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INTEGRATED STUDY MASTER'S THESIS

Surgical Management of Acromioclavicular Joint Dislocations

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Abbreviations: AC = acromioclavicular ACJ= acromioclavicular joint CC= coracoclavicular

1 Abstract

Objective: Although various surgical techniques exist, there is no established "gold standard" for the surgical approach of acute acromioclavicular joint dislocation. The treatment options are divided into elastic fixation and rigid fixation. The objective of this work was to review the different surgical treatments, their efficacy, complications and to compare different approaches of the treatment of dislocation of the acromioclavicular joint. In the end a case of acromioclavicular joint dislocation will be presented, detailing its treatment and subsequent complications.

Materials and methods: A literature review was performed by searching PubMed, Medline and Embase databases and one case report was presented. Only studies with comparative data were included.

Criteria of inclusion: Studies involving patients with acromioclavicular (AC) joint dislocations, Studies that categorize injuries based on Rockwood classification (Type III-VI), open reduction and internal fixation (ORIF), arthroscopically assisted techniques, hook plate fixation, Tight Rope system, Weaver-Dunn procedure and modifications, Kirschner-wire fixation, Bosworth-Screw, anatomical coracoclavicular ligament reconstruction.

Exclusion criteria: non-human studies

Key words: Surgical Management, Acute Acromioclavicular Joint Dislocation, arthroscopically assisted techniques, Open reduction and internal fixation (ORIF)

Conclusion: It has a promising future with the ongoing development of techniques and modified or augmented techniques of the treatment of acromioclavicular joint dislocation. The narrative review revealed that good results can be overall achieved with rigid fixation with the hook plate. It is less time-consuming, and clinicians can achieve good results in a shorter operation time, low technical effort and no foreign body residue after its removal. The bending process of the hook plate is important to reduce postoperative complications. The tight rope system exhibits highly satisfactory outcomes and has advantages such as simultaneous therapy of glenohumeral co-pathologies. It is a minimally invasive procedure, shows lower rates of complications, has high patient acceptance, early recovery and there is no need to do an implant removal after the procedure. However, further investigations and new studies are required to assess which technique will be a gold standard in the future. It is important to take into account different surgical treatments depending on the age of the patient and physical needs, requirements after surgery and the preference and experience in the certain approaches of the surgeon.

2 Introduction

The acromioclavicular joint (ACJ) is crucial for stabilization of the shoulder and is essential for facilitating various movements of the shoulder and arm. (1) Dislocations of the acromioclavicular joint is a common high-energy injury of the shoulder girdle, comprising about 10% of all shoulder injuries in urban populations, primarily observed in young males. (2) The trauma mechanism is mostly due to direct force to the superior acromion, e.g. in sports, particularly those involving physical contact like ice hockey, football and basketball. It depends on the severity of soft tissue damage and it is classified based to radiological and clinical findings according to Tossy or the most commonly used classification according to Rockwood. (1,3,4) Rockwood's Type I and II injuries are typically managed without surgery. In type III injuries there is still a lack of consens about the best treatment, whether conservatively or surgically. Type IV–VI often require surgical intervention due to their severity. More than 150 surgical procedures are described and over 60 different techniques for reconstructing the coracoclavicular (CC) ligaments following chronic injury. For acromioclavicular joint dislocations, treatment options are classified as either elastic fixation (such as the Tight Rope fixation system, dog bone button, tendon allograft reconstruction, or preloaded suture fixation) or rigid fixation (including Kirschner wires, clavicular hook plates, and screw fixation), or sometimes a combination of both approaches. However, there's no universally agreed-upon consensus regarding the most suitable surgical approach or gold standard and the results also vary, based on the type of approach of surgery and which device is used. (5,6,7,33,35)

Open reduction and fixation with a hook plate is still a common method, while k-wires and lag screws to connect the clavicle and the coracoid are becoming less used. (18) The dog-bone button and their arthroscopic implantation have shown certain advantages and promising results. (36) In the case of chronic acromioclavicular joint dislocation the crucial method is to do a reconstruction of the ligaments. Those techniques include the Weaver-Dunn procedure or synthetic tapes which provide initial stability; they promote the healing through fibroblast colonization. They have a lot of advantages and have shown positive results but there is also a risk for foreign body reactions. Another method to connect the ligaments is to use tendon grafts, autologous or allogenic. The advantage of biological tissue is that they have nearly the same strength to the natural coracoclavicular ligaments and less foreign body reactions. (88)

Surgically treating acromioclavicular joint dislocations comes with high complication rates, ranging from hardware failure and implant irritation to fractures of the clavicle and coracoid, as well as reconstruction failures and infections. (8)

A clinical case of acromioclavicular joint dislocation will be presented. It describes a patient which was treated with open reposition and fixation with Zip tight fixation. This anonymous case report was published with the consent of the patient and his family. Ethical approval was attained by the

department of traumatology, Respublikinė Vilniaus Universitetinė Ligoninė ethical approval board and the supervisor of this thesis Assoc. Prof. Igoris Šatkauskas.

3 Anatomy and Biomechanics

The acromioclavicular (AC) joint consists of the distal clavicle and the medial facet of the acromion of scapula. It is a diarthrodial joint and a synovial joint of the plane type, primarily facilitating gliding movements under normal physiological conditions. Its surface is covered with hyaline cartilage, while inside the joint, fibrous discs allow for horizontal sliding and rotation, though they gradually degenerate with age. It connects the scapula to the thorax, which includes the scapulothoracic, glenohumeral sternoclavicular joints, which enable additional motion of the scapula and aiding in arm movements like shoulder abduction and flexion.

Stabilization of the joint includes dynamic and static elements. The primary static stabilizers of the acromioclavicular joint include the fibrous joint capsule, the superior and inferior acromioclavicular ligaments, and the coracoclavicular ligament complex, comprising the conoid and trapezoid ligaments. (9,10,49)

Wong et al. (2024) explained that horizontal stability is enabled by the acromioclavicular ligament which includes superior, inferior, anterior, and posterior components, with the superior and posterior ligaments being the strongest. They are necessary for horizontal stability. Vertical stability is mainly made possible by the coracoclavicular ligaments, which comprises the conoid and trapezoid ligaments. They attach to the posteromedial and anterolateral regions of the surface of the distal clavicle. Additionally, the coracoacromial ligament which is a strong ligament and connects to the coracoid process. It also contributes to vertical stability. (9,10)

The acromioclavicular ligaments and the capsule provide anterior-posterior stability to the joint. Superior-inferior movement of the clavicle is allowed by the coracoclavicular ligaments, which include the trapezoid and conoid ligament. (11) The attachments of the muscluature and the beneath localized fascia of trapezius and deltoideus comprise the dynamic stabilizers. (12)

4 Classification

Two primary classifications determine the severity of acromioclavicular joint separation. Initially, in 1963, Tossy, Mead, and Sigmond introduced a three-degree classification. Subsequently, in 1984, Rockwood expanded upon this, adding three subdivisions, resulting in the widely adopted six-degree classification system. (4) Tossy et al. (1963) characterized Type I the acromioclavicular ligament is intact and the coracoclavicular ligaments are partially ruptured. After the injury in Type II the acromioclavicular ligaments are ruptured and partially the coracoclavicular ligaments as well. In Type III the ligaments are totally ruptured and it is a complete dislocated joint, which leads to vertical instability. (87) Allman's classification (1967) mirrored Tossy et al. (1963)'s. He characterized in Type II the injured coracoclavicular ligament in a different way (13). Rockwood

(1984) considered that a classification system for the ruptured acromioclavicular joint should consider the severity or strength of injury to the joint's ligaments and attaching muscles which support the joint (14,80). With the radiological examination with x-rays of the shoulder (anteroposterior, axillary, and so-called Zanca views), the Rockwood classification system describes the orientation and dislocation of the damaged shoulder joint in relation to the opposite side (10). However, he argued that Tossy et al. (1963)'s Type III classification was overly general, lacking differentiation for the mechanism of the injured shoulder, radiological findings, the disruption of the surrounding tissue and therapy. (14) Rockwood (1984) stated that type I involves only a sprain of the acromioclavicular ligament, while the ligament is torn in Type II injury. In Type III, both the acromioclavicular and coracoclavicular ligaments are ruptured, but there is no more than 100% displacement of the distal clavicle. Type IV involves tearing of both ligaments with posterior displacement of the distal clavicle. In Type V the deltotrapezial fascia is detached from its attachment and it is a complex injury. In Type VI the clavicle is dislocated into a subcoracoid position. (15,80)

Anatomical structure	**I**	**II**	**III**	**IV**	**V**	**VI**
AC-ligament	Sprain Injury	Complete tear	Complete tear	Complete disruption	Complete disruption	Complete disruption
ACJ	Intact	Disrupted	Dislocated	Dislocated	Dislocated	Dislocated
CC-ligaments	Intact	Sprained	Disrupted; up to 100%	Partial or complete disruption	Complete disruption	Intact
Deltoid and trapezius muscles	Intact	Possible partial detachment	High probability of detachment from distal clavicle	Posterior displacement of distal clavicle into trapezius fascia	High probability of detachment from distal clavicle	Intact, partial, or complete detachment, inferior displacement of the diatal clavicle into the subcoracoid position

Figure 1 - Source: Gorbaty JD, Hsu JE, Gee AO. Classifications in Brief: Rockwood Classification of Acromioclavicular Joint Separations. Clin Orthop Relat Res. 2017 Jan;475(1):283–7; Gorbaty JD, Hsu JE, Gee AO. Classifications in Brief: Rockwood Classification of Acromioclavicular Joint Separations. Clin Orthop Relat Res. 2017 Jan;475(1):283–7.

Types I and II typically respond well to non-operative treatments. Type III injuries may initially undergo non-operative treatment, but surgical management might be necessary. Types IV, V, and VI usually require surgical intervention. (4)

5 Clinical Presentation

The examination should be carried out standing or sitting. The weight of the arm increases the deformity of the arm. The mechanism of injury is usually a blunt trauma to the abducted shoulder and typically complain about pain in the anterosuperior part of the shoulder. It may radiate to the neck or arm of the affected side, which usually is painful with movement or when they lay on the affected side while sleeping. (84, 37) While clinical examination ecchymoses, swelling or a deformity is visible, due to the result of inferior displacement of the shoulder. The deformity is called the “piano key sign”, which is visible while the patient elevates the clavicle and with compression it rebounds like a piano key. (51) The patients mostly describe pain in this location and they also show a restrictive manner in range of motion in active and passive movements due to pain. There are some provocative tests described which can be useful to localize shoulder pain. Those tests are useful in minor injuries (I and II according to Rockwood). It is essential while examination to exclude fractures and the the injury of neurological structures and the vessels with neurovascular examination. (81,15)

6 Imaging

Radiographs are the primary imaging modality for the AC joint. For High-grade injuries magnetic resonance imaging is used to assist in classification and planning the surgical approach (101).

Knowledge of joint anatomy and biomechanics, injury grading, and the strengths and weaknesses of various radiological techniques will aid in choosing the most effective management approach and outcomes for affected patients (102).

After confirming the AC joint injury with X-Ray, surgeons should concentrate on assessing vertical displacement as well as horizontal and rotational instability (12). Zumstein et al. (2018) aimed to distinguish the most precise radiological parameters for evaluating horizontal and vertical instability in various Rockwood grades. They concluded that AC–DC for vertical and GC–PC for horizontal displacement are two new quantitative radiographic measures of vertical and horizontal instability in acromioclavicular joint dislocations that show excellent results in view of dependable validation and are reasonably inert to malpositioning (103). Measuring the coracoclavicular distance on a X-ray of both shoulders helps accurately diagnose vertical shoulder instability. The results are consistent between different observers and when repeated by the same observer. Bilateral views enable a direct evaluation between the coracoclavicular distance and the uninjured opposite

acromioclavicular joint (12).

7 Timing of Surgery

In the management of acute acromioclavicular joint injuries the timing of surgery is clinically significant. An injury is considered acute if treated within 3 weeks of the incident, and it is classified as chronic if treated 6 or more weeks after the incident. While definitive high-level evidence studies are lacking, based on the current available evidence, it is prudent to recommend that surgical treatment for acute acromioclavicular joint injuries be undertaken promptly, ideally within 3 weeks following the trauma, because their healing potential is diminished after three weeks following injury (10,29). Some studies suggest that early surgical intervention yields better outcomes. Rolf et al (2008) compared early and delayed surgery based on constant score, surgical efficacy, patient satisfaction, and complications, concluding that early surgery provides superior results (50). Song et al. (2016) concluded in regard to the management of acromioclavicular joint dislocations, early treatment may outperform the delayed procedure by yielding better functional outcomes and a more satisfactory reduction. Nevertheless, it is necessary to conduct studies of high-quality evidence to support this viewpoint more effectively in the future (76).

The approaches can be divided into acromioclavicular fixation techniques with the hook plate or Kirschner wires; Coracoclavicular fixation techniques with the Bosworth screw or Tight Rope or Tape Cerclage; or ligament reconstruction techniques with the Weaver-Dunn approach, the modified Weaver-Dunn approach, or allograft/autograft reconstruction or a hybrid method using a hook plate and ligament reconstruction or Bosworth screw and modified Weaver-Dunn or Tight Rope and allograft reconstruction (43).

7.1 Timing of Surgery in Case of Chronic Acromioclavicular Joint Dislocations

The chronic phase of acromioclavicular joint dislocation is described after 3 weeks after the injury and it can be initial delayed or after failed conservative or surgical treatment (85). Surgery is recommended for chronic acromioclavicular joint dislocation following three to six months of unsuccessful nonoperative therapy (12). The acromioclavicular and coracoclavicular ligaments tend not to heal after a period of 3 weeks after the injury because there is a lack of intrinsic healing and scar formation is possible in the tissue of the ligaments (12). Therefore, it can be challenging for surgeons to treat it and the results are usually worse. The complication rates are still high due to technical failures of the implant. Another issue is the persistent rotational and horizontal instability in the joint. In chronic situations, the biological capabilities are weakened, whereas the goal of acute treatment for acromioclavicular joint dislocations is to approximate the ends of the acromioclavicular and coracoclavicular ligaments which is important for the healing process.

Therefore, without biological augmentation, mechanical stabilization of the displaced joint could not be enough (1,85).

The classical approach in chronic acromioclavicular joint dislocation is the Weaver Dunn technique. Part of this surgery is to perform a transposition of the coracoacromial ligament. By including a coracoclavicular fixation with subcoracoid suture loops, the original Weaver-Dunn method was modified to improve the fixation's primary mechanical stability. (85) The Weaver-Dunn approach is becoming less useful in treating chronic acromioclavicular joint dislocations due to the development of autogenic and allogenic tendons in orthopedics and the introduction of improved implants. (1)

Rolf et al. (2008) conducted a comparison between two groups of patients: one group consisting of 29 individuals who received immediate treatment for shoulder injuries using the modified Phemister technique with added CC fixation via sutures, and another group of 20 individuals who underwent surgery after conservative treatment had failed, utilizing the modified Weaver–Dunn procedure. The outcomes were considerably better in the cohort of patients treated during the acute phase.

Von Heideken et al. (2013) conducted a comparison between 22 patients who received treatment during the acute phase (within the first 4 weeks post-injury) and 15 patients who were treated during the chronic phase (after at least 4 months of conservative management). The used technique for acromioclavicular joint fixation was the hook plate. The results in patients managed in the acute phase were significantly superior, both clinically and radiologically (89).

8 Surgical Techniques

Numerous surgical techniques, including screws, plates, muscle transfers, ligamentoplasty procedures, and ligament reconstruction using autografts or allografts, have been described. (18) Two different approaches are mentioned: an open approach and an arthroscopically approach. Open surgical methods can be classified into three main categories: direct fixation of the acromioclavicular joint, suspension device fixation in the coracoclavicular space and reconstruction of the coracoclavicular ligaments. (43)

The open approach of acromioclavicular dislocation can be classified into three main types. The first type involves direct acromioclavicular joint fixation, initially using Kirschner wire fixation and later evolving to clavicular hook plate fixation. The second type focuses on coracoclavicular ligament fixation, starting with the Bosworth screw and later including Tight Rope loop fixation with a titanium plate. The third type is ligament reconstruction, beginning with the Weaver-Dunn method and expanding to anatomical ligament reconstruction, autologous tendon grafting, and

artificial ligament reconstruction (49, 50). The arthroscopic technique involves reconstructing the coracoclavicular ligament under arthroscopic guidance, combined with suture-button suspension fixation. (90) Anatomical ligament reconstruction can be performed through open or arthroscopic methods, with the former involving deltoid detachment and extensive soft-tissue dissection, posing risks to neurovascular structures. (18)

In everyday clinical practice, both arthroscopically assisted stabilization of the acromioclavicular joint using "pulley systems" and hook plate fixation are considered standard techniques. (29) Pan et al. (2020) investigated that Tight Rope fixation and Hook Plate fixation are the most commonly used treatments and procedures for acromioclavicular joint dislocation because they effectively reduce the dislocation of the acromioclavicular joint. (18) Natera- Cisneros et al. (2016) assumed that most procedures utilize metal hardware, potentially altering acromioclavicular joint biomechanics and necessitating a second surgery for implant removal post-ligament healing. (90) Non-anatomical procedures like hook plates, acromioclavicular joint transfixion with K wires (Phemister technique), and coracoclavicular fixation with screws (approach with Bosworth screw) reduce mobility and are associated with high fixation failure rates and complications. Chang et. Al (2022) resolved that despite various options, consensus on a preferred surgical approach remains elusive, with early fixation techniques like K-wires being prone to failure due to hardware-related issues and disregard for the coracoclavicular ligament. (16)

8.1 Arthroscopic Approach in Acromioclavicular Joint Dislocation

Wolf et al. (2001) investigated the first arthroscopic approach of acromioclavicular joint dislocation. They used a PDS loop which was passed around the coracoid process. This technique has gained more reputation and was convincing for the surgeons in the last years (86). Ma et al. (2022) concluded that with advancements in shoulder arthroscopy, more surgeons are utilizing this technique to treat acromioclavicular joint injuries (49). Natera et al. (2016) performed a retrospective revision and showed that patients who have acute high-grade ACJ injuries and are treated arthroscopically with non-rigid CC fixation appear to have a better quality of life compared to those treated with a hook plate. (91) Arthroscopic procedures are believed to provide superior outcomes for both acute and chronic acromioclavicular joint injuries, offering benefits such as improved internal visualization, because it allows greater visibility around the coracoid; reduced trauma, smaller incisions and less soft tissue dissection, because the dissection of the deltotrapezial fascia is not required. Overall, it has an enhanced surgical precision and it allows to identify and treat pathologies within the glenohumeral joint and subacromial area. Additionally, the risk of an iatrogenic injury of the suprascapular nerve or the artery can be reduced due to the clearer visibility (49,15). Ruiz et al. (2021) performed a meta-analysis examining acute acromioclavicular joint

dislocations of Rockwood types III–V and concluded that intraarticular injuries were associated with 20% of cases (82).

Many arthroscopic-assisted techniques have been invented. Shin et al. (2015) concluded that the approach with the button-suture implant provided the primary coracoclavicular stability. (83)

During the procedure three trocars are used, one is posteriorly, one is anterolaterally which represents the trocar for the camera and an anterosuperior trocar. The patient is placed in a beach chair position. In arthroscopic-assisted techniques it is possible to reconstruct the coracoclavicular ligament with synthetic suture material and cortical fixation buttons. It turned out in the past that this approach led to a certain degree of instability. A new technique was developed that represents the reconstruction of the acromioclavicular joint. (1)

A study of Chernchujit et al. (2020) compared the radiological and clinical results after arthroscopic assisted and anatomical reconstruction of acromioclavicular joint injury. They performed a retrospective clinical cohort study with twenty-nine patients with grade III-V according to Rockwood. They examined the result according to the specific acromioclavicular score (SACS) and Nottingham score. The radiological investigations were performed to assess the stability of reduction and the complications. The anatomic acromioclavicular joint reconstruction showed better results in function and in view of radiological investigations. The group of the anatomical reconstruction proved better stability. (79) Nie et al. (2021) concluded the results of arthroscopically assisted fixation with the Tight-Rope system for acute acromioclavicular joint dislocation patients were better than those achievable with a clavicular hook plate. The Tight-Rope technique offers advantages over the clavicular hook plate for treating these patients, as it is a relatively straightforward and durable surgical method with fewer complications. (21)

Gowd et al. (2019) stated that there are no differences between arthroscopical or open surgical approaches in view of complicated cases, need for revision surgery or loss of reduction. (78)

8.2 Tight Rope Technique

The study of Balke et al. (2015) showed that despite being a relatively new technique, the arthroscopic approach with Tight Rope is now the second most used. (19) The Tight Rope system was originally developed for ankle syndesmosis injuries but was later expanded to include acromioclavicular joint injuries. (59)

Arthroscopic approach and the treatment of glenohumeral lesions are conducted with the patient in the beach-chair position under general anesthesia. Two portals are used: Antero-superior and antero-inferior portals. They help to expose the base of the coracoid bone from within the joint. A 2 cm skin incision is needed on the superior surface of the lateral clavicle, followed by drilling a guide pin from the clavicle to the base of the coracoid using a specialized guide system. Then the

Tight-Rope system is inserted, and the acromioclavicular joint has to be reduced under radiological control via x-ray. The Tight-Rope must be tightened. Afterwards the wounds are closed in layers (21).

However, concerns about secondary subluxation exist. Scheibel et al. (2011) stated that the most frequently reported complication is migration of hardware into the clavicle, coracoid or both, with migration rates reported as high as 89%. Many patients also experience persistent postoperative symptoms related to irritation of hardware at the superior site of clavicle fixation. (22). Jeong JY et al. (2020) performed biomechanical studies and considered that the non-anatomic vertical placement of these devices does not replicate the natural orientation of the coracoclavicular ligaments, potentially leading to persistent horizontal instability despite restored vertical stability. Theoretically, utilizing two or more vertical stabilizers along the path of the coracoclavicular ligament might improve the restoration anatomical and biomechanical properties. (17)

Scheibel et al. (2011) reported particularly good early clinical results using arthroscopic-assisted techniques with two Tight Rope devices. They examined 28 patients with acute acromioclavicular joint dislocation. (22) Similarly Venjakob et al. (2013) demonstrated reliable acromioclavicular joint stability in 96% of patients using arthroscopic-assisted double Endo-Button devices, with a mean follow-up of 58 months. (23) Despite these favorable outcomes, the use of two metallic coracoclavicular suspension devices carries the risk of clavicle or coracoid process fractures due to the diameter (4.0 mm) of the holes from the drill. (17) Martetschläger et al. (2013) highlighted that 20% of such fractures were attributed to technical errors during the drilling process. (24)

A study of Singh et al. (2016) examined the early failure rate of coracoclavicular ligament reconstruction with the Tight Rope system in nine patients. On average, subluxation occurred within 3.1 months after surgery. Three patients required revision surgery, with intraoperative findings indicating strap failure as the primary cause. Radiographs show widening of the clavicular tunnel, suggesting micromovements. This “wiper blade effect” phenomenon could be caused by anatomical conditions and biomechanical forces on the acromioclavicular joint during shoulder movement. The higher loads in the acromioclavicular and coracoclavicular joints could play a role in the observed failures. The placement of the coracoid button is important. An inferior position is ideal, but the curved shape of the coracoid makes correct positioning difficult, which can lead to medial displacement of the button. Singh et al. (2016) recommend caution when using synthetic grafts for acromioclavicular joint reconstruction due to the risk of failure with progressive acromioclavicular joint subluxation and increasing tunnel widening. (59)

Zhang et al. (2022) evaluated the midterm results for reconstruction using the tight rope system arthroscopically and concluded that it is a safe alternative to many other techniques, but early

subluxation (after 3-6 months) is a complication and they summarized that there is need for technique modification. (4)

8.3 Hook Plate Technique

The open surgical approach with the hook plate is used since 1980. (60) A study by Balke et al. (2015) showed that treatment methods have changed significantly since 2001. While most physicians previously relied on acromioclavicular joint transfixation or coracoclavicular cerclages, these techniques are now rarely used. They concluded that fixation with the Hook Plate appeared to be the "standard approach" for acute acromioclavicular joint dislocations, with 44% of surveyed surgeons considering it their preferred surgical method. Many surgeons choose this surgical approach because it is technically simple and yields satisfactory results. (19)

In the case of acute injuries this technique can be used and can be combined with ligament reconstruction for chronic injuries, yielding good short-term results. (17) The patients are all placed in beach-chair position under general anesthesia. A transversal incision of 6 cm along the acromion to the coracoid process is performed. Hematomas and any intraarticular fragments of cartilage are removed from the joint area. The usage of Kocher forceps is helpful to temporarily hold the distal part of a hook plate in place on the clavicle after positioning the hook portion of the plate under the posteroinferior side of the acromion. Afterwards the acromioclavicular joint is reducted and two or three fixation or locking screws are then used to secure it firmly. X-ray is used to verify the placement, screw and hook length. After inserting the implant, the wound is closed in layers, including the suturing of the deltotrapezial fascia. After 4 to 6 months the plate is planned to be removed after the initial surgery. (16, 28)

Advantages of the hook plates are early functional follow-up treatment possible up to 90° abduction, efficient basic care, low technical effort and no foreign body after implant removal. (40,44)

Originally intended for lateral end clavicle fractures, the Hook Plate has been adapted for acromioclavicular joint dislocations, but it carries several complications. These include acromial fractures, due to stress concentration at the point of plate insertion, plate bending, in some cases, the hook plate may migrate over time requiring revision surgery. Another disadvantage is that acromioclavicular arthritis rates as high as 41%, which may lead to persistent pain and dysfunction and often necessitating a second surgery for hardware removal (17).

An additional issue is that there is an increase in the coracoclavicular distance after its removal. (5,44) An additional limitation is that the treatment of glenohumeral co-pathologies is not possible (the prevalence is up to 20%, especially patients older than 45 years). Complications of this procedure are acromion osteolysis (the prevalence is 20-50%), impingement of the subacromial tissue (prevalence is up to 40%) and acromion fracture (prevalence is approximately 2%). (40,44)

Joo et al. (2021) stated that hook plate bending has an impact to reduce complications and improve postoperative pain and clinical outcomes. The radiological outcomes have been evaluated based on comparative coracoclavicular distance measurements. They investigated that the bended hook plate had certain advantages in comparison to an unbent plate. (61) Another study of Li et al. (2018) supplemented those results a reinforced this statement with an exact indication of how many degrees a plate should be bent. They figured out that the hook plate should be bent approximately 15 degrees. (62)

A study by Lee et al. (2023) concluded that using fixation with the Hook Plate with coracoclavicular augmentation is preferable for treating acute unstable acromioclavicular joint dislocations. While coracoclavicular augmentation didn't improve functional outcomes or pain, it did provide better maintenance of the reduction after implant removal and reduced the risk of acromial osteolysis by 73%. (26)

8.4 Weaver-Dunn Approach

The Weaver Dunn procedure, introduced in 1972, employs the coracoacromial ligament which replaces the torn coracoclavicular ligament, transferring it from the acromion to the lateral end of the clavicle. It is a commonly used technique and it involves a non-anatomical approach. Weaver and Dunn’s surgical technique involved resecting 2 cm of the distal clavicle in an oblique manner and transferring the acromial end of the coracoacromial ligament into the cavitas medullaris of the distal clavicle. The clavicle is positioned anatomically relative to the coracoid, and traction is applied to the coracoacromial ligament to determine the optimal length needed to maintain reduction. Non-absorbable sutures secure the coracoacromial ligament superiorly into the cavitas medullaris to restore the stabilizing function of the torn coracoclavicular ligaments. Postoperatively, the arm is immobilized, and circumduction exercises begin on the first day. Active range of motion exercises are initiated after 4 weeks. (16,30,34) However, the original procedure had limitations, including a 28% failure rate, as reported in the initial study by Weaver and Dunn. (41) However, biomechanical studies reveal that this transfer of the coracoacromial ligament without regard to the anatomy has strength that is only about 25% as strong as the native ligaments. This is due to the fact that the parent coracoclavicular ligament is anchored at the base of the coracoid, while the coracoacromial ligaments are more distally and more laterally attached. (16)

To improve the outcomes, Shoji et al. (1986) proposed a modification that involved extracting the coracoacromial ligament along with an acromial bone block, reinforcing the repair and potentially reducing the risk of postoperative complications. (42)

Additional fixation methods have been incorporated to enhance stabilization of the distal clavicle, particularly during the initial rehabilitation phase. Initially, transfer of the coracoacromial ligament

was primarily supported by fixation of the clavicle to the coracoid using techniques such as lag screws (e.g., Bosworth screw), Kirschner wires, hook plates, or coracoclavicular cerclage. (34) Anatomical coracoclavicular reconstruction provides greater stability in the anterior-posterior direction, closely mimicking the natural joint mechanics and effectively reconstructing the function of both the acromioclavicular and coracoclavicular ligaments. (45)

Galasso et al. (2020) showed that the functional outcomes which can be achieved through the modified Weaver done procedure have been comparable to age- and sex-matched healthy individuals. Joint stability can be effectively restored after surgery, which includes the reduction of the incidence of postoperative instability and recurrence. The study of them also seeks to determine in case of chronic acromioclavicular joint dislocations whether the modified Weaver Dunn procedure represents a reliable and durable surgical option. (33)

8.5 Bosworth Screw Technique

Historically, metal implants like the Bosworth screw have been noted for their effectiveness in surgically stabilizing grade III, IV, and V acromioclavicular joint dislocations. They are also recognized for their ease of implantation because it can be inserted percutaneously, making it a procedure with a short duration. (10, 32)

The fixation of the acromioclavicular joint using a screw between the clavicle and coracoid provides a rigid stabilization that has been attractive in orthopedic practice. Open screw insertion is preferred by most surgeons due to lower rates of technical failure compared to percutaneous techniques, which have been associated with a high failure rate. (74)

The patients are all placed in beach-chair position under general anesthesia. A 3-cm incision medial of the acromioclavicular joint is performed. The fascia of the trapezius and deltoid muscles is opened and visualized and the deltoid muscle is separated from the anterior part of the clavicle. The surgeon identifies the ligament injury in the coracoid region. Kirschner wires were introduced parallel and percutaneously achieving a temporary fixation. Holes for the Bosworth screw with a diameter of 3,5 mm are drilled from the lateral clavicle into the processus coracoideus. Another thread is drilled (6,5mm) in the clavicle and the processus coracoideus. Next step is the length measurement and afterwards the Bosworth screw is inserted. In most cases the Kirschner wires are left in all patients until the ligaments are healed, and the removal of the implants is approximately after 2 months. (77)

However, due to the inherent movement between the coracoid and clavicle during shoulder motion, implants can experience fatigue over time. Ammon et a. (2005) conducted a biomechanical study on this technique and figured out that the fixation strength of the titanium Bosworth screw was comparable to that of an intact acromioclavicular ligament. According to Rockwood et al. (1984)

implant failure or fatigue can be provoked with motion between the coracoid and the clavicle. (3, 11,25,52,53,80)

Balbhulkar et al. (2014) concluded that coracoclavicular screws reduce joint motion and significantly increase joint contact pressures, which may contribute to early joint degeneration. Failures associated with this technique can manifest as osteolysis at the lateral end of the clavicle, failure of hardware, or fractures of the coracoid process or clavicle. There have been reports indicating a relatively high incidence of mechanical device failures in clinical settings. In summary, while screw fixation offers initial stability for the acromioclavicular joint, clinicians must consider the potential for long-term complications and failures associated with implant fatigue and joint degeneration (11).

Due to the frequent occurrence of migration of hardware and implant failure which compromises breakage of the screw, resurgery and implant removal is usually necessary between 8 and 12 weeks. (17)

Cetinkaya et al. (2017) performed a study and compared Bosworth and modified Phemister techniques and retrospectively evaluated their follow-ups after the surgical treatment. Their findings indicate that both techniques are dependable and achieve sufficient reduction, with comparable outcomes in terms of function of the joint and subjective pain perception following Type III acromioclavicular joint dislocations. The coracoclavicular fixation method using the Bosworth screw appears to offer advantages such as lower rates of early wound site infections and late postoperative acromioclavicular joint arthrosis compared to the acromioclavicular fixation method employing Kirschner wires. Therefore, the coracoclavicular fixation with the Bosworth screw may be preferred as a surgical approach. (31)

Karaduman et al. (2020) performed a retrospective study and compared the clinical and radiological outcomes with the approach with modified Bosworth technique and the Endobutton. However, outcomes were superior with the Endobutton technique, which is straightforward and avoids the need for secondary surgery. Patients treated with the Endobutton reported better functionality and lower pain levels. Moreover, the Endobutton technique has superior results in comparison to the Bosworth screw-fixation method due to its lower incidence of late postoperative wound infections. (1)

8.6 Kirschner Wires

Only Kirschner Wire fixation for acromioclavicular joint injuries is now rarely used and is used to ensure temporary stabilization and reduction during a procedure or with the help of other devices. (92)

A case report of Norrell et al. (1965) showed that migration of a threaded Steinmann pin, used for acromioclavicular joint fixation, can lead to complications, including injuries which can be life-

threatening. The case report highlights the rare but serious risk of pin migration into the spinal canal, emphasizing the need for careful surgical technique, secure fixation, and close postoperative monitoring to prevent such complications. (54)

Another case report of Mazet et al. (1943) reported about two cases that described migration of a Kirschner Wire from the shoulder region into the lung. The report presents two cases in which this occurred, emphasizing the potential risks of foreign body migration and highlighting the need for careful placement, monitoring, and follow-up after surgical procedures involving Kirschner wires to avoid such life-threatening complications. (55)

When applied, the wire is passed between the acromion and the distal clavicle for stabilization. To prevent migration, the lateral end of the wire is left partially outside the skin. Postoperatively, patients wear a shoulder bandage for three weeks. Vertical wall climbing exercises can begin on the first postoperative day, followed by active and passive movements after three weeks. By six to eight weeks, shoulder abduction typically reaches 90 degrees, and the wire is removed at that time. (46,47,48,31)

Algarín-Reyes et al. (2010) performed a prospective, longitudinal, observational study with the aim to determine the efficacy of minimal invasive surgery in acromioclavicular joint dislocations. They used the UCLA and DASH score for evaluation. The patients received a percutaneous reduction, a placement of a 4,5mm cortical screw and 11mm metallic washer and 1,6 mm Kirschner wires. They decided that minimal invasive surgery is a good treatment for the management of acute acromioclavicular joint dislocation type III. (93)

Wang et al. (2013) performed a study to evaluate the results of the treatment with the transfer of coracoid process and temporary Kirschner wire fixation. They used the visual analog score (VAS), the Constant-Murley scoring system and additionally the UCLA shoulder rating system. They concluded that this is a reliable treatment for acromioclavicular joint dislocation (46).

8.7 Reconstruction with Allo- and Autografts

Tendon grafts are used in acute and chronic acromioclavicular joint dislocation, but the outcomes in chronic acromioclavicular joint injuries are superior and show more benefits. (97) Reconstruction mostly utilizes semitendinosus, gracilis, or long toe extensor tendon grafts. (88)

Lee et al. (2019) investigated whether utilizing tendon graft during repair is superior and shows lower complication rates in the treatment of acromioclavicular joint dislocations. (95) Fauci et al. (2013) compared the outcomes after treatment with biological allograft or synthetic ligament. They performed x-rays to assess the joint stability. They accomplished that biological graft showed better clinical and radiological outcomes in patients with chronic acromioclavicular joint dislocation. The

main disadvantage of both procedures was the main weakness and that both needed improvement. (96)

Lee et al. (2003) compared also the biomechanical characteristics of tendon graft reconstructions with those of the native coracoclavicular ligaments and several other repair techniques. They concluded that the reconstruction with tendon grafts showed superior initial biomechanical properties compared to coracoacromial ligament transfer, with failure strengths comparable to those of the native coracoclavicular ligaments. The tendon graft failures happened in the midsubstance of the grafts, rather than at their fixation points. In terms of clinical relevance, tendon graft reconstruction might reduce the necessity for postoperative immobilization and facilitate a faster rehabilitation program. (88)

Saccomanno et al. (2021) examined clinical and radiographic outcomes of anatomical reconstruction of the coracoclavicular and acromioclavicular ligaments using a single-strand semitendinosus tendon graft for chronic acromioclavicular joint dislocation treatment. They accomplished that the treatment of chronic acromioclavicular joint dislocation through anatomic reconstruction of the coracoclavicular and acromioclavicular ligaments with a semitendinosus tendon graft showed favorable clinical and radiographic outcomes (98).

Costic et al. (2004) assessed the cyclic behavior and structural characteristics of reconstructing tendons of the coracoclavicular ligament complex after a simulation of the acromioclavicular joint dislocation. They presume that the small degree of permanent elongation after cyclic loading indicates that the anatomic reconstruction complex may endure early rehabilitation. However, the reduction in structural properties and stiffness of the clavicle must be considered when optimizing the anatomic reconstruction technique. The incorporation of the usage of biological tissue could improve the overall structural characteristics while the healing process (99).
Mazzoca et al. (2006) compared an anatomical coracoclavicular ligament reconstruction against a modified Weaver-Dunn procedure and outlined an arthroscopic technique that employs ultra strong nonabsorbable suture material. They concluded that the anatomical coracoclavicular reconstruction demonstrates reduced anterior and posterior translation. That resembles the intact state and restores the function of the acromioclavicular and coracoclavicular ligaments. Regarding the clinical relevance the free tendon graft of both the trapezoid and conoid ligaments may provide more strength and stability and leads to a permanent solution for acromioclavicular joint dislocation. It could reduce the recurrence of subluxation and pain and permits earlier rehabilitation (100). Mori et al. (2024) hypothesized that acromioclavicular joint stability and improved function at the final hospital visit are provided by arthroscopically assisted double-bundle semitendinosus tendon autografts with coracoclavicular and acromioclavicular ligament reconstruction for

acromioclavicular joint reconstruction. They investigated that after an average follow-up period of 31.7 months, patients with chronic acromioclavicular joint injuries who had double-bundle coracoclavicular and acromioclavicular ligament reconstruction using cortical buttons showed a notable enhancement in shoulder function, with no clinically related complications or revision surgeries occurring. On the other hand, the rates of total acromioclavicular joint instability in both planes (vertical and horizontal) were not satisfactory, yet they aligned with those reported in earlier research. The findings of this study imply that the index procedure can be regarded as a comparably effective alternative to other coracoclavicular reconstruction methods in chronic cases (104).

9 Comparison of Different Surgical Approaches

Options for surgery for acromioclavicular joint dislocation vary markedly. A comparison with various aspects and the results from various studies are now presented in the following subchapters to provide an overview of the advantages and disadvantages of the individual procedures.

9.1 Hook Plate vs. Tight Rope Fixation

Six different studies were analyzed and the results regarding the choice of surgical procedure were summarized.

Jensen et al. (2014) compared the results in acute high-grade acromioclavicular joint instabilities of double tight rope technique and open hook plate. Their aim was to assess differences in pain levels, functional recovery, complication rates, and recurrence of instability between the two methods. Both surgical techniques led to comparable clinical outcomes, with no significant differences between the two groups. Despite this, partial recurrent vertical instability was observed in both groups.

They concluded that the arthroscopic approach including the tight rope technique has certain advantages. The main advantages are that it is not obligatory to remove the implant, unlike the hook plate, which often requires a second surgery for removal. Also, there is a better assessment and management of concomitant glenohumeral injuries which may go unnoticed with the hook plate technique. Overall, both surgical methods are effective, and the choice of technique should be based on patient-specific needs, surgeon expertise, and consideration of potential complications. (20)

Another study which was performed by Nie et al. (2021) comprise also the clinical outcomes of arthroscopically assisted Tight Rope fixation with clavicular hook-plate fixation for the treatment of acute high-grade acromioclavicular joint dislocations. They assessed differences in pain levels, functional recovery, complication rates, and surgical factors such as incision size, hospitalization time, and blood loss. In their study the tight-rope fixation demonstrated better clinical outcomes compared to the clavicular hook-plate group. The outcomes showed higher constant scores and lower VAS pain scores at the end of the follow-up.

The advantages of fixation with tight-rope are shorter hospitalization time, smaller skin incision and reduced estimated blood loss.
Fixation failure was common in the hook plate group (11,9%) and less common in the tight-rope group (7,1%). Due to these benefits they concluded that Tight Rope fixation is the preferred surgical option for managing acromioclavicular joint dislocations. (2)
Both studies examine similar focuses and consider aspects that are not discussed or discussed to a lesser extent in the other study.
The study by Nie et. al. concluded that the tight rope procedure is a minimally invasive technique with smaller skin incisions, shorter hospital stays and less blood loss. (21) This aspect is not mentioned in the study by Jensen et al. (2014). The study by Jensen et al. (2014) focuses more on functional results and stability. (20) In the study by Nie et al. (2021) the matching procedure enables higher sampling accuracy to ensure better comparability. In the study by Jensen et al. (2014) consecutive hoarding is examined. In the study of Jensen et al. (2014) sonographic measurements are used for assessment and it is checked whether the stability remains comparable after the operation. (20) The study by Nie et al. (2021) does not take such objective imaging criteria into account. The study by Nie et al. (2021) only uses the constant score and the VAS pain score. (21) The study by Jensen et al. (2014) also uses this, but the simple shoulder test as well as the Taft score and the sonographic coracoclavicular distance are also examined. (20) This makes a more comprehensive functional assessment possible. The study by Nie et al. (2021) does not examine re-stability and partial instability. This is only examined in the study by Jensen et al. (2014) (20).
In another study by Gültaç et al. a retrospective analysis of 35 consecutive patients was performed. In this study, they differentiated between Rockwood Type 3 and 5 injuries, which were not analyzed separately in the other two studies. The study includes examining the relationship between reduction quality and functional outcomes, which was not explicitly examined in the other studies. Postoperative osteoarthritis was also discussed, which was not mentioned in the other two studies. The third study takes into account the duration of the operation, with the tight rope technique taking significantly longer than the hook plate technique - this is not examined in the other two studies. (38)
Another study of Cai et al. (2018) aimed to compare the clinical outcomes for acromioclavicular joint dislocations type III according to Rockwood in adults. 69 Patients were randomly categorized into two groups. One group with the tight-rope system and the other with the clavicular hook plate. They were followed up for 12 months and the interest was in clinical outcomes, radiological results and the recorded complications. Results showed that both treatment options resulted in similar clinical and radiological outcomes. The Tight-Rope system had advantages such as shorter incisions, less blood loss, better pain management post-surgery and no need for a second operation. (39)

Another study by Ko et al. (2023) compared the long-term clinical outcomes of Tight-Rope versus fixation with Hook Plate for acute acromioclavicular joint dislocation. They agreed that there were no significant differences in regard to the outcome of function, the final coracoclavicular distance or complications between hook plate and tight-rope fixation. Tight-rope fixation resulted in slightly better forward flexion. Complications occured in some patients which where treated with the Hook Plate. The main complication was subacromial erosion (40%). This did not impact long-term VAS pain scores. Both surgical techniques are effective and relatable treatment options for acromioclavicular joint dislocation. (27)

In a retrospective study, Dündar et al. (2022) concluded that both nonrigid Tight-Rope fixation and AO clavicular hook plate can effectively repair unstable distal clavicle dislocations, resulting in good functional outcomes. The minimally invasive Tight-Rope system had additional benefits, such as fewer reoperations for removal of the implant and a lower risk of subacromial distal clavicle osteolysis. (28)

Pan et al. (2020) agreed that the Tight-Rope technique shows superior functional recovery and reduced pain compared to the clavicular Hook Plate method. This includes improved shoulder function and reduced discomfort during daily activities. Moreover, it does not increase the risks of loss of reduction, coracoclavicular distance or duration of the surgery. Except for implant migration, it is not linked to other complications and does not necessitate internal fixation removal. Therefore, their findings suggest that the tight rope technique may be preferred for treating acromioclavicular joint dislocations, because it offers advantages in terms of functional recovery, pain management and complication rates compared to alternative surgical approaches for acromioclavicular joint dislocations. (18, 22, 23)

In summary it can be said that all the mentioned studies complement each other and together provide a comprehensive picture of the advantages and disadvantages of both procedures and emphasize that the minimal-invasive procedure with the tight-rope system has certain advantages against the open procedure with a hook plate.

9.2 Hook plate vs. Dog Bone Method

Hess et al. (2023) performed a study where they compared the clinical outcomes, complication rates, and treatment costs associated with two procedures. They compared the dog-bone method and the hook plate method. Both techniques have shown excellent outcomes for both groups, that suggests that both methods are effective treatment options. Both techniques have shown advantages and disadvantages. The hook plate method was associated with lower pain scores, but higher rate of scarring and sensory disturbances. Conversely the arthroscopic dog-bone technique led to a higher incidence of frozen shoulder. (36)

Madi et al. (2022) compared the outcomes of hook plate technique with the dog bone button with dual fiber tape. They evaluated the results radiologically by assessment of the reduction, measurement of the coracoclavicular distance and extent of subacromial erosion. They concluded that both techniques showed satisfactory functional and radiological outcomes, but the dog bone group showed more cases of reduction loss. (94)

9.3 Hook Plate vs. Bosworth Screw

Four different studies were analyzed to determine whether treatment with a hook plate or treatment with a Bosworth screw is more suitable for treating acromioclavicular joint dislocations.

Gumustas et al. (2018) performed a study where they compared those two techniques for type III acromioclavicular joint dislocation. For evaluation they used the UCLA and DASH score to comprise certain advantages and disadvantages of the two approaches. The time to return to work was also investigated. Early reconstruction was associated with better reduction, less complications and higher satisfaction of the patient. The hook plate showed better clinical outcomes in view of UCLA and DASH score, but there was no difference for the patients in the time when they returned to work.

The advantage of the hook plate which has turned out in the study was that it provided superior functional results. The disadvantage was that the hook plate showed in some cases subacromial impingement and implant-related complications. The approach with the Bosworth screw showed in their results less cases with an arthritis rate, but it also required a second surgery for removal of the screw and had risk of reduction loss. Both groups had biomechanical complications. The most important was re-dislocation after implant removal. They investigated in their study that early motion exercises after surgery were emphasized for better recovery and they concluded that early surgical intervention leads to better outcomes and the timing of implant removal must balance preventing breakage and to avoid deformities. The limitations of this study were that they are lacking long-term results, it was a retrospective study, and they had no control group of conversative treatment. (63)

Another study of González-Velázquez et al. (2014) investigated the quality of life in patients with type III acromioclavicular joint dislocation. They compared three different approaches: Hook Plate, Weaver-Dunn and the Bosworth technique. 47 patients were included, mostly received the hook plate (26 patients). All the patients had no difference in sex, age distribution or time after surgery. All of them had similar results in quality-of-life outcomes in all techniques. Mild disability symptoms had been reported from nearly all patients. (64)

Kezunović et al. (2013) examined over a period of five years two approaches. The first approach was the traditional AO method or Bosworth method (with Kirschner wire, tension bands or coracoclavicular screw. The other group included the fixation with the Hook Plate technique. The average age was similar and the majority in this study were male which got injured during athletic activities. More complications, infections and implant loosening occurred in the traditional AO method approach. The satisfaction of the patient was significantly higher (p=0,007) in the hook plate group. Also, the function and mobility were slightly improved in this group but not statistically significant. The time for removal and post-operative immobilization time were nearly the same in both groups. They concluded that the hook plate group showed better stability, earlier mobility and fewer complications. (65)

A study of Qiao et al. (2021) investigated the relationship between the clavicular hook plate design and the incidence of the impingement syndrome after acromioclavicular joint dislocation and the surgical approach with the hook plate technique. Some patients may experience limitations in shoulder abduction, pain and discomfort. They investigated that it develops because of choosing the wrong hook plate. They measured the hook end depth and the acromial height and concluded that the difference was significantly larger in the group which experienced subacromial impingement syndrome. The preoperative imaging of acromial height could help to choose a proper hook plate size. (66)

All three studies compared the same surgical techniques for treatment of acromioclavicular joint dislocations. The patient demographics and injury were similar across the studies. The hook plate showed better functional results, and the Bosworth screw had lower rates for arthritis but a higher risk of reduction loss. More complications occurred with the approach with the Bosworth screw. In some cases, the fixation with the Hook Plate led to subacromial impingement. The study of Qiao et al. (2021) showed that the subacromial impingement syndrome could be avoided by choosing the right suitable hook plate size. (63,64,65,66)

9.4 Hook Plate vs Kirschner Wires

Two different studies were analyzed to determine whether hook plate treatment or Kirschner wire treatment is more appropriate for treating acromioclavicular joint dislocations.

Dou et al. (2014) evaluated in their study the security and effectiveness of the hook plate approach and the control group received the approach with Kirschner wires. Both groups showed significant improvement in JOA scores postoperatively in 6^{th} and even more in 12^{th} week. The hook plate showed significantly higher results in the 12^{th} week than the Kirschner wire control group ($P < 0.05$). 100% of the patients which have been treated with the hook plate approach showed excellent

or good outcomes. Only 60% in the control group had the same outcome. The recurrence rate of complications like fractures or re-dislocation was significantly lower in the hook plate group ($P < 0.05$). They proved that the hook plate approach provides better stability, earlier mobilization and less complications. They concluded that it is a safe and effective approach to use the hook plate in clinical practice. (67)

Rhee et al. (2014) compared also the clinical and radiological outcomes between Kirschner wire transfixation and using the hook plate fixation technique. Seventy-seven patients were included in the study, 56 received Kirschner wires and 21 received the hook plate approach. In the last follow-up after 61 months the UCLA score was higher in the hook plate group. Also, in radiological investigations where the coracoclavicular and acromioclavicular distance was examined both techniques. The hook plate group showed better outcomes than the Kirschner wire group. All in all, they agreed on the fact that the technique with Kirschner wires leads to a higher complication rate. (68)

Both studies conclude that the approach via hook plate has more advantages in functional outcomes, radiological examinations and shows lower complication rates compared to the approach via Kirschner wires. The hook plate does not provide only better clinical results, it showed better stability, earlier mobilization and less complications, making it a more effective and safer approach treating acromioclavicular joint dislocations.

9.5 Hook Plate vs. Weaver Dunn

Ye et al. (2014) aimed to show the therapeutic effects between hook plate fixation and the approach with modified Weaver-Dunn for treatment of acromioclavicular joint dislocations. Forty patients with type III acromioclavicular joint dislocation according to Rockwood classification were examined. Two groups have been built: one hook plate fixation group and one modified Weaver-Dunn group. The follow up was over an average 24 months. The functional usage of the shoulder was assessed using the Lazzcano standard, Constant-Murley score, and imaging changes before and after surgery. Both groups showed significant increase in improvement postoperative to preoperative scores. However, no statistically significant difference could be evaluated at the last follow-up in both groups. They concluded that the modified Weaver-Dunn technique showed better therapeutic outcomes with less complications postoperatively. Compared to the hook plate the combination of the usage of an allograft tendon transplantation, anchor fixation to strengthen the coracoclavicular ligament and partial transposition of the acromiocoracoid ligament showed a more useful and safer fixation and less complications. (69)

Another study of Moatshe et al. (2018) compared the clavicular fixation with hook plate and modified Weaver-Dunn combined with hook plate fixation in Tossy III acromioclavicular joint

dislocation. Two groups have been investigated, and they compared operative time, blood loss, imaging changes, complications, and Constant-Murley scores at 3-, 6-, and 12-months post operation. They concluded that both approaches are effective and safe treatment options. The advantage of the hook-plate technique offers less trauma. The modified Weaver-Dunn technique with the hook-plate fixation showed stronger reconstruction of the coracoclavicular ligament. This leads to earlier removal of the hook-plate and earlier improvement of the shoulder function. (70)

Another study of Windhamre et al. (2010) showed the evaluation of the Weaver-Dunn procedure for chronic acromioclavicular joint dislocation which was augmented with a temporary hook plate or a PDS loop suture. Their result was that the reconstructed chronic acromioclavicular joint dislocation leads to good shoulder function and high satisfaction for patients. The patients which received the Weaver-Dunn technique with the hook plate reported more pain while moving and resting. The hook plate had no advantage and the functional outcome was not improved. Additionally, another surgical procedure for removal of the implant is necessary, which is a disadvantage of the hook plate. (71)

9.6 Augmentation of Conventional Weaver-Dunn with Tight Rope

The augmentation of the conventional Weaver-Dunn technique was examined, and the subsequent studies show what advantages and disadvantages this augmentation has.

The conventional Weaver-Dunn approach of the acromioclavicular joint has the disadvantage that it results in superoinferior or anteroposterior instability. The new method of Weaver-Dunn augmentation with the tight rope has been described in a study of Zooker et al. (2010) They investigated a study were they examined cadaveric shoulders. One shoulder pair received a tight rope augmentation and one a tape cerclage augmentation. They tested the movement of the joint pre and postoperatively and the measurements were taken under load immediately after surgery. To simulate the wear and to evaluate the stability and durability it was assessed after 1 load of cycle and after 2000 load cycles. They concluded that the Tight Rope augmentation had a lower superoinferior and anteroposterior translation. This is important for clinical relevance, and it could decrease the complications and allow earlier mobilization and earlier rehabilitation. (72)

Al-Ahaideb et al. (2014) performed also a study about the same procedure for chronic acromioclavicular joint dislocation. Nine patients underwent this surgery, and they evaluated the results after surgery with constant scores and radiological investigations. The follow-up was approximately 20 months. The constant score which indicates shoulder function was 97% which are excellent results. The radiological investigations showed that seven patients showed anatomical repositioning in the vertical plane and two patients had a slight loss of reduction. All patients could return to their normal function of the joint after the surgery and had high satisfaction. They

investigated that it is an effective surgical approach for treating chronic acromioclavicular joint injuries with excellent functional results and high rate of return to pre-injury activity levels. (73)

Zooker et al. (2010) showed that the augmentation of the Weaver Dunn technique using a tight rope system has many advantages and promises better functionality and fewer complications after the operation than the conventional operation. (72)

9.7 Weaver-Dunn vs Bosworth screw

A study of González et al. (2014) compared the quality of life with different curative approaches in Tossy III acromioclavicular joint dislocation injuries. They used the DASH score (Disabilities of the Arm, Shoulder and Hand) and evaluated the functioning postoperatively in the hook plate technique, which was most frequently used, the Weaver-Dunn technique and the Bosworth technique. The results showed that all groups had mild disabilities and symptoms (64).

Another study of Pavlik et al. (2001) reported in their study about a modification of the Weaver-Dunn technique in chronic acromioclavicular joint dislocation following Tossy III. The surgical technique included no lateral clavicular end resection, and the graft was sutured to the inferior part of clavicle with trans osseous sutures. Afterwards a Bosworth screw was used for 8 weeks for graft protection. They assessed all patients for 37 months with a constant score, subjective evaluation and radiological investigation. The mean constant score was 91,9%. One patient experienced screw loosening which leads to reduction loss and discomfort. One of the patients could not return to work and one could not return to the initial functionality. The study showed 11 excellent and 6 good results. The radiological findings showed that most of the cases had anatomical reposition postoperatively in the vertical plane. 6 cases showed slight loss of reduction (2-4mm difference) and 2 cases had partial loss of reduction (4-8mm difference). The modified Weaver-Dunn procedure showed good functional and subjective outcomes. It is ideal for young patients, because arthrosis is more frequent in older patients, making the resection of the end of the clavicula obligatory (75).

The studies show that an extension of the Weaver-Dunn technique using a Bosworth screw can achieve better results and that the joint use of these implants is effective in the treatment of chronic acromioclavicular joint dislocations, especially for young patient (64,75).

9.8 Bosworth Screw vs. Kirschner Wires

Cetinkaya et al. (2017) performed a study about acromioclavicular joint dislocation fixation with Kirschner wires and coracoclavicular fixation with the Bosworth screw technique in acromioclavicular joint dislocations type III according to Rockwood. They examined 32 patients and their long-term clinical and radiological results of the investigations. One group received the Bosworth Screw and one received the approach with Kirschner wires. The follow up was about 95

months. According to Cetinkaya et al. (2017) both are reliable techniques, offering adequate reduction and similar functional results, but the Bosworth screw technique may be the preferred surgical option due to lower risks of wound infections and lower rate of arthrosis in the postoperative period. (31)

Another study of Tiefenboeck et al. (2017) presented a study with data of long-term follow-up patients which were treated with the Bosworth Screw and k-wiring additionally. It was a retrospective single center data analysis and the numbers of patients which participated in the study was 22 with grade II-V according to Rockwood. The clinical outcome was measured with different scores like the DASH score, UCLA score and the VAS Score. All achieved a good to excellent result and most of the patients (86%) were satisfied with the result. 68% were able to participate in sports again and 73% had no limitations at work. Complications appeared in 14% of the patients. (77) According to the first study the use of K-wires poses a risk of infection, however the results show that the use of the Bosworth screw together with K-wires shows very good results.

10 Case Report

The patient presented with a positive piano sign and the radiological investigation (Figure 1) confirmed the clinical findings. The surgery was performed under regional and intubation anesthesia, whereas the patient was positioned as if seated in a beach chair. Skin disinfection is carried out with Cutasept solution. Preoperative antibiotic prophylaxis included 1gramm of Cefalozin before performing surgery. The joint was examined with an arthroscope through the posterior incision. They found disseminated chronic synovitis. A rotator cuff resection was performed. The Biceps tendons have been stable in the joint. Afterwards the articular lip was torn and the subcoracoid bursa was cleared. The Coracoid process of the scapula is exposed. Diffuse bleeding started under the clavicle when cleaning the torn riders with the shaver, so the shaver was not used. An incision of about 2.5 cm is made above the clavicle and at the coracoid process. With the help of a special drill, the clavicle and coracoid process were drilled. Repositioning and fixation of the clavicle with a special Zip Tight fixation system was performed. It was firmly fixed. Clinically it was a good position of the clavicle (Figure 2) and sufficient relative stability were obtained. Afterwards a careful hemostasis was obtained. The wound was sutured according to the layers and a tape and bandage was used. The shoulder was tied with a Gilchrist bandage. The duration of the surgery was 1 hour and 35 minutes.

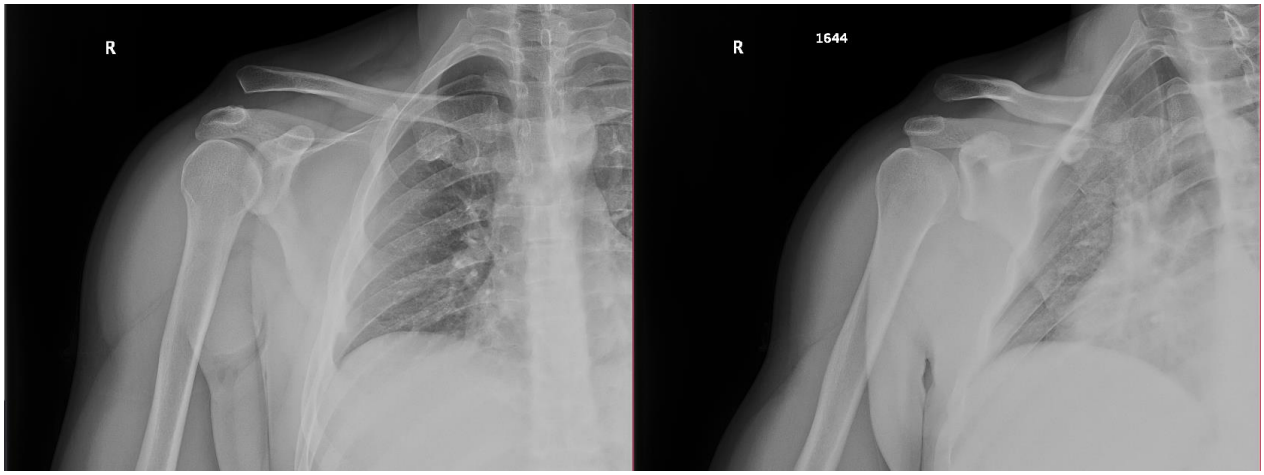

Figure 1: 06.07.2021 X-Ray Right Shoulder

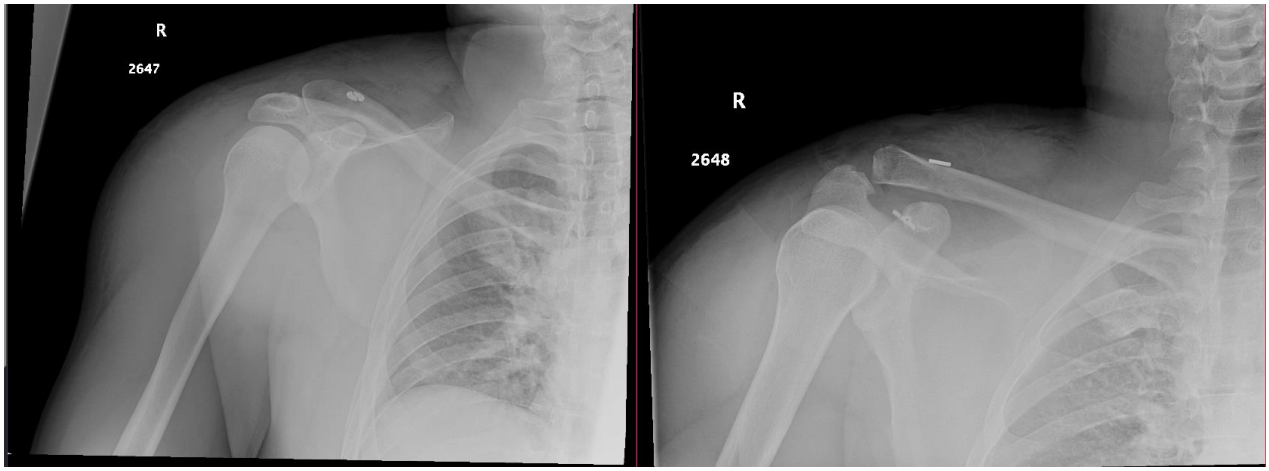

Figure 2: 10.07.2021 X-Ray Right Shoulder

10.1 Outcome and Follow-up

After a few months the patient came back to the hospital, and they examined the shoulder. The shoulder was not swollen and the deltoid muscle had normal function. It was painful on palpation in the area of the acromioclavicular joint. The acromioclavicular joint was deformed, and the clavicle was unstable on palpation. They found a positive "key" symptom. X-ray (Figure 4) was performed and a submergence of the acromial end of the clavicle was visible. Surgical treatment was indicated again which included reposition of the clavicle and refixation. Surgical treatment options, possible complications and postoperative rehabilitation were explained to the patient. The patient was hospitalized for surgery. Ultrasound guided interscalene block and intubation anesthesia were performed. The patient was positioned in the beach chair position. The skin was again disinfected with Cutasept solution. Preoperative Antibiosis with Cefazolinum 2g. was given intravenously. They did an incision of about 6 cm at the distal end of the clavicle. The coracoid process of the scapula was exposed after cutting the layers. The old Zip Tight system implant was removed. With the help of a special drill, the clavicle and coracoid process were drilled in a new place.

Repositioning and fixation of the clavicle with a Zip Tight fixation system was performed. In addition, the clavicle was fixed with a Fiberwire suture at the medial clavicle to the upper button and at the acromioclavicular joint. It was firmly fixed. Again, clinically it was a good position (Figure 5) of the clavicle and sufficient relative stability was obtained. They performed careful hemostasis and afterwards the wound was sutured and a tape and bandage were used. The shoulder was tied with a Gilchrist bandage. Duration of the surgery was 1 hour and 30 minutes.

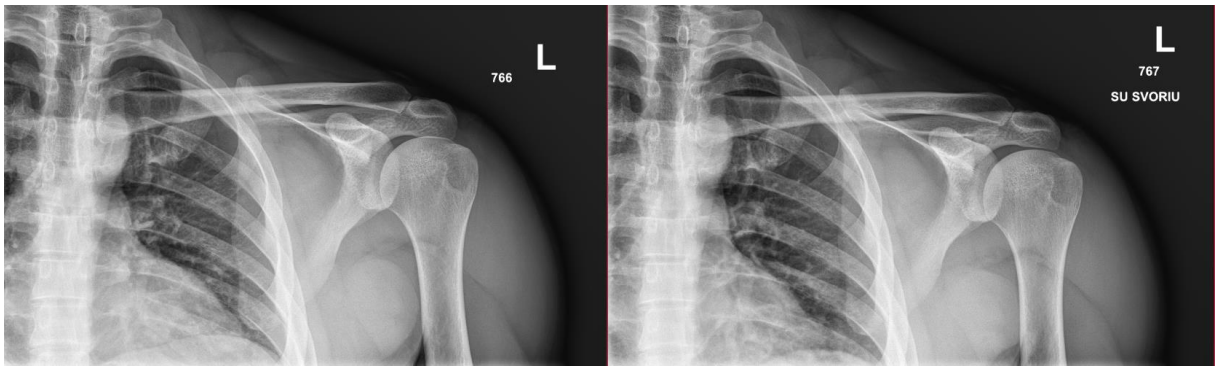

Figure 3: 07.12.2021 X-Ray Left Shoulder

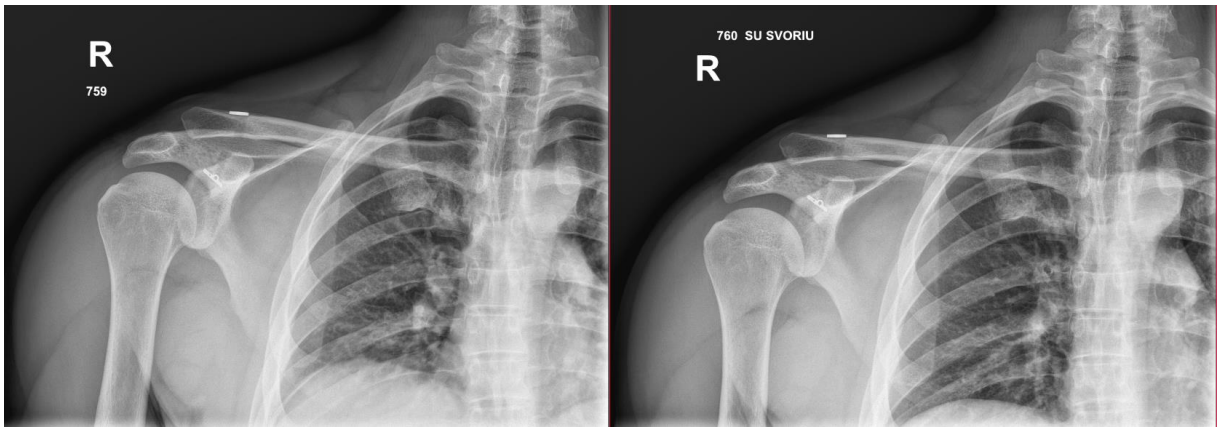

Figure 4: 07.12.2021 X-Ray Right Shoulder

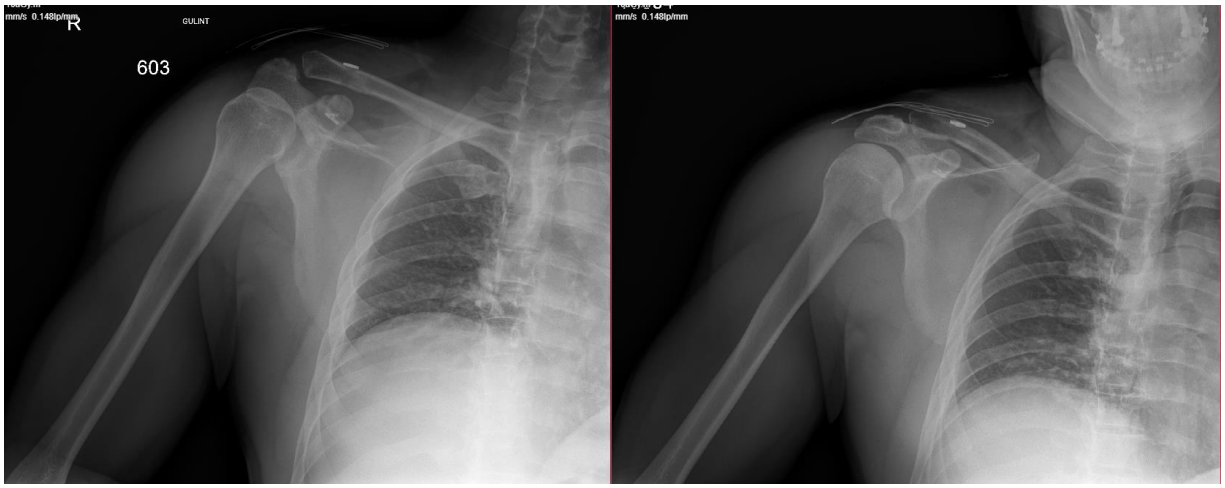

Figure 5: 30.12.2021 X-Ray Right Shoulder

10.2 Case Discussion

There are many techniques to maintain reduction and fixation of the coracoclavicular and acromioclavicular ligaments. However, there is no guarantee that there will be no complications after the operation like loss of reduction or residual pain. This case report describes and shows a failure of a Tight Rope or Zip Tight system. Postoperative acromioclavicular joint instability can be a challenging situation for the surgeon, because there is no “gold standard” for revision surgeries. The presented studies showed that concerns about secondary subluxation exists. The most frequently reported complication is hardware migration into the clavicle, coracoid or both. The tight rope system does not replicate the natural orientation of the coracoclavicular ligaments, potentially leading to persistent horizontal instability despite restored vertical stability. It is described as a technically complex procedure for specialists. Additionally, there is limited literature on the most effective method and it's important to identify the underlying cause of reinjury. Patient compliance is also an important point, it is part of the factors of the result. (19,17,21,22,23,24,40)

Zhang et al. (2022) suggest that the Zip tight system may need an augmented technique because early subluxation after 3-6 months is a common complication. (4) In general this case showed that isolated use of Zip Tight or Tight Rope system for high-grade acromioclavicular joint dislocation was insufficient and the use of a modified technique with the Fibrewire was necessary to increase the stability, the healing of the acromioclavicular and coracoclavicular ligaments and prevents re-dislocation.

11 Conclusion

Techniques which implant hardware to reduce the acromioclavicular joint, like the Hook plate is widely used due to its simplicity but requires removal and has notable complications. Tight Rope is a strong alternative, as a second most used technique. On the one hand the minimal invasive approach encourages high patient satisfaction. On the other hand, it is technically challenging. Bosworth screw and Kirschner wires can lead to significant long-term complications and are less favored by the surgeons. The modified Weaver-Dunn technique showed in general better functional outcomes and less complication. On the one hand, with the hook plate technique faster recovery is possible and it is less trauma to the patient. On the other hand, it is associated with more pain and an additional procedure is necessary to remove the implant.

Methods which reconstruct the ligaments are comparatively new and early reports showed that they achieve biomechanical function similar to the native joint.

Therefore, it is crucial to select the appropriate surgical treatment based on the age of the patient, physical requirements, and the expertise of the surgeon. More investigations and studies should be performed in the future to determine the most suitable approach for acromioclavicular joint dislocation and reconstruction.

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