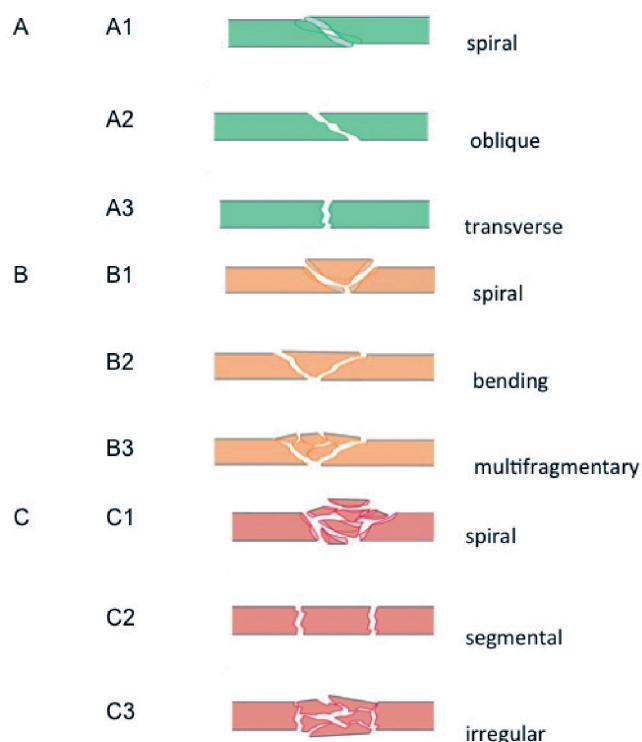


Fig. 3. AO classification of diaphyseal fractures of the long bones. According to the current AO and OTA classification, the clavicle is numbered "15" (29).

## BIOMECHANICS

When the clavicle fractures the whole structure of the shoulder girdle is disrupted. The function of the clavicle as a strut between the shoulders and the trunk is lost. Fractures of the clavicular mid third are frequent and the lateral fragment with the glenohumeral joint is generally displaced caudally and ventrally by the muscular force of the pectoralis major combined with gravity and the weight of the arm, whereas the sternocleidomastoid pulls the medial fragment in a cranial and dorsal direction (40). This leads to shortening of the clavicle often combined with restricted shoulder function, obvious deformities and imminent danger of skin perforation, whereby open fractures and severe soft tissue injuries are rarely seen (7, 24). Conventional radiographs are the gold standard for diagnosis.

## TREATMENT

For a long time, fractures of the clavicular diaphysis have been the domain of non surgical treatment (20). Displaced diaphyseal fractures of the clavicle often healed uneventfully after non-surgical closed reduction and many researchers have reported good functional outcomes. However, surgical fixation techniques have been gradually modified and currently controversial discussion is ongoing as to the optimal management of displaced clavicle shaft fractures. In recent years, more and more publications report a poorer clinical outcome after

non surgical treatment of displaced clavicle fractures than was previously assumed (5, 27, 36).

## NON-SURGICAL TREATMENT

As early as 1954 Nicoll discovered that despite the generally uneventful course of healing after non surgical management more than 200 non-surgical treatment methods have been described in the literature (19). Additional studies showed that the outcomes were almost completely unrelated to the method of bandaging, and that after primary reduction the majority of fractures consolidated in their anatomical position.

The most commonly applied systems were figure-of-eight bandaging and Gilchrist's bandage. If necessary, the figure-of-eight bandage can be tightened after fracture reduction as an attempt to retain the position. The idea is that fragment reduction and disimpaction combined with posterior positioning of the shoulder joint will restore the length of the clavicle and thus the lever arm. This should lead to better functional outcomes for the shoulder and for arm mobility. Another advantage of the figure-of-eight bandage is that the patient can use both hands, and the elbow and glenohumeral joint on the affected side are freely mobile.

Regular assessment at short intervals should focus on peripheral blood circulation, motor and sensory functions and topical findings in order to diagnose neurovascular disorders or skin affections early.

The figure-of-eight bandage should not be applied to lateral clavicle fractures because the lateral fragment cannot be stabilized by the bandage. In these cases, immobilization of the affected arm in a Gilchrist bandage or a simple sling is recommended (3). Injuries to the clavicle due to birth trauma are generally treated by immobilizing the arm on the affected side, most often by simply pinning the sleeve to the clothes (43). A bandage is worn for 3-4 weeks depending on the age of the patient. A period of 2-3 weeks is generally adequate in children.

Physiotherapeutic exercises are recommended after removal of the bandage. Light activities are possible after 6 weeks. Full loading capabilities can be expected after about 3 months. It is only after this period that contact sports can be recommenced (42).

In older studies primary treatment was non surgical in about 90% of all clavicle fractures (19, 42).

## SURGICAL PROCEDURE

There is general consensus that undisplaced or only slightly displaced stable clavicle fractures will respond well to non surgical treatment in most cases. However, there are situations in which surgical intervention is indicated.

The recommendation of treatment for open fractures and fractures with neurovascular injuries is generally surgical. Reconstruction and revascularization of the affected part of the subclavian artery is followed by fracture stabilization at the same surgery. Surgical interven-



tion is also recommended as the primary treatment for pathological fractures.

Surgery is again indicated in cases of simultaneous unstable clavicle fracture and ipsilateral scapular neck fracture (22). The glenohumeral joint loses its second stabilizing attachment and is separated from the shoulder girdle as in “floating shoulder“. Osteosynthesis of the clavicle fracture will usually establish adequate stability and lead to anatomical consolidation of both fractures. Even in these cases minimally dislocated fractures of the clavicle and scapular neck can be managed without surgery (8). In the context of multiple injuries such as ipsilateral injury to the sternum, ribs or contralateral clavicle, surgery may be indicated to stabilize the thorax and improve positioning options.

Surgical intervention is also recommended if skin perforation is imminent or fragments are exerting excessive pressure on soft tissue structures. Experience has shown that these situations are characterized by a severely displaced, possibly split fragment, that often consolidates poorly. If the skin has been perforated, the wound should be excised as required and the fracture treated by reduction and stable fixation.

The level of evidence is unclear with regard to displaced fractures. Until recently studies confirmed that non surgical management led to satisfactory outcomes even for more severely displaced fractures. However, the latest research indicates that patients with all three types of clavicle shaft fracture according to the AO classification and treated non-surgically experienced worse out-

comes than their surgical counterparts in terms of pain intensity, pseudarthrosis rate, clavicle shortening, function, cosmesis, and satisfaction (4, 18, 23, 27). This can be attributed partly to the patient samples of earlier studies, which included children for whom healing rates tend to be high after non surgical treatment, and partly to improved scoring systems for the evaluation of patient satisfaction and the fact that patients have become more demanding in terms of what they expect from a therapeutic outcome. Quantification of strength and measurement of function has become well established. Implants and surgical techniques have been further developed and improved.

## SURGICAL TECHNIQUE

A whole range of osteosynthesis procedures have been described for clavicle fractures.

Currently the most popular are plate fixation and intramedullary nailing. Good outcomes have also been reported for the so-called Knowles Pin (9) although we have no experience of our own with this implant. According to a Cochrane review in 2009, there is no evidence to indicate that any technique is particularly advantageous (25).

Plate fixation is performed according to the concept of “open reduction and internal fixation“ and often employs the locking or non-locking 3.5 mm AO reconstruction plate or the newer ASCP (Anterior Superior Compression Plate, (Fig. 4). The plate is suitable for

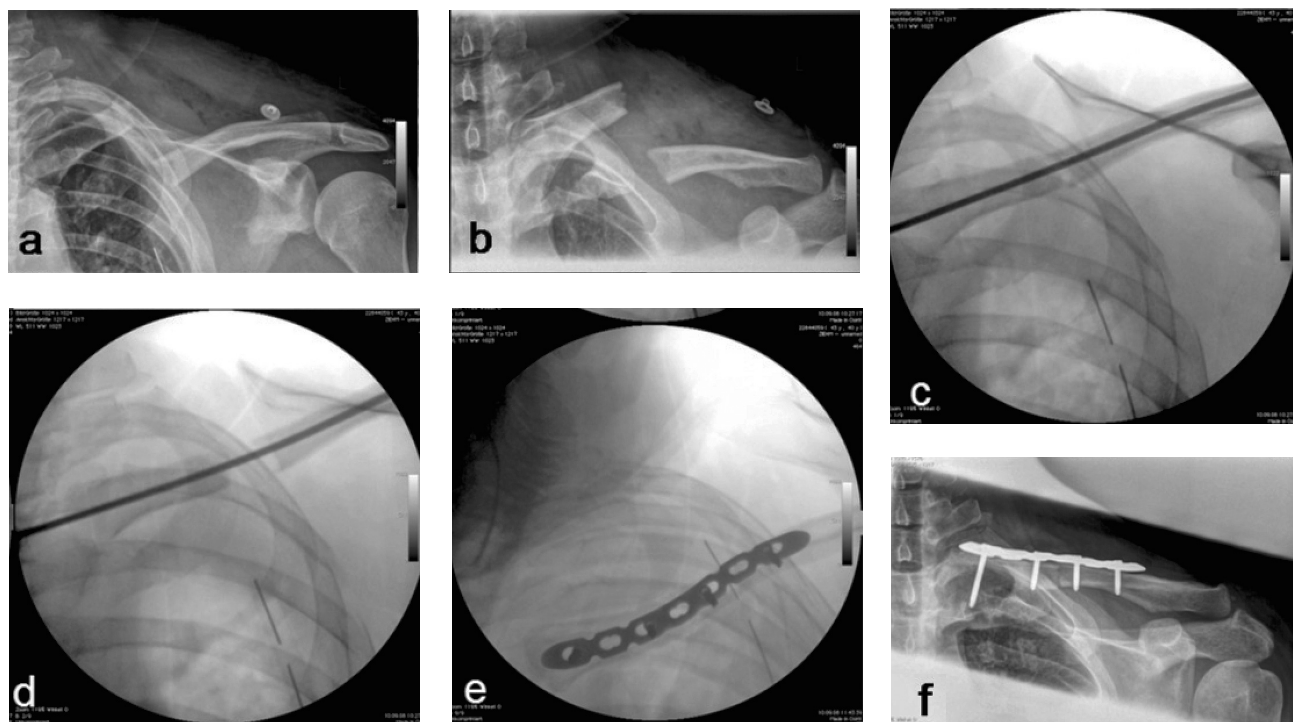


Fig. 4. 40-year old patient who sustained this dislocated clavicle shaft fracture (15 A2 according to AO classification) in a motor-bicycle accident. An X-ray was performed in a.p. and lateral view (a) and (b). Initially, closed reduction and internal fixation with an intramedullary nail was performed (c). During surgery the stability of the osteosynthesis was tested and revealed a significant mobility of the bone fragments (d). Procedural method was switched to open reduction and internal fixation with an ASCP (anterior superior compression plate) (e) and (f).



Fig. 5. 18-year old male patient after a motorcycle accident with a fall on his left shoulder. Mid-shaft fracture of the clavicle (Type 15 B3 according to the AO classification). Open reduction and osteosynthesis with a reconstruction plate and one lag screw was performed (b) and (c).



Fig. 6. Sagittal approach like a sabre-cut. On the medial side there is an additional incision for a locking screw.

all fracture types, especially multifragmentary fractures.

Good outcomes have also been reported for LC-DC-Plates, which are clearly biomechanically more stable than Reconstruction-Plates (Fig. 5) but, in our opinion, are not well suited to the clavicle because they cannot be anatomically contoured and the plate-to-bone interface is extensive. Nevertheless our implant of choice is the reconstruction plate because in our opinion it is stab-

le enough for this fracture types and can be shaped in an anatomical and fitting form.

We generally prefer the “sabre-cut incision” (sagittal approach, Fig. 6) perpendicular to the clavicle rather than a horizontal incision along the clavicle, partly in an attempt to minimize scar irritation along the plate.

Intramedullary nailing with an elastic titanium nail is usually performed through a median approach after open or closed reduction (17, 38). This procedure appears to be especially well suited to simple fractures (Fig. 7).

In implant selection for plate fixation it is important that the plate is long enough to allow insertion of at least three conventional screws or two locking screws (4 cortices, Figure 4) both medial and lateral to the fracture to guarantee proper anchorage (2, 42). In the case of A1, A2, B1 and B2 fractures (AO classification), additional lag screws may be inserted to improve fragment contact (Fig. 8).

In case of fractures in the region of the increasingly flatter lateral clavicle, Radius-T-plates can also be applied and have good vertical anchorage (Fig. 8). Coracoclavicular screw fixation was also described in some earlier studies (14). A new implant, namely, the lateral ASCP is now available for application if the lateral fragment is long enough.

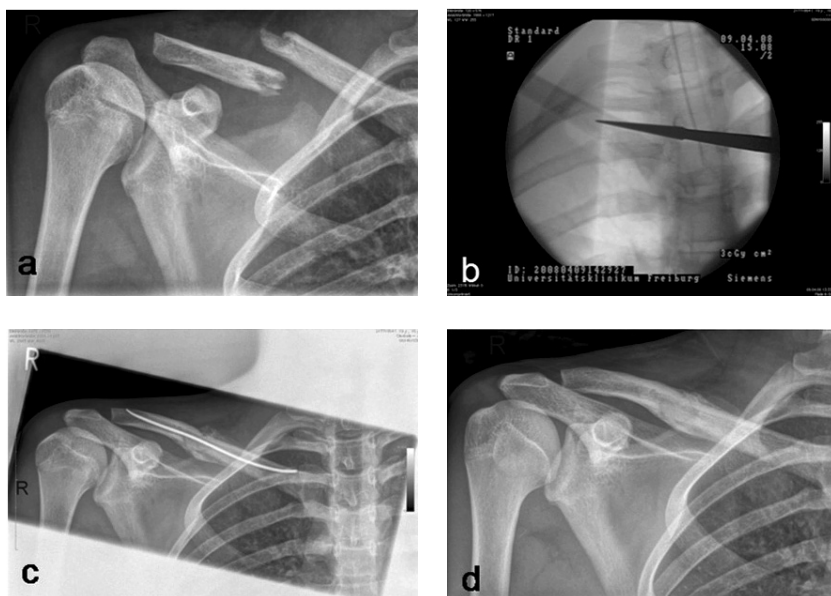


Fig. 7. 16-year old boy with a mountain-bike accident. Clavicle shaft fracture 15 A1 (a). Closed reduction and osteosynthesis with an intramedullary nail was performed (b). 7 weeks after injury and osteosynthesis, callus formation can be seen (c). 3 month after injury and nail removal, the fracture is healed with callus formation (d).

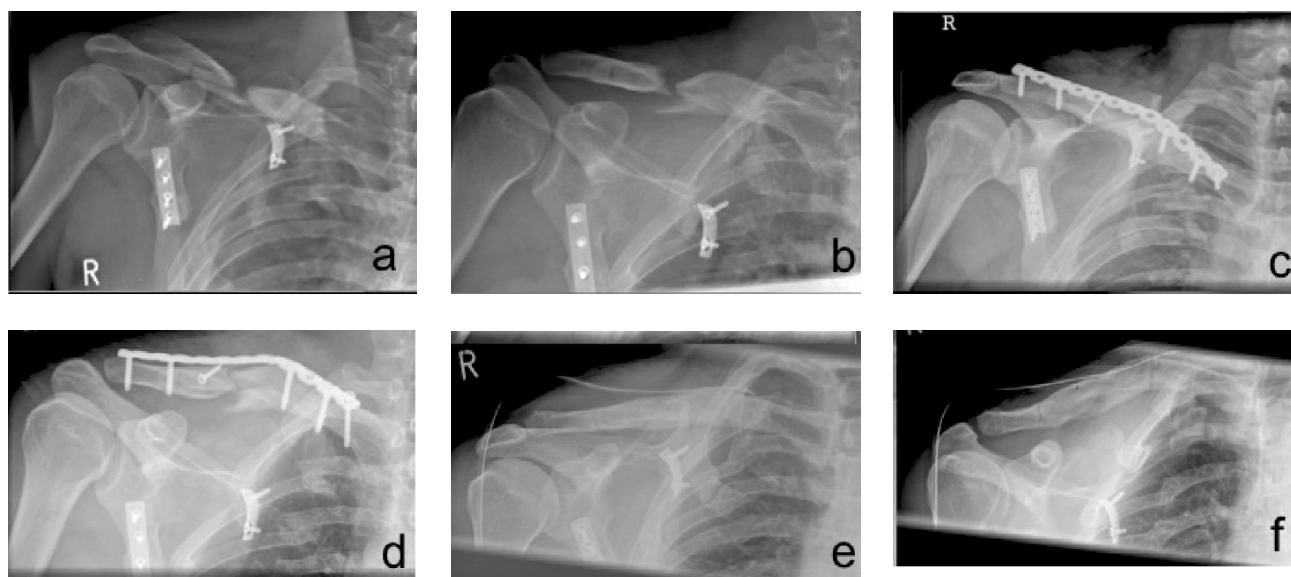


Fig. 8. 31-year old motor cyclist with a second fracture of the right clavicle 1.5 years after a complex shoulder injury on the same side. (a, b) demonstrates the multifragmentary clavicle re-fracture, it was stabilized with a long reconstruction plate and additional lag screw (c, d). One year after surgical stabilization the clavicle healed which is demonstrated after implant removal (e, f).

In the case of acromioclavicular joint involvement or insufficient screw anchorage in the lateral fragment, the hook plate is a suitable implant (28) (Fig. 9).

Depending on the degree of displacement, surgery may be indicated for lateral clavicle fractures. As a rule this applies to Type IIA injuries according to Jäger and Breitner (Fig. 10), which are severely displaced in most cases, and to IIB and Type III injuries depending on the degree of stability. The more seldom Jäger and Breitner Type IV fracture in children also requires surgical intervention. If there is cranial rupture of the periosteal sheath, severe deformity can be expected with a high rate of malunion and increased callus formation under non surgical therapy. The displaced fragment should be redu-

ced under full anesthetic and, if instability of the periosteal sheath persists, it should be sutured (21).

## COMPLICATIONS

The pseudarthrosis rate after non surgical management of clavicle shaft fractures varies in the literature between 1.25% (19), 4.5% (4) and 7% (42), whereby there is no explicit differentiation between radiologically proven pseudarthroses and those that cause clinical symptoms. Lateral clavicle fractures, especially Jäger and Breitner Type IIA fractures, show a non-union rate of up to 40% after non surgical management (21). More recent studies report more pain, poorer shoulder function, increased

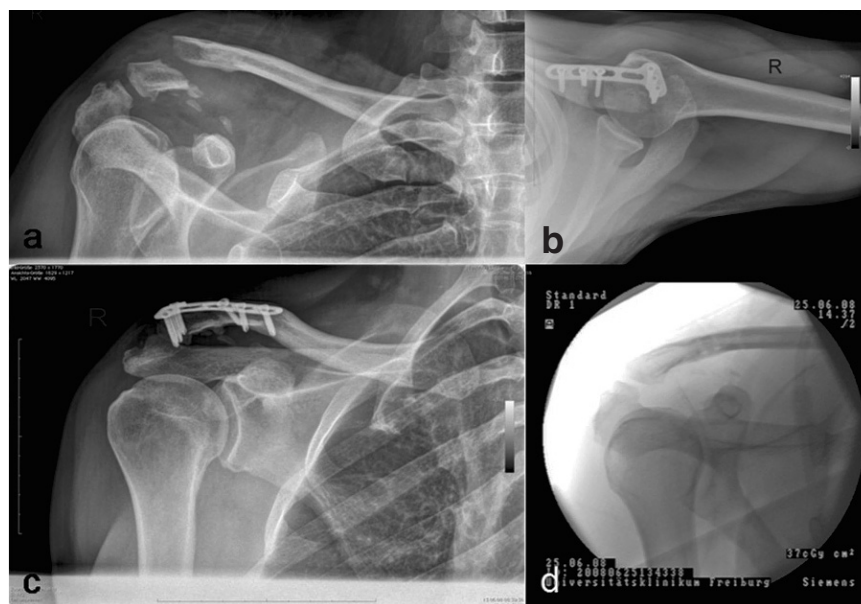


Fig. 9. 45-year old male patient who fell onto his right shoulder. Lateral clavicle fracture was classified as Jäger and Breitner type 2a (a). Open reduction and osteosynthesis with a locking radius-T-plate was performed (b) and (c). One year after injury the fracture was healed and the plate could be removed (d).



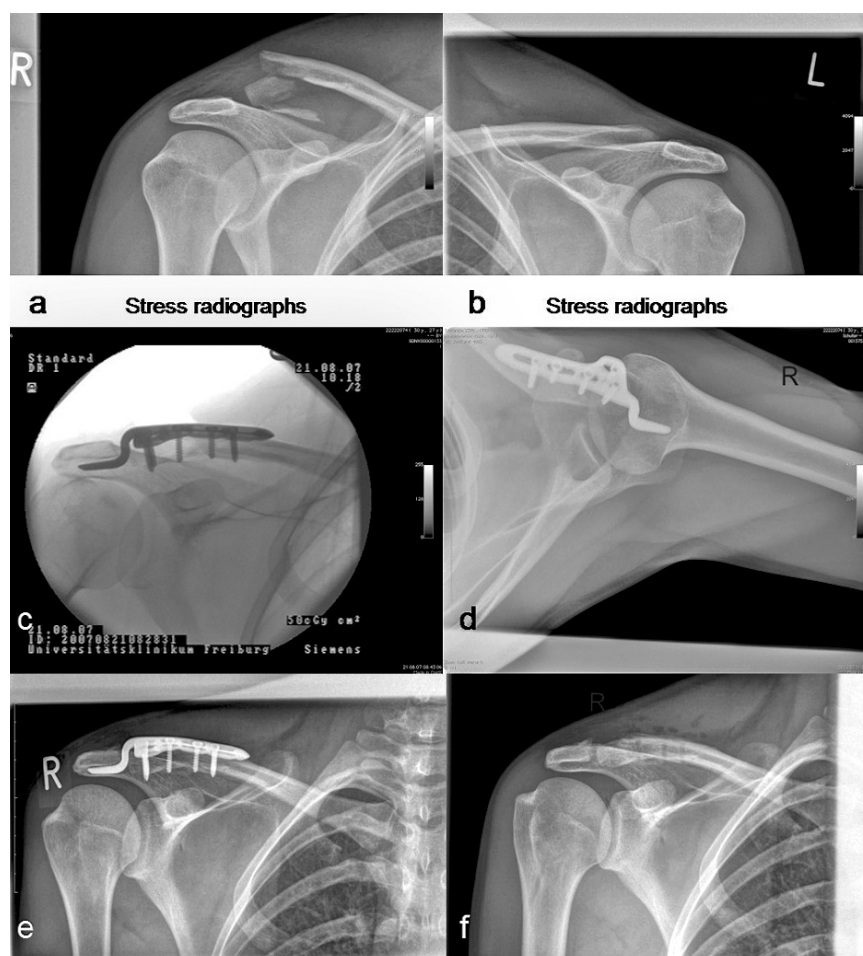


Fig. 10. 27-year old patient who fell onto his shoulder when playing soccer. He suffered a lateral clavicle fracture type 2a according to Jager and Breitner (stress radiographs ipsi- and contralateral (a) and (b). Osteosynthesis was performed using a hook plate (c) and (d). Healed fracture after 13 weeks (e). Hook plate was removed 14 weeks after injury (f).

callus formation with nerve or skin irritations, malunions with deformities, complaints related to the Gilchrist or figure-of-eight bandages, and poorer cosmetic results after non surgical therapy (2, 4, 27). Symptomatic pseudarthroses should be stabilized surgically, possibly revitalized and filled with cancellous bone graft.

Nevertheless, surgery also has its risks and complications. Complications are reported for up to 15% of surgical interventions at the clavicle including implant loosening, implant failure, wound infection, disordered wound healing, nerve irritations, and non union (4). We also saw irritations of the brachial plexus after intramedullary nailing with a hematoma in the region of the plexus and a perforation of the subclavian vein during stabilization with an antramedullary nail.

## DISCUSSION

For a long time there has been no agreement on whether primary surgical treatment of displaced clavicle fractures has any advantages over non surgical therapy. Furthermore, the good outcomes achieved after late surgical intervention in cases of non union bolster the argument for a reserved attitude to the indications for primary surgical intervention (6, 18, 39).

However, larger and more recent studies have recorded much poorer outcomes for clavicle fractures treated non-surgically in terms of a higher incidence of non uni-

ons, pain, clavicular shortening with subsequent ROM and strength deficits at the shoulder, and less resilience to loading than previously assumed. Standardized scoring systems have revealed lower patient satisfaction and poorer outcomes for shoulder mobility and cosmesis (4, 23, 27).

Possible explanations for the poorer clinical results documented in these more recent studies might be modified scoring systems, higher patient demands and outcome expectations and, consequently, a more differentiated self-assessment by the patient. In addition, newer studies have shown that changes at the shoulder girdle such as clavicular shortening and deformation play a much more important biomechanical and functional role than previously believed. Surgery is bound to achieve a better approximation to anatomical restoration of the fractured and displaced clavicle than non surgical management. Overall, current literature states that non surgical treatment of initial clavicular shortening > 15-20 mm and more severely displaced fractures will lead to a poorer outcome than surgical intervention (11, 44).

According to a survey published by Pieske et al. in 2008 about 26% of all clavicle fractures presenting in Germany are treated surgically regardless of fracture type (33). The choice of treatment takes into account bone contact between fragments and number of fragments since these are risk factors for pseudarthrosis.

Other considerations important to the choice of treatment include the patient's general condition, age, physical exertion at work, sports activities and expectations of rapid rehabilitation.

## OSTEOSYNTHESIS

Intramedullary nailing is a relatively non-invasive procedure, but has disadvantages in terms of stability, longer intraoperative screening times and the difficulty of closed reduction. Intramedullary nailing is also associated with higher rates of functionally relevant clavicular shortening, plexus irritation and implant failure. An additional portal is often required to perform open reduction of the fracture (18).

Plate fixation is an invasive procedure with high stability. Open reduction and plate fixation offer the advantages of early stability for exercises, rotational stability and lower rates of shortening with good functional outcomes, especially in multifragmentary fractures and more severe displacement. Currently, the preferred implants are dynamic compression and locking plates since reconstruction plates have shown less stability and plate deformation can occur leading to an increased rate of malunion (18). The advantages of reconstruction plates are their malleability permitting better adaptation to the bone and less prominence of the plate under the skin.

The preformed "anterior superior locking compression plate" was designed to combine the advantages of greater stability with better anatomical form-fit. The anterior-superior position of the plate reduces the risk of vascular injuries due to screw insertion, lessens plate prominence under the skin and, consequently, may possibly reduce the high rate of implant extractions due to skin and scar irritation. Furthermore, Iannotti et al. found that a superior implant position was advantageous, especially in the absence of inferior fragment contact (15). The future will show to what extent the newer ASCP contributes to a lower complication rate for plate fixation, in particular, a lower incidence of implant loosening.

Standardized fracture classification systems are essential to improve and guarantee the reliability and objectivity of future studies. With regard to the scientific subclassification of fractures, the AO classification of diaphyseal fractures and the OTA classification are the most comprehensive tools currently available. However, the classification of Allman and that of Jäger and Breitner remain of great importance in clinical routine. The Edinburgh classification by Robinson as recommended by Bohme et al. is a highly objective and good prognostic tool that is practicable in clinical routine (4).

## CONCLUSION

Standard, objective classification of fractures is important to the optimization of their management. It is desirable to have classification systems that meet both

scientific and clinical requirements. The AO classification of fractures of the clavicular diaphysis is scientifically sound and very detailed, but the classification of Allman and the Edinburgh Classification are easier to handle in clinical routine. The AO classification does not currently include lateral or medial clavicle fractures.

Undisplaced or only minimally displaced, simple clavicle fractures have high healing rates and good functional outcomes following non surgical treatment.

Optimal treatment of displaced clavicle fractures is currently the subject of controversial discussion.

Given the poor clinical outcomes for more severely displaced and multifragmentary clavicle fractures, the range of indications for surgery should be broader than has been propagated in the past. Taking into account general operability factors and surgical risks, the pros and cons of surgical versus non surgical management for displaced fractures should be discussed in detail and the indications for surgery broadened, in particular, when considering young patients and their need for optimal functional outcomes, full weight bearing and sports activities as soon as possible as well as a rapid return to work.

Intramedullary nailing seems to offer a good alternative to plating for simple fractures without interposed fragments. In multifragmentary and more severely displaced fractures that require open reduction, plate osteosynthesis will be the method of choice. Plate osteosynthesis is highly stable and leads to rapid restoration of the pre-injury activity level in most cases.

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