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REVIEW ARTICLE

ANTERIOR SHOULDER INSTABILITY IN THE THROWING ATHLETE

PRZEDNIA NIESTABILNOŚĆ BARKU U ZAWODNIKÓW RZUCAJĄCYCH

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ABSTRACT
Instability in the shoulder of the throwing athlete differs significantly from that of the collision athlete or the everyday non-athlete populations. The pathogenesis, clinical presentation, workup, diagnosis, and management of instability for the thrower have unique features and require a deeper understanding of the continuum from beneficial adaptive laxity to pathologic instability. Success rates for return to play after both non-operative and surgical management are much lower for throwers than for other athletes, due in no small part to the need to balance stabilization against over-constriction of the glenohumeral joint. Multiple nonoperative and surgical techniques exist and continue to evolve for management of this challenging condition.

Keywords: anterior shoulder instability, throwing athlete; bankart tear, SLAP tear, posterior labral tear, posterosuperior internal impingement (PSI)

STRESZCZENIE
Niestabilność barku u zawodników rzucających znacząco różni się od tej występującej u sportowców uprawiających sporty kontaktowe oraz osób nieaktywnych fizycznie. Patogeneza, obraz kliniczny, diagnostyka oraz leczenie niestabilności u zawodników rzucających mają unikalne cechy i wymagają dogłębnego zrozumienia kontinuum od korzystnej adaptacyjnej wiotkości do patologicznej niestabilności. Wskaźniki powrotu do gry po leczeniu zachowawczym i operacyjnym są znacznie niższe u tej grupy sportowców niż u innych, głównie z powodu konieczności znalezienia równowagi między stabilizacją a unikaniem nadmiernego ograniczenia ruchomości stawu ramienno-łopatkowego. Istnieje wiele metod leczenia, zarówno zachowawczego, jak i operacyjnego, które nadal są udoskonalane w celu skuteczniejszego zarządzania tym wymagającym schorzeniem.

Słowa kluczowe: przednia niestabilność barku, zawodnik rzucający, uszkodzenie Bankarta; uszkodzenie SLAP, tylne uszkodzenie obrąbka, tylno-górny, wewnętrzny konflikt (PSI)

Introduction

Shoulder instability represents a common condition in younger, active populations. Amongst collision athletes, shoulder dislocation or separation events cause the vast majority of subsequent instability complaints. In-season injury management can be more

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conservative in cases of collision athletes, with many sports medicine professionals opting to allow patients to continue to play after an injury, even through the end of the season (Owens *et al.,* 2012, Ward & Bradley, 2013). When appropriate, operative management usually focuses on repair or reconstruction of the capsule and labrum, with bone-based techniques such as the open and arthroscopic Latarjet and distal tibial allograft procedures becoming more popular in recent years.

The pathogenesis of instability and its subsequent management, however, differ significantly in the shoulder of a throwing athlete. Instability can sometimes originate in a singular traumatic event, but often it finds its roots in overuse and attritional laxity over time. A certain amount of laxity actually helps throwers attain higher velocities in their throws, but it can insidiously lead to chronic pathologic changes and even overt injury. Once it reaches a critical point, instability renders overhead athletes and throwers unable to perform their required tasks, even if nonoperative in-season management is attempted (Owens *et al.,* 2012, Ward & Bradley, 2013). Unlike with collision athletes, "finishing out the year" therefore usually does not work with throwers. Because of the differences in etiology, surgical treatment of instability in the throwing athlete also proves much more complex and nuanced than in the collision athlete or the non-athlete. Likewise, multiple studies have shown that rates and times for return to play after surgical treatment tend to be much lower for throwing athletes as opposed to collision athletes (Gouveia *et al.,* 2023, Gowd *et al.,* 2021).

Surgeons must understand the unique features of instability in the thrower's shoulder in order to provide effective treatment. Appropriate history, exam, workup, and treatment varies on an individual basis. Management techniques for this condition continue to evolve.

Etiology of instability

For a thrower, more laxity generally means a faster throw. Rotational velocity translates into linear velocity as the shoulder moves from cocking through release, and the thrower can generate higher velocity with a larger arc of rotation. Since the release point of the throw generally remains fixed, a larger arc originates from increased external rotation during wind-up and cocking. Increased external rotation finds its roots in adaptive capsular laxity of the glenohumeral joint, and sometimes even in acquired retroversion of the bony glenoid itself. As such, many successful high-level throwers have an impressive level of capsular laxity and external rotation (Figure 1).

Figure 1. Excessive External Rotation in an American Baseball Pitcher (c/o Tread Athletics, 2016)

Laxity in a thrower, however, represents a proverbial double-edged sword. As the level of shoulder laxity increases, the athlete may experience higher rates and levels of arm pain – even if the patient has no history of an instability event nor overt instability symptoms (Wardell *et al.,* 2022). Increased laxity can cause imbalances such as a glenohumeral internal rotation deficit (GIRD) that predispose the athlete to injury. Likewise, overuse in the setting of laxity can lead to multiple attritional and degenerative conditions that affect performance. Dynamic sensorimotor changes can also occur that predispose the thrower to micro-instability and its sequelae, especially with fatigue. Muscular imbalances combined with posterosuperior instability (PSI) can lead to tearing of the labrum and/or of the rotator cuff (Mornieux *et al.,* 2018).

Instability in a thrower thus occurs along a spectrum, and multiple diagnoses should be kept in mind – as they are distinct but also not mutually exclusive (Table 1). Gelber, Soloff, and Schickendantz have proposed that "injuries to the shoulder of the overhead athlete can be generally classified into three groups: internal impingement, internal impingement with acquired secondary anterior instability, and primary anterior or multidirectional instability" (Gelber *et al.,* 2018). Savoie and O'Brien, meanwhile, have suggested two classifications: "traumatic anterior instability that happens to occur in a throwing athlete and excessive anterior subluxation because of overuse that occurs in conjunction with the disabled throwing shoulder" (Savoie & O'Brien, 2014). Other diagnoses in the differential must also be considered and ruled out when appropriate, including vascular and neurological pathology such as cervical radiculopathy, peripheral neuropathy or entrapment, and Paget-Schroetter Syndrome (effort thrombosis) (Bushnell *et al.,* 2009).

Table 1. Specific diagnoses associated with instability in the throwing shoulder.

• Adaptive hyperlaxity
• Acquired excess external rotation
• Acquired bony glenoid retroversion
• Glenohumeral internal rotation deficit (GIRD)
• Posterioinferior glenohumeral ligament ossification (Bennett lesion)
• Posterosuperior internal impingement (PSI)
• Superior labral tear from anterior to posterior (SLAP)
• Anteroinferior capsulolabral tear (Bankart tear)
• Posterior labral tear
• Pan-labral tear
• Bicipital tendinitis/tendinopathy/subluxation
• Posterior articular-sided partial-thickness rotator cuff tear (PASTA lesion)
• Posterior bursal-sided partial-thickness rotator cuff tear
• Full-tickness posterosuperior rotator cuff tear

Clinical presentation

Categorization of an instability situation as either chronic or traumatic can usually be easily determined by the presence or absence of a singular event in the patient's history. Other features such as pain, loss of velocity or control, "dead arm" sensation, tingling and numbness, and even swelling can characterize overuse or impingement cases. Anterior instability can prove more subtle in throwers as proposed to non-throwers. When reporting an actual event, throwing athletes tend to present clinically with subluxation events instead of overt dislocation events (Wibur *et al.,* 2022). Posterior instability cases will frequently present with pain rather than classic instability complaints (Kercher *et al.,* 2019). In such cases, it remains critical to distinguish between adaptive capsular laxity and labral injury with pathologic instability (Sheean *et al.,* 2020). Pain may sometimes localize directly to the anatomic area of involvement, but not always. Biceps pathology can also contribute to instability symptoms and pain, and it can be more common in non-overhead throwers such as cricket bowlers and windmill-pitch softball players (Boden *et al.,* 2024).

Imaging

Various predictable and identifiable patterns of injury and pathology can be noted in throwing athletes with instability on imaging workup, which usually includes plain radiographs, computed tomography (CT), and magnetic resonance imaging (MRI) (Wo *et al.,* 2017). Ultrasound can have some utility as well, especially as a dynamic study, but it is completely user-dependent. Radiographs will show acute dislocation events and residual subluxation. MRI in PSI often reveals cysts in the humeral head and "kissing" lesions of the posterosuperior cuff and adjacent labrum (Goes *et al.,* 2023). Ossification of the posteroinferior glenohumeral ligament is known as a Bennett lesion, and can be seen on radiographs for CT. It is usually caused by repetitive traction microtrauma to the area (Goes *et al.,* 2023). In both cases, increased laxity of the anteroinferior capsule can contribute to the formation of these lesions (Wo *et al.,* 2017). Tears of the labrum are usually readily identified by MRI with arthrogram. Throwers with instability complaints tend to have injury patterns more consistent with PSI, posterior labral tears, and SLAP lesions rather than "pure" anteroinferior Bankart tears (Funakoshi *et al.,* 2023). MRI, both with and without arthrogram, will usually reveal tears of the rotator cuff.

Treatment options and outcomes

Treatment of instability in the thrower's shoulder should always begin with attempted conservative management (Owens *et al.,* 2012, Ward & Bradley, 2013, Gelber *et al.,* 2018, Savoie & O'Brien, 2014, Sheean *et al.,* 2020, Boden *et al.,* 2024). Rest, anti-inflammatory medications, and even occasional injections can help reduce the pain and inflammation of certain conditions. Physical therapy can also help, and therapists should focus on the structures most involved in each individual case. For example, posterior capsular stretching in cases of GIRD can help to re-balance the glenohumeral motion arc (Sheean *et al.,* 2020). Likewise, strengthening of the rotator cuff can improve sensorimotor deficits and also improve dynamic stabilization during the throwing motion (Mornieux *et al.,* 2018, Gelber *et al.,* 2018, Savoie & O'Brien, 2014).

Nonoperative treatment, however, often proves unsuccessful – especially as an athlete advances further along the spectrum of injury. The size and location of lesions strongly influence the chances of success. Smaller labral tears, especially in the Bankart area, may respond well to conservative treatment. Tears in the posterior labrum and in the SLAP area, however, have proven notoriously resistant to nonoperative treatment (Kercher *et al.,* 2019, Waterman *et al.,* 2023). When conservative treatment fails, appropriately-indicated surgical intervention can improve the athlete's chances of returning to play. The surgery must focus on the specific structure(s) involved in each individual case, and surgeons must be prepared for the need to address more than one pathology at a time. For example, many cases of worsening symptomatic PSI will require treatment of both a labral tear and a rotator cuff tear.

Kvitne and Jobe described one of the first techniques for surgical treatment of symptomatic anterior shoulder instability in throwers – the open anteroinferior capsulolabral reconstruction with a subscapularis split (Kvitne *et al.,* 1995, Kvitne *et al.,* 1995). In the decades since then, operative techniques have evolved into mostly arthroscopic approaches that begin with meticulous analysis of the joint and diagnosis of all pathology, followed by repair or reconstruction of the affected structures.

Arthroscopic Bankart repair with a concomitant remplissage procedure has seen reported return to play rates of 46%–79% in throwers

(Gouveia *et al.,* 2023). Park, *et al.,* have reported 82% return to play rates for baseball players with anterior instability who underwent standard Bankart repair (Park *et al.,* 2019). These rates of return to play lag behind those of non-throwers, which have been reported to exceed 90% in many cases Gouveia *et al.,* 2023, Gelber *et al.,* 2018, Savoie & O'Brien, 2014, Waterman *et al.,* 2023). Several studies have shown risk factors for failure or persistent symptoms to include older age, male sex, higher BMI, large Hill-Sachs lesions, and certain positions within a sport (e.g., backcourt in handball or pitching in baseball) Gowd *et al.,* 2021, Gelber *et al.,* 2018, Savoie & O'Brien, 2014, Waterman *et al.,* 2023). While it seems intuitive, research has also confirmed that players with injuries to the throwing arm are less likely to return to play than throwing athletes with injuries to the non-throwing arm (Park *et al.* 2019). Even when appropriate surgical management and postoperative rehabilitation does succeed, throwing athletes take significantly longer to recover and return to play after surgery in comparison to collision athletes and non-athletes (Ward & Bradley, 2013, Gouveia *et al.,* 2023, Gowd *et al.,* 2021).

Certain instability-related problems seem to respond better to surgery than others. SLAP tears have historically shown terrible success rates with attempted labral repair, but recent studies have reported significant improvement in return to play and often excellent results in cases of biceps tenodesis rather than repair (Waterman *et al.,* 2023). Posterior labral injury likewise has seen reliable surgical outcomes. In 2019, Kercher and colleagues reported 94% patient satisfaction and 94% return to sport for baseball players of various skill levels who underwent posterior labral repair (Kercher *et al.,* 2019). Most of these players reported pain as their primary pre-operative complaint, rather than instability. As posterior capsular tightness can hinder the athlete's ability to throw, surgeons should take great care not to over-constrain the shoulder when repairing the posterior labrum (Skeean *et al.,* 2020).

Researchers continue to seek out additional techniques that optimize the athlete's chances of returning to play – especially in cases of anterior capsulolabral injury. In the last several years, bone-based procedures have become quite popular – especially in collision athletes – but the literature about their success in throwers remains sparse. Bauer and colleagues reported good results in professional handball players using an open Latarjet-Patte procedure to stabilize the shoulder. In their 2024 study, they found a high level of both return to play (85%) and return to play at the same level (80%) in this high-risk sport involving both overhead throwing and collision demands on the shoulder (Bauer *et al.,* 2024). Other surgeons have shown reluctance to pursue bone-based procedures out of concern for over-tightening the shoulder and sacrificing motion (and thus velocity) in favor of more stability.

Maiotti, *et al.,* performed a multi-center study of several different surgical techniques for anterior shoulder stabilization in 2023. They found that soft-tissue augmentation of standard Bankart repair procedures (remplissage and subscapularis augmentation) can improve results to those similar to bone-based procedures such as the open or arthroscopic Latarjet technique (Maiotti *et al.,* 2023). Funakoshi, *et al.,* have described the use of hamstring autograft for anteroinferior glenohumeral ligament reconstruction in symptomatic overhead throwers with anterior instability and posterosuperior internal impingement (Funakoshi *et al.,* 2022).

Other surgeons have taken the approach of changing the arm position for repair rather than trying to alter or add to the repair technique itself. Mitsui and colleagues have proposed performing anterior stabilization in an intra-operative position of abducted external rotation that mimics the late cocking phase of the throwing motion (Mitusui *et al.,* 2024, Mitsui *et al.,* 2024). This "dynamic anterior glenohumeral capsular ligament tensioning (DAGHT) procedure" has shown improved outcomes for throwers in terms of better external rotation, better clinical outcomes, and better return to play at the same level (Mitsui *et al.*, 2024).

Conclusion

Instability in the thrower's shoulder remains a daunting clinical problem. The inherent need for maximum range of motion to generate velocity in throwing makes over-tightening of the shoulder a cardinal sin. Excess instability, likewise, can start the shoulder on an irreversible downhill slide of pathologic progression. Return to play rates and times for throwers therefore lag behind those of other instability patients, as finding the perfect balance between "too loose" and "too tight" proves exceptionally difficult. In the ongoing quest to maximize outcomes, surgeons have added soft-tissue supplementation such as remplissage, subscapularis augmentation, tendon grafting, and selective-positional tightening to the classic surgical techniques of capsulolabral repair and reconstruction, with varying results. Since each and every specific case of instability in a thrower represents a unique challenge, surgeons must pursue an individualized approach to care from presentation through resolution.

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REVIEW ARTICLE

AUGMENTED GLENOID COMPONENTS IN REVERSE TOTAL SHOULDER ARTHROPLASTY

WZMOCNIONE KOMPONENTY PANEWKOWE W ODWRÓCONEJ ENDOPROTEZOPLASTYCE STAWU RAMIENNEGO

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ABSTRACT
Over the last several years, multiple commercially-available implant systems have begun to feature augmented glenoid components for reverse total shoulder arthroplasty (RTSA). Augmented glenoid baseplate components can have a flat-backed geometry or a wedge-backed geometry. Flat-backed options serve primarily to lateralize the center of rotation of the arthroplasty. Wedge-backed options, however, can provide for quick, simple, and reliable correction of multi-planar angular deformity that otherwise would prevent appropriate version and inclination of the glenoid baseplate. Bony structural deformity of the glenoid presents a significant challenge to shoulder surgeons performing RTSA, but wedge-backed augmented glenoid components enable us to attack this problem with confidence. A growing body of literature about these components continues to expand with multiple studies showing favorable outcomes using this technology.

Keywords: reverse total shoulder arthroplasty, augmented glenoid component, wedge glenoid component, RTSA, wedge, augment

STRESZCZENIE
Przez ostatnie kilka lat wiele dostępnych komercyjnie systemów implantów zaczęło wykorzystywać wzmocnione komponenty panewkowe w odwróconej endoprotezoplastyce stawu ramiennego (RTSA). Wzmocnione podstawy panewkowe mogą mieć geometrię z płaskim podparciem lub klinowym podparciem. Opcje z płaskim podparciem służą głównie do lateralizacji środka obrotu endoprotezy. Natomiast opcje z klinowym podparciem umożliwiają szybkie, proste i niezawodne skorygowanie wielopłaszczyznowych deformacji kątowych, które w przeciwnym razie uniemożliwiłyby uzyskanie odpowiedniej wersji i inklinacji podstawy panewkowej. Deformacje strukturalne panewki stanowią istotne wyzwanie dla chirurgów wykonujących RTSA, jednak wzmocnione komponenty panewkowe z klinowym podparciem pozwalają skutecznie stawić czoła temu problemowi. Coraz liczniejsze publikacje na temat tych komponentów wskazują na ich korzystne wyniki kliniczne, co potwierdzają liczne badania dotyczące tej technologii.

Słowa kluczowe: odwrócona endoprotezoplastyka stawu ramiennego, wzmocniony komponent panewkowy, komponent panewkowy z klinowym podparciem, RTSA, klin, augmentacja

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Introduction

Glenoid deformity and bone loss presents one of the most common challenges in performing total shoulder arthroplasty (TSA). Whether from chronic glenoid wear or as sequelae from a traumatic event, bony structural abnormalities can cause inappropriate glenoid version and/or inclination. Retroversion and superior inclination of the glenoid tend to occur most frequently in cases of rotator cuff tears and/or rotator cuff arthropathy as well as with primary arthritis, but other bony deformities such as medialization, anteversion, and inferior wear can occur with advanced primary arthritis or traumatic arthritis. Surgeons must correct these multiplanar angular deformities during glenoid component implantation for both anatomic (aTSA) and reverse (RTSA) total shoulder arthroplasty procedures in order to obtain and maintain soft-tissue balance, prevent asymmetric glenoid loading, and maximize the longevity of the arthroplasty.

The simplest means of deformity correction involves the use of a glenoid reamer to take down the "high side" of the native glenoid, usually anterior and/or inferior. This technique, however, is limited to low levels of angular deformity and can also result in bone loss which will compromise the fixation of the implant. The reamer, furthermore, is hard to control – exemplifying the old orthopedic adage of "measuring with a micrometer, but cutting with a chainsaw" Especially in cases of osteoporosis or small native glenoid architecture, glenoid reaming can quickly create problems without a good solution. Finally, glenoid reaming serves to medialize the overall construct center of rotation – running counter to the usual goal of lateralization.

Pascal Boileau popularized the use of the Bony Increased Offset-Reversed Shoulder Arthroplasty (BIO-RSA) as a means of achieving lateralization and correcting glenoid multiplanar angular deformities when implanting the glenoid component (Boileau *et al.,* 2017). Some subsequent studies have shown similar biomechanical performance and clinical outcomes when comparing BIO-RSA to augmented glenoid components (Van de Kleut *et al.,* 2022). Drawbacks of bone grafting, however, include technical difficulty, increased surgical time and cost, and risk of nonunion of the graft (Contreras *et al.,* 2023, Malahias *et al.,* 2020).

Over the last several years, the orthopedic community has witnessed a proverbial explosion of options for glenoid design in total shoulder arthroplasty (Mourad *et al.,* 2020, Wright *et al.*, 2025). Over a decade ago, researchers began using trabecular metal augments to glenoid components in aTSA for correction of glenoid retroversion (Sandow & Schutz, 2016). Implant design for aTSA has also addressed the problem of glenoid multiplanar angular deformity with wedged polyethylene glenoid components (Grey *et al.,* 2020, Shields, *et al.,* 2024).

In addition to wedge-augmented glenoid design in aTSA systems, several manufacturers have developed wedge-backed glenoid components for RTSA as well. Across the world, the use of RTSA has seen a meteoric ascent over the last decade – likely driven in no small part by the availability of these implants. While individual system designs may vary, the overall concept remains fairly similar: a circular glenoid baseplate with holes for screw fixation sits atop a monoblock metallic wedge with varying degrees of inclination (Figure 1) (Endell *et al.,* 2020). The advent of wedge-backed glenoid components has arguably revolutionized RTSA techniques and made the surgery substantially more user-friendly.

Technique

Debate still lingers over the supremacy of lateralized implants versus medialized (Grammont-style) implants in RTSA, and such discussion extends beyond the scope of this article. Likewise, I will refrain from delving into a detailed comparison of biological (graft-based) lateralization versus metallic (implant-based) lateralization, but the technique of metallic-augmented component implantation is inarguably relatively simple compared to biologic augmentation procedures (Maggini *et al.,* 2024).

Once the surgeon has made the decision to lateralize via the implant, metallic lateralization can be accomplished with either a flat-back augment or a wedge-back augment. Most companies offer multiple sizes of lateralized flat-back designs (such as 0, +3, and +6 mm options), but these models cannot correct angular deformity without differential reaming. In cases involving minimal angular bony deformity but still requiring lateralization, a flat-back augment can easily accomplish the intended biomechanical goals. Wedge-back augmented baseplates, however, have been shown to require less bone reaming and provide more lateralization than standard baseplates (Abdic *et al.,* 2020, Shah *et al.,* 2024). Because of their ease of use and effectiveness, wedge-backed glenoid components have quickly become the standard of care in cases of deformities greater than ten degrees in any plane.

With the widespread availability of computed-tomography (CT) based templating software for RTSA from most implant companies, surgeons will typically plan for implementation of a flat-backed augment or a wedge as part of their preoperative preparation. Alternatively, intra-operative findings may drive the selection of an augmented or wedged implant if the surgeon encounters unexpected levels of deformity or surprisingly poor bone quality. In a study of surgical planning, Werner and colleagues found that wedge-augmented glenoid components resulted in statistically significantly greater correction of glenoid deformity, improved total and cortical baseplate contact area, less cancellous reamed bone, and greater glenoid lateralization (Werner *et al.,* 2024). Many commercially-available systems offer varying degrees and designs of wedges – such as “half” versus “full” wedge, or wedges that are designed for superior versus posterior placement (Figure 2). Templating can help surgeons determine the appropriate wedge design option for each individual case.

Most cases requiring use of a wedge-back glenoid component involve glenoid wear in the posterosuperior quadrant of the glenoid. As such, placement of the wedge usually occurs posteriorly and cranially, roughly between the 10:00 and 12:00 o’clock positions on the native glenoid (Abdic *et al.,* 2020, Guehring *et al.,* 2023). Surgeons can choose to ream selectively to improve the fit of the wedge against the bone – combining preoperative templating with intraoperative assessment. After appropriate glenoid preparation, the surgeon then simply matches the shape of the wedge to the shape of the deformity (Figure 3). Most implants involve a central screw design for primary fixation, and the surgeon should take care to ensure that the wedge does not mal-rotate during initial screw fixation (Bobko *et al.,* 2021). The wedge-backed glenoid component can also be used for anterior-based bone loss, simply by spinning it in the other direction to match the required area for augmentation (Anastasio *et al.,* 2024).

Outcomes

Over the last few years, a growing body of literature has appeared in support of wedge-backed glenoid components. Most studies have been smaller retrospective cohorts, but journals have also recently published studies that are larger, prospective, multi-center, and even randomized. As surgeons perform further research on these implants and as they continue to grow in popularity, the availability of more compelling scientific support of their use seems highly likely.

Liuzza and colleagues reported in 2020 that a high percentage of patients achieved minimum clinically important difference (MCID) and substantial clinical benefit (SCB) thresholds with use of posterosuperior wedge augmentation for cases of superior glenoid wear (Favard E1, E2, and E3 deformities) (Liuzza *et al.*, 2020). Virk and associates published a study in 2020 of 67 RTSA patients with posteriorly augmented glenoid components that showed excellent clinical and radiographic outcomes out to a mean follow-up of 3.5 years (Virk *et al.,* 2020).

Sandow and Tu performed a prospective review in 2020 of 75 shoulders that underwent wedge-backed glenoid component RTSA with correction of Walsh B2 or C glenoids (Sandow & Tu, 2020). They reported excellent radiographic and clinical outcomes with no major complications related to the implants. Kirsh and colleagues showed significant correction of glenoid retroversion, glenoid inclination, and multiple outcome scores with the use of augmented baseplates in a small 2021 retrospective review (Kirsch *et al.,* 2021).

In a 2022 retrospective multi-center trial, Levin, *et al.,* found that augmented baseplates offered greater postoperative improvements in multiple planes of AROM and greater improvement of multiple clinical outcome metric scores in comparison to standard baseplates (Levin *et al.,* 2022). Another multi-center study by Levin and colleagues in 2024 found improved patient-reported outcomes and shorter operative times with superior-wedge-augmented baseplates compared to standard baseplates (Levin *et al.,* 2024).

Parker, *et al.,* prospectively followed 73 wedge-baseplate patients for a minimum of two years and found increased active elevation, increased external rotation, and good clinical outcomes in their study published in 2024 (Parker *et al.,* 2024). Baumgarten and Max performed a prospective study in of 187 patients undergoing RTSA and divided them into Standard and Lateralized Baseplate groups (Baumgarten *et al.,* 2024). The Lateralized group in this 2024 report included full-wedged baseplates, and at two years, the Lateralized constructs had better patient-determined outcome scores and lower rates of scapular notching.

Complications

The most commonly reported complications of wedge-backed glenoid baseplate use are stress reactions and stress fractures, usually of the acromion or the coracoid (Parker *et al.,* 2024). Some authors have postulated that lateralization of any kind can lead to increased stress on these areas, and often these complications relate more to the patient's bone density than to the specifics of the implant design. Many other studies have shown no difference in complication risk with augmented components compared to other glenoid implant options, and some have even shown improvement in postoperative scapular notching (Baumgarten *et al.,* 2024). Because metallic-augmented glenoid components do not require the additional bone healing necessary for BIO-RSA, nonunion, malunion, and collapse are essentially not a problem with this technique.

Conclusion

Augmented glenoid components have revolutionized shoulder arthroplasty over the last several years. Metal-backed augmentation in RTSA has helped the orthopedic community conquer the challenges of lateralization and multi-planar angular deformity without the unpredictability of selective reaming or the added time, cost, risk, and complexity of graft-based biologic augmentation. Multiple commercially-available systems exist for both flat-back and wedge-back glenoid components, with several options for the size, angle, and location of the augmentation. Operative techniques for augmented glenoid implantation remain surprisingly simple, and reported outcomes show that these implants perform as well or better than standard glenoid components, especially in certain situations involving complex wear or bone loss. It seems likely that outcomes will continue to improve as we refine our understanding of this technology and it appropriate applications in the years ahead.

Appendix

Description of surgical technique by Endell, *et al.* for preparation and implantation of a wedge-backed glenoid component (Endell *et al.,* 2020).

The patient is placed in conventional beach-chair position. After marking all bony landmarks

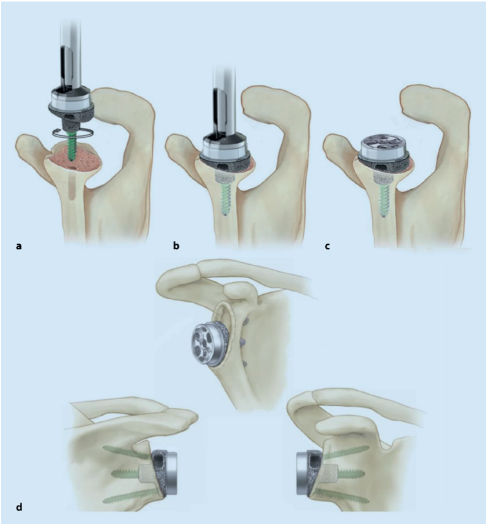

Figure 1. Concept of Implantaion of Monoblock Metallic Wedge-Backed Glenoid Component (Reprinted as Open-Source Access from Endell, *et al.*, Endell *et al.*, 2020)

Figure 2A shows 25 mm and 29 mm Flat-Backed Glenoids with + 3 mm and + 6 mm Augmentation (Stryker).

Figure 2B shows glenoid options for both superior and posterior augmentation in various combinations (Exactech).

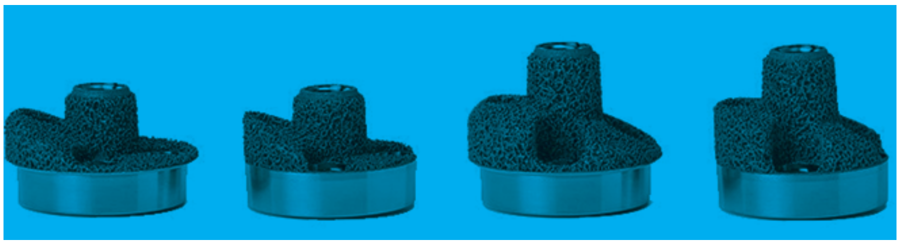

Figure 2C shows 25 mm and 29 mm Half-Wedge and Full-Wedge Options (Stryker).

Figure 2D shows Small, Medium, and Large Half-Wedge Buildup options (Zimmer-Biomet).

Figure 2. Examples of Varying Sizes of Flat-Backed Metallic Augmented Glenoid Components (A) and Varying Types of Metallic Wedge-Backed Augmented Glenoid Components (B–D)

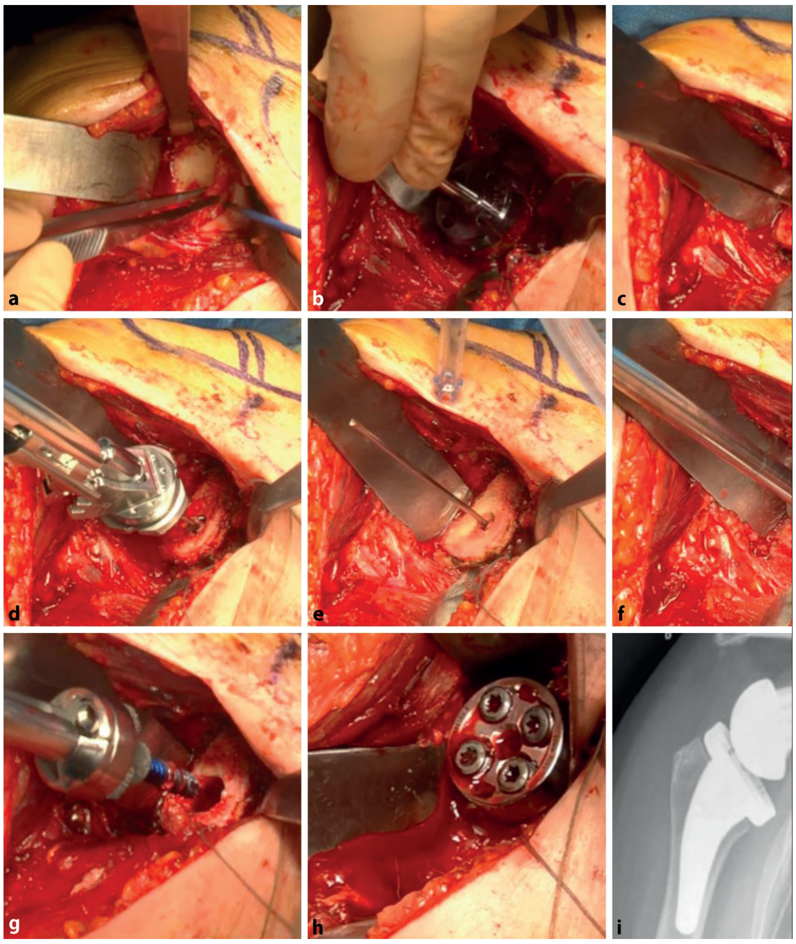

Figure 3. Glenoid Preparation and Implantation of Metallic Wedge-Backed Glenoid Component (a–h) and Post-Operative Radiograph (i). (Reprinted as Open-Source Access from Endell, *et al.*, Endell *et al.*, 2020). See Appendix for text describing the technique in detail

a standard deltopectoral approach is used, with retraction of the deltoid muscle laterally and the pectoralis major and the conjoined tendon medially. The subdeltoid mobilization and resection of its bursa follows in order to achieve sufficient lateralization of the deltoid muscle. The tendon of the subscapularis muscle is detached close to its insertion and armed using FiberWire® sutures (Arthrex, Naples, FL, USA) in an adapted Mason-Allen technique. After careful dislocation of the humerus and tenotomy of the long head of the biceps tendon, the resection of the humeral head is performed in preparation for the humeral stem component (e.g., Aequalis™ Ascend Flex™ or Aequalis™ Reversed II, Wright Medical Group, Arlington, TN, USA). After impaction of the metaphysis, a protection device is placed. Using retractors, the humerus is pushed posteriorly to allow for sufficient glenoid exposure. Under protection of the axillary nerve, residual labral tissue is excised (Fig. 2a), and the capsule is released superiorly, posteriorly, and inferiorly. Initially, the size and slope of the paleo- and neoglenoid, using full-wedge templates, have to be assessed (Fig. 2b). The template is used to estimate the size and alignment of the wedge implant. Ideally, intraoperative measures match the preoperatively planned 3D-CT simulation. After placing the central guiding pin (Fig. 2c), the asymmetric reamer is now used cautiously (Fig. 2d). Under constant supervision the reaming is completed (Fig. 3e) until full alignment of the asymmetric reamer onto the glenoid surface is achieved. Excessive reaming and glenoid fractures ought to be prevented. A drill bit is used over the central guiding pin to create the cylindrical seat for the post of the baseplate (Fig. 3f). Subsequently, the pilot hole for the central screw is over-drilled and its length measured. An optional tap may be used and is recommended for central screws with a wider diameter in order to prevent fractures around the screw. The full-wedge baseplate (Aequalis™ Perform™ Reversed, Wright Medical Group) is now assembled. Multiple 1.6-mm holes are drilled into the glenoid for better bony integration of the implant. Now the wedge baseplate is set in place (Fig. 3g). Special attention is needed when placing the central screw to prevent rotation and false alignment of the wedge onto the glenoid (Fig. 1a–c). Further stabilization is achieved by using up to four fixation screws, which can either be used as compression or locking screws (Fig. 3h). In the thick portion of the full-wedge augmentation, the choice is limited to a compression screw due to the implant design. In order to achieve optimal stabilization of the additional offset created by the wedge augmentation, the peripheral screws ideally are longer than the central one (Fig. 3i).

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REVIEW ARTICLE

DISTAL BICEPS TEARS: DOUBLE APPROACH VS ANCHORS VS ENDOBUTTON – CASE SERIES AND LITERATURE OVERVIEW

ZERWANIA DALSZEGO ŚCIĘGNA MIĘŚNIA DWUGŁOWEGO RAMIENIA: PODEJŚCIE DWUNACIĘCIOWE VS KOTWICE VS ENDOBUTTON – SERIA PRZYPADKÓW I PRZEGLĄD LITERATURY

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ABSTRACT

Introduction

Treatment of a ruptured distal biceps tendon is mostly surgical, however there is still a debate and controversy about the surgical approach and the fixation method.

Purpose

Our purpose is to review the literature and our own cohort regarding single or double incision technique, different types of fixation methods and their clinical outcomes.

Materials and methods

In our review study we included only the complete distal biceps ruptures. A comprehensive search was made in the current literature regarding the surgical treatment of distal biceps tears. Numerous studies were found comparing single incision versus double incision approaches, as also for the type of fixation. Besides the literature found we also reviewed our own cohort between 2019–2024. The range of motion (ROM), Disabilities of the Arm, Shoulder and Hand (DASH) scores, Mayo Elbow Performance Score (MEPS) scores were assessed, as also the complications.

Results

In our cohort, we only used single incision (long „lazy S", or small horizontal). We did not perform double incision in none of the cases. Also, surgeons' preference was to use anchor or cortical button fixation. Small incision technique and cortical button fixation had better cosmesis, better MEPS score and lower complication rate (heterotopic ossification, pain, supination).

Conclusions

Regarding the literature, there was no significant difference between single or double incision technique. If using anchors, it is advisable to use two anchors, whcih have the same results as endobuttons.

Keywords: single incision, double incision, cortical button, anchor, heterotopic ossification, neuropraxia, posterior interosseus nerve

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STRESZCZENIE

Wstęp

Leczenie zerwania dalszego ścięgna mięśnia dwugłowego ramienia jest najczęściej operacyjne, jednak nadal istnieje debata i kontrowersje dotyczące wyboru dostępu chirurgicznego oraz metody fiksacji.

Cel

Celem naszej pracy jest przegląd literatury oraz analiza naszego własnego materiału dotyczącego techniki pojedynczego i podwójnego nacięcia, różnych metod fiksacji i ich wyników klinicznych.

Materiał i metody

W naszym przeglądzie uwzględniono wyłącznie całkowite zerwania dalszego ścięgna mięśnia dwugłowego ramienia. Przeprowadzono kompleksowe wyszukiwanie aktualnej literatury dotyczącej chirurgicznego leczenia tych urazów. Znaleziono liczne badania porównujące podejście jedno- i dwunacięciowe oraz różne metody fiksacji. Oprócz przeglądu literatury przeanalizowaliśmy również naszą własną kohortę pacjentów operowanych w latach 2019–2024. Oceniano zakres ruchu (ROM), wskaźnik DASH (Disabilities of the Arm, Shoulder and Hand), wynik MEPS (Mayo Elbow Performance Score) oraz powikłania.

Wyniki

W naszej kohorcie stosowano wyłącznie dostęp jednonacięciowy (długie nacięcie typu „leniwe S" lub małe poziome nacięcie). W żadnym przypadku nie wykonano techniki dwunacięciowej. Preferowaną metodą fiksacji było użycie kotwic lub guzika korowego. Technika małego nacięcia i fiksacja guzikiem korowym zapewniały lepszy efekt kosmetyczny, wyższy wynik MEPS oraz niższy odsetek powikłań (heterotopowe kostnienie, ból, osłabienie supinacji).

Wnioski

Na podstawie przeglądu literatury nie stwierdzono istotnych różnic między techniką jedno- i dwunacięciową. W przypadku stosowania kotwic zaleca się użycie dwóch kotwic, które dają wyniki porównywalne z guzikiem korowym.

Słowa kluczowe: pojedyncze nacięcie, podwójne nacięcie, guzik korowy, kotwica, heterotopowe kostnienie, neuropraxia, nerw międzykostny tylny

Introduction

Distal biceps tears are relatively uncommon injuries, approximately 1.2–2.2 per 100.000 person per year. Patients are almost exclusively middle-aged men between 30–60 years (Miyamoto *et al.*, 2010). They occur after excentric load, lifting heavy items with a popping sound. Complete rupture of the distal tendon is mostly easy to diagnose just by physical examination, like Hook test described by O'Driscoll (O'Driscoll *et al.*, 2007, Luokkala *et al.*, 2020). Partial ruptures may need additional special tests, like pronation provocation test and diagnostic imaging like FABS view on MRI (Caekebeke *et al.*, 2021). There is a consensus, that these patients most likely need surgical intervention, since it yields better functional outcomes. Baker and Bierwagen identified decrease in supination strength, supination endurance, in elbow flexion strength, and elbow flexion endurance compared with the operated patients (Baker & Bierwagen, 1985, Cuzzolin, *et al.*, 2021). Surgery is only not indicated if the patient is not fit for surgery, or low demand patients, who doesn't want intervention (Cuzzolin, *et al.,* 2021).

There are two main determining question regarding the surgery, and these are the chosen approach and the fixation method. Patient must be informed about possible complications, that can occur and are more frequent related the approach or fixation method. These too are the predictors of our anatomic or non-anatomic intervention. The aim of this literature review is to help in decision making regarding the evidence.

Regarding the surgical approach, we can make a single incision, with is on the anterior aspect of the arm. This can be an extended „lazy S" type which can give an excellent view to the surgical field. It is now a bit out of fashion, but still an option, particularly for chronic cases, where grafting is necessary.

A modification is a minimal invasive, limited anterior approach, which can be either a continuation of the Henry approach, so a longitudinal one, or a vertical approach which respects the Langer's lines. This limited approach is positioned over the bicipital tuberosity. In case we can't find or are unable to reach or find the stump of the distal biceps tendon, we can make an accessory incision 5–7 cm above the elbow flexion crease, but making so, our main approach will be still a single incision technique.

Other option is the double incision technique, which was introduced by Boyd and Anderson (Boyd & Anderson, 1961), they referred to the "normal point of insertion on the radial tuberosity". Later modified by Morrey *et al,* described the insertion as the posterior aspect of the radial tuberosity (Morrey *et al.,* 1985). The first incision on the volar aspect of the elbow to reach the tendon stump, and the second incision is a muscle splitting approach on the posterolateral side of the proximal forearm. After exploring the torn distal biceps, a 5–7 cm incision is made through the extensor mass. In this way, it is easy to reach the bicipital tuberosity, and the anatomic insertion.

The main difference is reaching the insertion site is the pro-supination position of the forearm to stay away and not to violate the PIN (Posterior Interosseus Nerve) (van den Bekerom *et al.,* 2016).

After we have made our approach to the distal biceps, we must choose our fixation method, which can be either an onlay, or inlay fixation, metal or metal-free implant.

Since anchors are available on the market, torn ligaments and tendon fixations are made easy. Anchors can be metal, or all-suture anchors which can get stuck in the bone cavity or in the cancellous bone, and they are loaded with sutures. Other option is using a cortical button. Of course, drill holes, and transosseous suture are still an option as well as interference screws.

Purpose

The purpose of this paper is giving a review in the literature of the state of art in the distal biceps tendon fixation considering approaches, fixation methods and complications.

Methods and materials

According to our database, between 2019 and 2023 we treated 21 patients with distal biceps ruptures surgically, and 6 patients conservative. Surgery was either not indicated, or the patient did not want the operative approach. Out of those patients, who underwent surgical intervention 16 agreed in follow-up. 7 patients with cortical button fixation and 9 with metal suture anchor (Mitek GII, Johnson & Johnson).

We checked Mayo Elbow Performance Score (MEPS), pain, paresthesia, and radiologic control looking for heterotopic ossification or radioulnar synostosis. Suture anchor fixation was done by 3 shoulder and elbow experts, of which 2 always uses an extended anterior approach. Limited anterior single incision was done by 1 surgeon, as the cortical button fixation too.

Results

In the suture anchor group, we were able to follow up only 9 patients. They were operated by three experts in the field. All of them had a single incision technique with a lazy "S" type approach, and a fixation method of one metal suture anchor.

7 patients had 100, 1 had 85 and 1 had 80 points in MEPS score. Regarding the complications 8 patients developed heterotopic ossifications, of which 3 were severe. 2 patients had decreased supination, and supination strength.

In the Endobutton group we were able to follow up 6 patients, with one surgeon using the limited anterior approach according to the lines of Langer. All patients had 100 points in MEPS, with great patient satisfaction. Regarding the complication 1 patient developed a minor HO, one had a neuropraxia to LABCN, and one had a transient PIN palsy, which has spontaneously recovered.

Discussion

Complete rupture of the distal biceps is mostly easy to diagnose and is treated with surgery. Athwal *et al.* proved (Athwal *et al.,* 2007), that biceps tendon insertion is located on the extreme ulnar margin of the tuberosity, and as it approaches the insertion it thickens in length and width, thus attaches in an actual footprint. Also, it has been shown, that it is not a round, cylindrical shape, rather than oval. It's unique in orientation, origination as lateral (long) and medial (short) head, and inserting 90-degree rotation, so that short head inserts distally. From this short head, lacertus fibrosis is originating (Baker & Bierwagen, 1985). The biceps tendon passes over the ridge of the tuberosity to insert on its ulnar aspect; the footprint does not include the ridge, which functions as a pulley, where the tendon is spanned, increasing the mechanical advantage. Forthman *et al.* (Forthman *et al.,* 2008) evaluated the insertional anatomy and orientation of the radial tuberosity and biceps brachii tendon.

Radiographic images showed that the mean bicipital tuberosity axis of orientation is 65-degree, but 11 form 30 cadaveric specimens had more pronated tuberosity, thus, would not be repairable anatomically with the current 1-incision techniques.

They concluded that decreased tuberosity height reduces the biceps supination moment arm, and so limiting the peak supination torque. Their recommendation is to assess the orientation of the bicipital tuberosity through the anterior approach, and if the apex is found to be oriented more than 60-degree from anterior, a second posterior muscle-splitting incision is considerable. The fixation method can be the conventional method with burr and drill holes or with suture anchors. If the first method is used, the height should be maintained to maximize the supination moment arm of the biceps (Athwal *et al.,* 2007, (Forthman *et al.,* 2008). Hasan *et al.* investigated the repair site position, where the mean tunnel occupancy of the original footprint between the 2 approaches was significantly different (Hasan *et al.,* 2012). The virtual bone tunnels made from an anterior approach were mostly outside the original footprint area. An anterior approach would thus lead to a lateralized repair of the tendon, almost completely outside the original footprint area. The posterolateral approach, in contrast, led to the placement of the tunnel mostly inside the original footprint. A tendon repair thus would be more anatomically situated through the posterior approach. 2-incision technique using a posterolateral muscle-splitting approach to the bicipital tuberosity allows for a more anatomic repair of a ruptured distal biceps tendon as compared with a repair through a single anterior incision (Hogea *et al.,* 2023, Ernstbrunner *et al.,* 2023).

These studies adumbrate our fixation methods to achieve strong, as anatomic as possible fixation. Anchors are one of the most reliable methods to fix tendons, ligaments to the bone. These techniques fix the distal biceps on the cortical surface. Cortical buttons abut either the outer or the inner surface of the cortex of the radius. No significant differences exist between the IM and EM techniques in loss of force and tendon gap formation under cyclic loading or load to failure conditions

(Aditi *et al.,* 2021). IM fixation may adequately facilitate optimal bone-tendon apposition, with less risk of iatrogenic injury to the PIN. With the cortical buttons, we mostly insert our tendon in the bone (Bain *et al.,* 2000), but also, we can do an onlay fixation too (Bellringer *et al.,* 2020). There was no significant difference in bone-tendon healing in onlay or inlay technique, suggesting no need to put the stump of the distal biceps in the bone cavity (Pierreux & Carlier, 2023).

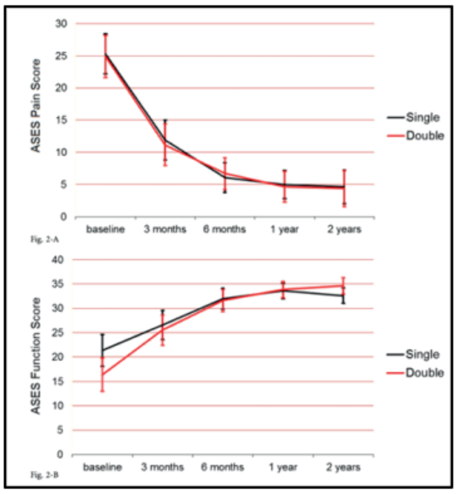
Endobutton fixation was first promoted by Bain *et al.* from a single anterior approach bone (Bain *et al.,* 2000). The cortical button was delivered through the far cortex and lock it there. The later Phadnis and Bain suggested a more anatomic reconstruction with an onlay technique and endobutton fixation, but on the anterior cortex (Bellringer *et al.,* 2020). Siebenlist *et al.*18, 19 concluded in their study that double intramedullary cortical button fixation provides significantly higher loads to failure than single intramedullary or extramedullary cortical button reconstruction in a biomechanical setup (Siebenlist *et al.,* 2019, Siebenlist *et al.,* 2011).

The other fixation method is the suture anchor, where the most frequently used implant was Mitek GII, but unfortunately this had the highest rerupture and failure rate (Citak *et al.,* 2011). However, the number of anchors required for a stable fixation remains unclear, as most studies use two or even more anchors for tendon refixation, Weißenberger *et al.* reported a case repost with bilateral tendon rupture, where one side was treated with one, the other with two anchors (Weißenberger *et al.,* 2020). They found that one-point fixation might provide enough tendon healing, a safe and stable fixation technique with both patient-related and economic benefits. Also, there was no significant difference in the type of anchor used. More recently metal-free anchors are favorable. A recent study by Otto *et al.* showed no significant difference in mean peak failure load or repair construct stiffness between titanium suture anchor and all suture anchors (Otto *et al.,* 2019). A recent meta-analysis demonstrated no significant difference in postoperative strength ratio to the uninjured limb with flexion and supination strength when comparing cortical buttons, suture anchors, and transosseous suture. Citak *et al.* compared Corkscrews, Mitek anchors or transosseous sutures, where they found comperable results to the other techniques (Citak *et al.,* 2011). Lappen *et al.* presented their study using all-suture anchors, where they found good-to-excellent results in terms of clinical outcome, ROM, and restoration of strength (Lappen *et al.,* 2023). Colantonio *et al.* presented their study on twenty paired fresh-frozen human cadaveric elbows, where they were randomized to onlay distal biceps repair (Colantonio *et al.,* 2022). The authors concluded that distal biceps repair with 2 all-suture anchors has similar maximum strength to repair with an intramedullary button and that both are viable options for fixation.

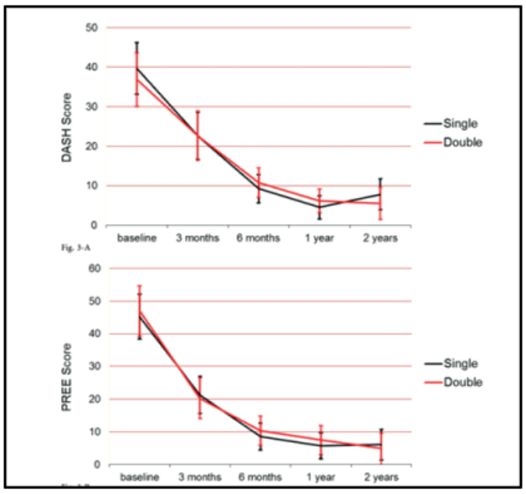
Complications

Different surgical approaches and fixation methods have different complications. Higher complication rate in 1-incision techniques as compared with 2-incision techniques, and most of these complications are minor and transient. The most frequent complication for the single incision is the neuropraxia of the lateral antebrachial nerve (LABCN) (Matzon *et al.,* 2019). Single-incision technique had a greater rate of overall nerve palsy (PIN, LABC nerve, and radial nerve) and rerupture rates compared with the double-incision technique. The double-incision technique had greater rates of heterotopic ossification compared with the single-incision approach (Amin *et al.,* 2016).

Bucci *et al.* reported a fracture of the proximal radius, which appears to be very rare. Because the fracture was undisplaced, and the tendon repair had its integrity, conservative treatment was chosen. At 3 months' follow-up, the fracture had successfully healed with anatomic alignment on radiographic studies (Bucci *et al.,* 2020).



Mean ASES elbow scores over time for the two groups. Pain subscale (p = 0.89). Function subscale (p = 0.46) (Grewal *et al.*, 2012).



Patient-reported pain and disability over time for the two groups. Mean DASH score (p = 0.89). Mean PREE Score (p = 0.73) (Grewal *et al.*, 2012).

Double incision technique was associated with higher rates of radioulnar synostosis, which could be caused by penetrating the interosseus membrane, or the bone trough. Following tables show the most complications regarding incision or fixation method (Amarasooriya *et al.,* 2020, Amin *et al.,* 2016).

Heterotopic ossification (HO) incidence was similar for most fixation techniques: cortical button (6.1%), interference screw (5.8%), suture anchors (5.4%), bone tunnel (4.9%). The incidence of HO was lower when button and screw fixation was utilized (1.5%). This study also confirmed that the incidence of HO is higher with the double incision technique. Following tables show the most complications regarding incision or fixation method. Dave *et al.* proved, that indomethacin is not necessary to use this routinely due to its limited efficacy in preventing HO and potential risks (eg, GI upset, bleeding) associated with the medication (Dave *et al.,* 2024). Also a recent study showed, that three weeks of indomethacin was not superior to meloxicam for 1 week for the prevention of HO after single-incision distal biceps tendon repair (Wörner *et al.,* 2022).

Complications of Distal Biceps Repair by Surgical Incision[a]

	Limited Single (n = 814)		Standard Single (n = 233)		Nonspecified Single (n = 1021)		Double Incision (n = 411)	
	n	%	n	%	n	%	n	%
Major								
PIN	7	0.9	2	0.9	22	2.2	6	1.5
Rerupture	4	0.5	7	3.0	18	1.8	2	0.5
R-U synostosis	0	0.0	0	0.0	0	0.0	4	1.0
Total	11	1.4	9	3.9	40	3.9	12	2.9
Minor								
HO	28	3.4	12	5.2	34	3.3	24	5.8
LABCN	79	9.7	12	5.2	53	5.2	20	4.9
SRN	17	2.1	14	6.0	19	1.9	4	1.0
Total	124	15.2	38	16.3	116	11.4	48	11.6
Total	135	16.6	47	20.2	156	15.3	60	14.5

[a]HO, heterotopic ossification; LABCN, lateral antebrachial cutaneous nerve; PIN, posterior interosseous nerve; R-U, radioulnar; SRN, superficial radial nerve.

Complication of Distal Biceps Repair by Fixation Method[a]

	Suture Anchors (n = 865)		Cortical Button (n = 360)		Interference Screw (n = 69)		Button and Screw (n = 324)		Bone Tunnels (n = 425)	
	n	%	n	%	n	%	n	%	n	%
Major										
PIN palsy	15	1.7	12	3.3	2	2.9	3	0.9	7	1.7
R-U synostosis	0	0.0	0	0.0	0	0.0	0	0.0	4	1.4
Rerupture	15	1.7	3	0.8	1	1.5	3	0.9	5	1.2
Total	30	3.4	15	4.2	3	4.3	6	1.8	16	3.8
Minor										
LABCN paresthesia	67	7.7	67	18.6	9	13.0	26	8.0	25	5.9
SRN paresthesia	36	4.2	12	3.3	1	1.5	16	4.9	2	0.5
HO	47	5.4	22	6.1	4	5.8	5	1.5	21	4.9
Stiffness	15	1.7	2	0.6	0	0.0	0	0.0	4	0.9
Total	165	19.0	103	28.6	14	20.3	47	14.5	52	12.2
Total	195	22.4	118	32.8	17	24.6	53	16.4	68	16

[a]HO, heterotopic ossification; LABCN, lateral antebrachial cutaneous nerve; PIN, posterior interosseous nerve; R-U, radioulnar; SRN, superficial radial nerve.

Conclusion

Distal biceps tears are to be treated mostly surgical. Single incision and double incision techniques both provide excellent outcomes. No statistical difference was found in the forementioned approaches or fixation methods regarding outcomes. Some complications were more likely associated with the approach, thus those operated with single incision had more complaints about lateral antebrachial cutaneous nerve neuropraxia, double incision with radioulnar synostosis, and some with the implant used.

In our cohort, extended anterior, single incision had significantly more heterotopic ossification, pain compared to limited single incision. There was no significant difference in MEPS and DASH scores. Cosmesis although played little role, limited incision had better subjective results.

Considering all the facts and evidence, techniques, probably the most anatomic repair with the least complication rate is a double fixation onlay technique with intramedullary cortical button from single incision to reduce heterotopic ossification and synostosis.

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REVIEW ARTICLE

SOME PROS AND CONS OF THE NEUROMONITORING DURING THE SCOLIOSIS SURGERY. A NARRATIVE REVIEW

NIEKTÓRE ZALETY I WADY NEUROMONITORINGU PODCZAS OPERACJI SKOLIOZY. PRZEGLĄD NARRACYJNY

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ABSTRACT
Introduction. Apart from the undisputable advantages of intraoperative neuromonitoring using the recording of motor evoked potentials (MEPs) used during spine surgery, there are certain limitations of this method that may give rise to doubts about its actual reliability. The presented narrative review aims to discuss some pros and cons of neuromonitoring during scoliosis surgery. Methods and results. The anaesthesiology-related influences, like neuromuscular blockade (0.5 mg/kg of Rocuronium bromide), seem to moderate evoke the diminishing of the MEPs amplitude parameters, especially when they are recorded from nerves in comparison to the muscles recordings in lower extremities. The proper communication between the anesthesiologist and the neurophysiologist in maintaining the relationship between Bispectral Index Monitor (BIS, 40–60) and applied transcranial electrical stimulation stimulus strength (TES, 130–95 mA) is crucial. The non-invasive approach for paediatric purposes of using the surface electrodes during MEP recordings in scoliosis surgery has been proven to be as precise enough as the needle approach. Disadvantages of using surface electrodes may include technical aspects related to their higher resistance than needle electrodes and their possible displacement from the bioelectric signal source, effectively resolved by adhesive, hermetic, and sterile protection tape. Conclusions. "Real-time neuromonitoring", intraoperative neuromonitoring mainly based on simultaneous recording, inspection and comparison of evoked potential and camera parameters by neurophysiologists, reduces surgery duration

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and minimizes anaesthesia's impact on cardiac and vascular systems and the nervous system. This requires advanced knowledge of the neuromonitoring person regarding the subsequent steps of the surgical procedure during scoliosis correction.

Keywords: neurophysiological neuromonitoring, motor evoked potentials recordings, advantages and disadvantages, pitfalls

STRESZCZENIE
Wprowadzenie. Oprócz niewątpliwych zalet śródoperacyjnego neuromonitoringu z wykorzystaniem rejestracji ruchowych potencjałów wywołanych (MEP) stosowanych podczas operacji kręgosłupa, istnieją pewne ograniczenia tej metody, które mogą budzić wątpliwości co do jej faktycznej niezawodności. Przedstawiony przegląd narracyjny ma na celu omówienie niektórych zalet i wad neuromonitoringu podczas operacji skoliozy według opinii innych ekspertów i naszych własnych doświadczeń. Metody i wyniki. Wpływy związane z anestezjologią, takie jak blokada nerwowo-mięśniowa (0,5 mg/kg bromku rokuronium), wydają się nieznacznie zmniejszać parametr amplitudy MEP, zwłaszcza gdy są rejestrowane z nerwów w porównaniu do rejestracji z mięśni kończyn dolnych. Właściwa komunikacja między anestezjologiem a neurofizjologiem w utrzymaniu odpowiedniej zależności między Bispectral Index Monitor (BIS, 40–60) a zastosowaną siłą bodźca przezczaszkowej stymulacji elektrycznej (TES, 130–95 mA) ma kluczowe znaczenie. Nieinwazyjne podejście do celów pediatrycznych polegające na stosowaniu elektrod powierzchniowych podczas rejestracji MEP w chirurgii skoliozy okazało się równie precyzyjne jak podejście igłowe, nawet jeśli amplituda sygnału rejestrowanego z mięśnia była o połowę mniejsza. Wady stosowania elektrod powierzchniowych mogą obejmować aspekty techniczne związane z ich wyższą opornością niż elektrod igłowych oraz ich możliwym przesunięciem od źródła sygnału bioelektrycznego, skutecznie rozwiązywanym przez klejącą, hermetyczną i sterylną taśmę ochronną. Wnioski. „Neuromonitoring w czasie rzeczywistym", śródoperacyjny neuromonitoring oparty głównie na jednoczesnym rejestrowaniu, badaniu i porównywaniu potencjałów wywołanych i parametrów z kamery przez neurofizjologa, skraca czas trwania operacji i minimalizuje wpływ znieczulenia na układy sercowo-naczyniowy i nerwowy. Wymaga to zaawansowanej wiedzy od osoby neuromonitorującej, dotyczącej kolejnych etapów procedury chirurgicznej podczas korekcji skoliozy. Wreszcie zwiększa bezpieczeństwo operacji poprzez ograniczenie komunikacji chirurg-neurofizjolog i uniknięcie ryzyka dekoncentracji.

Słowa kluczowe: neuromonitoring neurofizjologiczny, rejestracja ruchowych potencjałów wywołanych, zalety i wady, pułapki

Introduction

Adolescent idiopathic scoliosis (AIS) surgery aims to distract and derotate the spine pathological curvature with no neurological side effects as well as to improve the spine biomechanical abilities and silhouette aesthetic. The incidence of neurological complications following scoliosis surgery was identified at 3.2% in 2010 (Malhorta and Shaffrey 2020), and in 2020 it was already 8.2%, due to the need for more AIS surgeries and increasingly complex techniques bringing the increase of risk following the curvature correction.

Motor evoked potentials (MEP) are considered as more useful for neurophysiological intraoperative monitoring than somatosensory evoked potentials (SEP) in cases of surgeries applied for patients with AIS (Daroszewski *et al.,* 2023). Somatosensory evoked potentials from the very beginning of its clinical intraoperative used to verify the conduction of afferent pathways were burdened with the instability of parameters, mainly amplitude of recording at subsequent stages of surgical procedures and the influence of changes in the anaesthesia level (Padberg *et al.*,1998). The principles of their utilization are recordings at different levels of afferent transmission in peripheral and central nervous systems following electrical stimulation of lower extremity nerves. The average amplitude of SEP in normal conditions ranges from 2–10μV, but in AIS patents at about 1–2μV. On the other hand, the motor evoked potentials induced with magnetic field transcranially and recorded at different levels of efferent transmission in central and peripheral nervous systems, mainly from muscles, do not require averaging. The amplitude of MEP ranges in normal conditions at 500–4000μV, while in AIS patients at 200–1500μV. It is evident that utilization of the latter is easier because no averaging is required, however MEP can be affected by anaesthesia and relaxation procedures applied during AIS surgery (Charalampidis *et al.* ,2020). The solution to this problem is to record MEPs from nerves along their anatomical course rather than from muscles (Garasz *et al.* 2023), avoiding the effect of anaesthetic relaxation at the level of the neuromuscular synapse; one of the best candidates is the peroneal nerve at the level of the popliteal fossa (Daroszewski *et al.,* 2024).

Apart from the undoubted advantages of intraoperative neuromonitoring using the recording of motor evoked potentials during spine surgery, there are certain limitations of this method. They may be related to the effects of transcranial electrical stimulation (TES), related to the effects of muscle relaxation and anaesthesia, related to the interpersonal relationship between the anaesthesiologist and the surgeon and related to the patient's health status as well as intraoperative neuromonitoring (IONM) technical issues. This review is devoted to the abovementioned aspects as the pros and cons of the IONM utilization.

Patients, methods, results and discussion

Exclusion criteria for TES application to evoke MEPs during the neuromonitoring include pregnancy, which is usually rare because of the AIS patient's young age. The same holds for epilepsy as the possible iatrogenic TES-induced exogenic effect; therefore, multiple brain stimulation in a short period with trains of the electrical pulses in epileptic-treated patients is forbidden (MacDonald 2002). Patients with past cortical lesions or skull surgeries, convexity skull vault defects, raised intracranial pressure, cardiac diseases, applied proconvulsant medications or anaesthetics, implanted intracranial electrodes, vascular clips or shunts, cardiac pacemakers, and other implanted biomedical devices are of the special precautions or even abandoned for TES (Pastorelli *et al.,* 2011).

The success of scoliosis correction without complications in the functioning of the nervous system depends primarily on the masterful skills of the surgeons and nursing staff. The significant influence comes from good cooperation between the neurophysiologist and anaesthesiologist performing neuromonitoring at every stage of the surgical procedure. The appropriate communication between the anesthesiologist and the neurophysiologist in maintaining the suitable depth of anaesthesia employing a relationship between Bispectral Index Monitor (BIS, 40–60) and applied transcranial electrical stimulation stimulus strength (TES, 130–95 mA) is crucial for good neuromonitoring conditions and stable MEP amplitude recording (Daroszewski *et al.,* 2023a).

The anaesthesiology-related influences, like neuromuscular blockade (0.5 mg/kg of Rocuronium bromide), seem to moderate evoke the diminishing of the MEPs amplitude parameters, especially when they are recorded from nerves in comparison to muscles of lower extremities (Daroszewski 2023).

Our experience relating to the concept of "Surgeon -neurophysiologist" (neuromonitoring based on interactive verbal reports) versus the concept of "Real-time neuromonitoring" (based on the simultaneous MEPs recordings with the direct visual inspection of the operation field via the camera, without verbal reports) confirms a safer and shorter course of scoliosis correction surgery in cases where the latter was used. A greater increase in the surgeon's concentration was demonstrated, due to lower bidirectional communication with about 1 hour shorter averaged time of surgery (Daroszewski 2023a).

One of the most important aspects limiting the difficulties of intraoperative neuromonitoring is the precise diagnosis of the neurological condition of the patient with scoliosis, with particular emphasis on the transmission of the spinal cord pathways conducting efferent neuronal impulses (Iorio *et al.* 2016). This can be achieved by estimating more the amplitude than latency parameters of MEP recordings performed preoperatively following transcranial single-pulse magnetic stimulation (TMS). The similar amplitude parameters in recordings from analogous muscles and nerves on the left and right sides should be observed following TMS and TES (Figure 1).

In a significant percentage of operated scoliosis patients, improvement in the efferent transmission is visible immediately after the application of corrective instrumentation (33% of 525 operated scolioses), postoperatively the day after surgery in 45%, a week after the surgery in 65%, and half a year after the surgery in 92%.

In parallel with bilateral intraoperative MEP recordings, EMG recordings of spontaneous activity can provide valuable information about the effects of anesthesia or the effect of performed surgical procedures. An increased amplitude parameter in EMG recordings above 100 μV characterizing increased muscle tension, can be a sign of "shallow anesthesia". In addition, visible "burst-like" spontaneous activity in EMG recordings correlates with a deterioration of the MEP amplitude parameter, being a sign of neural structures irritation (Figure 2).

The non-invasive approach for paediatric purposes of using the surface electrodes during MEP recordings in scoliosis surgery has been proven to be as precise enough as the needle approach (Daroszewski *et al.*, 2023, Gadella *et al.*, 2023, Dulfer *et al.*, 2023), even if the amplitude of the signal recorded from muscle or nerve was about half as small in normal conditions. Disadvantages of using surface electrodes may include technical aspects related to their higher resistance than needle electrodes and their possible displacement from the bioelectric signal source, effectively resolved by hermetic, sterile tape protection (Daroszewski *et al.*, 2024). The lack of bruising and extravasation following the use of needle (Darcey *et al.*, 2016) versus surface electrodes is a convincing argument for neuromonitoring performed in children with scoliosis.

MEP recordings may be distorted by signals from devices generating the external electric and magnetic fields, cauterizers, coagulators, X-ray devices, operating lamps, and anaesthesia unit systems (Carl *et al.*, 2010).

MEP recording aberrations caused by accidental electrode disconnection or body movement artifacts are rare. Occasional protrusion of subcutaneous needle-stimulating electrodes implanted overcranially caused by movement artifacts can lead to false alarms due to the lack of MEP potential recordings (Deletis 2007, Kobayashi *et al.*, 2017, Mac Donald 2006).

Heating bone and muscle structures with a cautery during surgical spine exposure in the MEP recordings can be temporarily expressed by slowing down the conduction of nerve impulses within the fibers of the spinal pathways, usually eliminated by cooling the surgical field with a physiological saline solution (Daroszewski 2023a). Moreover, accidental contact of the cautery with the transpedicular screw can cause a massive movement artifact caused by the stimulation of the root structures or the spinal cord itself with electrical charges, affecting the temporary decrease in the amplitudes of the recorded MEP.

According to our observations, the paradoxical distribution of motor centres located

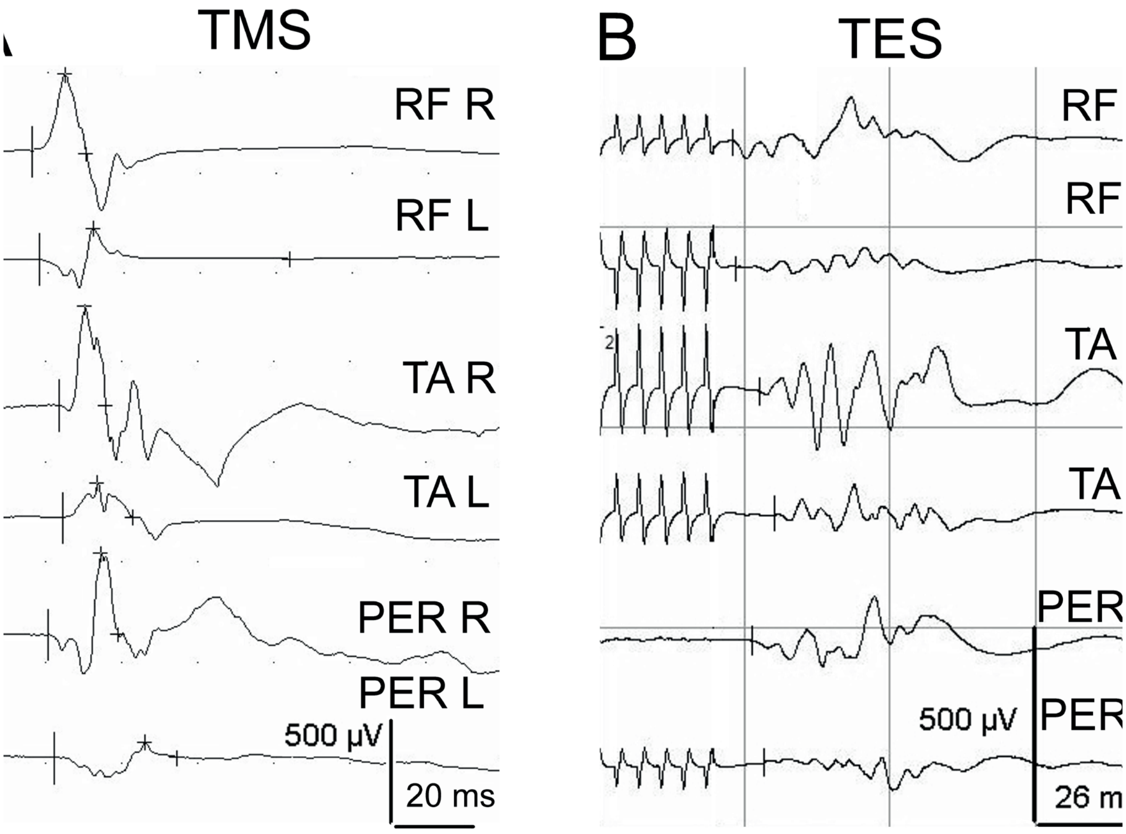

Figure 1. Comparison of motor evoked potential recordings from muscles and nerves preoperatively (A) and intraoperatively (B) before implantation of corrective instrumentation. The potentials were induced transcranially with magnetic field stimuli (A, TMS) and electrical stimuli (B, TES). Note the similar amplitude parameters in recordings from analogous muscles and nerves on the left and right sides. Abbreviations: R – right side, L – left side, RF – rectus femoris muscle, TA – tibialis anterior muscle, PER – peronal nerve

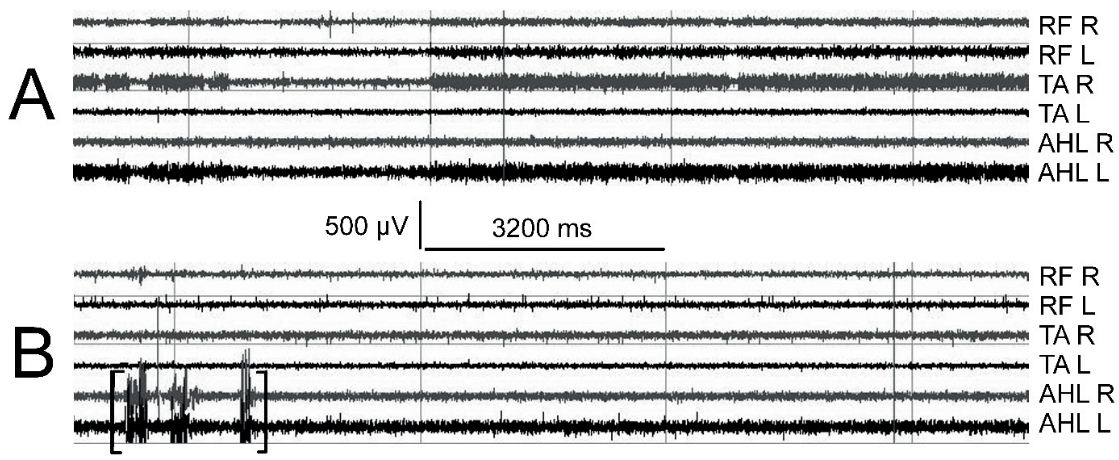

Figure 2. Examples of intraoperatively recorded EMG with amplitude parameters exceeding 100 μV could be a sign of low anaesthesia level (A) and "burst-like" spontaneous activity (B, indicated by the bracket) correlates with a deterioration of the MEP amplitude parameter, being a sign of neural structures irritation. Abbreviations: R – right side, L – left side, RF – rectus femoris muscle, TA – tibialis anterior muscle, AHL – abductor halluces longus muscle

rostrally to the Rolandic sulcus (in 9% of 525 scoliotic patients) may not be consistent with the 10–20 system calculation. Still, it can be verified by preoperative MEP recordings and marking the stimulation electrodes insertion sites for TES purposes.

Despite the significant development of equipment for recording evoked potentials during neuromonitoring during scoliosis correction, using motor rather than somatosensory evoked potentials seems more justified, especially in patients with a large lateral curvature angle of the spine. Although initial attempts to involve AI in intraoperative neuromonitoring services in spine surgery are already reported in the media, too many variables resulting from external factors mentioned in this review that may affect the procedure's success indicate moderate involvement in the future.

Conclusions

Intraoperative neuromonitoring, using the recording of motor evoked potentials during scoliosis surgery provides more pros than cons. Limitations of this method may be related to the effects of transcranial electrical stimulation (TES), the effects of anaesthesia procedures, the interpersonal relationship between neurophysiologists, anesthesiologists and the surgeon, and rarely the neuromonitoring technical issues. "Real-time neuromonitoring" shortens the duration of surgery, minimizes the impact of anesthesia on the cardiovascular and nervous systems, and increases the safety of surgery for patients with scoliosis. However, this requires advanced knowledge of the neuromonitor regarding the neurophysiology of the nervous and muscular systems and the subsequent stages of the surgical procedure during scoliosis correction. This strategy provides comfort to the operating team, reducing the risk of attention disorders during the necessary communication between the surgeon and neurophysiologist.

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REVIEW ARTICLE

ADVOCACY IN SHOULDER IN POLAND – WHERE ARE WE

ORĘDOWNICTWO W ZAKRESIE LECZENIA BARKU W POLSCE – GDZIE JESTEŚMY?

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ABSTRACT

This paper is focused on analysis of current state of healthcare advocacy within orthopedic surgery, specifically focusing on shoulder and elbow surgery in Poland. While the Polish healthcare system has achieved significant improvements since 1989, challenges persist, particularly in funding and accessibility of specialized care. Orthopedic surgery, including shoulder and elbow procedures, has been comparatively underfunded, leading to long waiting times and a shift of procedures from the public to the private sector. The Polish Shoulder and Elbow Society (PSES), established in 2015, has successfully fostered education and research but lacks a formal framework for political advocacy. This gap limits the society's ability to influence healthcare policy and funding. The study highlights the need for increased surgeon engagement in advocacy to address funding disparities and improve patient access to specialized orthopedic care. It emphasizes the necessity for the PSES to establish formal channels for cooperation with policymakers to ensure that the concerns of shoulder surgeons are addressed. Future directions include developing structured advocacy programs and fostering greater political engagement within the medical community to improve the quality and accessibility of shoulder and elbow surgery in Poland.

Keywords: advocacy, shoulder, orthopaedics, healthcare

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STRESZCZENIE
Niniejsza praca koncentruje się na analizie obecnego stanu orędownictwa w ochronie zdrowia w zakresie chirurgii ortopedycznej, ze szczególnym uwzględnieniem chirurgii barku i łokcia w Polsce. Chociaż polski system opieki zdrowotnej od 1989 roku przeszedł znaczące zmiany, nadal istnieją wyzwania, zwłaszcza w zakresie finansowania i dostępności specjalistycznej opieki. Chirurgia ortopedyczna, w tym procedury dotyczące barku i łokcia, jest relatywnie niedofinansowana, co prowadzi do długich czasów oczekiwania i przenoszenia zabiegów z sektora publicznego do prywatnego.

Polskie Towarzystwo Barku i Łokcia (PTBŁ), założone w 2015 roku, skutecznie wspiera edukację i badania naukowe, jednak brak formalnych struktur rzecznictwa politycznego ogranicza jego wpływ na politykę zdrowotną i alokację funduszy. Analiza wskazuje na potrzebę większego zaangażowania chirurgów w działania orędownicze w celu zmniejszenia nierówności w finansowaniu oraz poprawy dostępu pacjentów do specjalistycznej opieki ortopedycznej. Podkreślono konieczność utworzenia przez PTBŁ formalnych kanałów współpracy z decydentami politycznymi, aby zagwarantować uwzględnienie potrzeb chirurgów barku w procesie kształtowania polityki zdrowotnej.

Kierunki przyszłych działań obejmują opracowanie strukturalnych programów rzeczniczych oraz zwiększenie zaangażowania politycznego środowiska medycznego w celu poprawy jakości i dostępności chirurgii barku i łokcia w Polsce.

Słowa kluczowe: orędownictwo, bark, ortopedia, opieka zdrowotna

Introduction

The role of surgeons in healthcare advocacy

Role of advocacy in orthopedic surgery in Poland, and even more so in shoulder and elbow surgery has never been described or deeply analyzed. Apart from surgical training and practice that are core of our professional lives, we are starting to realize the necessity to navigate the intricacies of healthcare regulations, medical education, societal health awareness, and the funding mechanisms that support surgical procedures. They all have major impact on our patients and what we do in our daily clinical practices.

We have debated that issue over the years, as we have founded and built our society in Poland. Yet only recently raised that issue to understand the situation thoroughly to address it effectively.

The lack of advocacy in orthopedic surgery

While there have been calls for greater engagement by surgeons in healthcare advocacy, particularly in the field of orthopedics, there remains a lack of comprehensive knowledge on this subject, especially in Poland. This issue extends beyond our borders and is not confined to orthopedic surgery alone. Advocacy is not a routine part of medical or specialty training, and its definition is often unclear. The actions required for advocacy in healthcare, particularly in orthopedics and shoulder surgery, remain underexplored. Most literature on medical advocacy comes from the United States, where government regulations intersect closely with healthcare delivery. The development of advocacy programs in the U.S. has been well-documented, with organizations like the American Academy of Orthopaedic Surgeons (AAOS) leading efforts in the political arena. Through the establishment of Political Action Committees (PACs), the AAOS has created a platform for orthopedic surgeons to become involved in the advocacy process, focusing on supporting legislation that benefits musculoskeletal care providers. Various levels of involvement have been described, from voter participation to active campaigning and financial support for relevant causes (Abboud *et al.,* 2018, Davis 2021, Earnest *et al.,* 2010, Kirkpatrick *et al.,* 2020, Luft 2017).

In Poland, however, there is no such well-established framework. The Polish Shoulder and Elbow Society (PSES), which represents shoulder surgeons in the country, has yet to engage in significant advocacy efforts. This gap raises the question: how can we ensure that our voices are heard, and our concerns are addressed, particularly when it comes to the funding and organization of shoulder surgery services?

The healthcare system in Poland: achievements and challenges

Poland has seen significant improvements in its healthcare system since the political transformation in 1989. Life expectancy has risen, and infant mortality has decreased substantially. According to the Organization for Economic Co-operation and Development (OECD), Poland performs above the OECD average in nearly 32% of health indicators, including health status, risk factors, and quality of care. Despite these successes, challenges remain, including persistent funding shortages and inefficiencies in service delivery (OECD 2023, Nieszporska 2017).

The Polish healthcare system consists of two main sectors: public and private. The National Health Fund (NFZ), which finances the public sector, provides near-universal coverage to 91% of the population. The private sector accounts for a smaller portion of healthcare spending but has grown steadily due to long waiting times in the public system. Approximately 40% of patients use both public and private healthcare services, and 37% rely solely on the public system. Although the public system covers the majority of healthcare expenses, gaps persist. Primary care and hospital care are largely financed publicly, but outpatient pharmaceuticals are not fully covered. Dental services are another area of exclusion from public benefits, leading to challenges in accessing comprehensive care.

Hospital infrastructure in Poland is mostly publicly owned, with regional government bodies managing most facilities. While some private hospitals focus on elective procedures, public hospitals tend to perform more complex surgeries, particularly in specialized fields. However, the diagnosis-related group (DRG) payment system has led to inefficiencies in care coordination and financial sustainability, contributing to financial pressures on the public healthcare system.

Despite financial constraints, Poland's healthcare system has seen reforms targeting key health issues such as cancer, cardiovascular diseases, and mental health. However, orthopedics, including shoulder surgery, has not received sufficient funding compared to other specialties. While funding for hip and knee arthroplasties has increased, funding for shoulder surgery remains limited, leading to long waiting times and reduced accessibility in the public sector (Medical Procedure Report 2024, Central Base 2024).

Shoulder and elbow surgery: challenges in the polish system

The practice of shoulder and elbow surgery in Poland has been significantly impacted by the national healthcare system. Some procedures are covered by the public system, but many are performed in the private sector. The lack of accurate data on the proportion of procedures in each sector complicates the analysis. However, it is clear that many shoulder procedures, especially arthroscopies, have shifted from the public to the private sector. The main drivers behind this shift include inadequate reimbursement rates for arthroscopic surgeries, long waiting lists, and the migration of specialists to the private sector.

The reimbursement for shoulder surgery in public hospitals is low and often not related to complexity of pathology. This has made shoulder arthroscopy economically unfeasible for many hospitals, leading to a reduction in the number of these procedures. Consequently, the number of shoulder surgeries in the public system has decreased, with many patients turning to private providers for care. In the private sector, patients bear the full cost of the procedures, and it is related often to the complexity of the surgery.

The disparity in reimbursement and access between the public and private sectors has important implications for the availability and quality of shoulder surgery in Poland. While some highly trained surgeons perform these procedures in the private sector, the cost remains a barrier for many patients. The financial strain on the public system means that many patients face long waiting times or are unable to access specialized care. (Medical Procedure Report 2024, Central Base 2024, Sowada *et al.,* 2022).

The Polish Shoulder and Elbow Society: growth and challenges in advocacy

The Polish Shoulder and Elbow Society (PSES) was established in 2015 as an independent organization. Its primary goal has been to improve professionalism within the field of shoulder and elbow surgery in Poland. The society has seen rapid growth, from 28 founding members to 120 active members. PSES aims to integrate a diverse range of professionals, including physiotherapists, medical students, and researchers, to promote education and research in shoulder and elbow surgery.

Despite its success in fostering collaboration and promoting education, the society's involvement in advocacy and policy change is still in its infancy. One of the main reasons for this is the lack of political engagement within the medical community. The healthcare system's political processes have historically focused on other areas of health, such as cancer or cardiovascular diseases, rather than specialized surgery fields like orthopedics.

The PSES has made efforts to raise awareness about the challenges faced by shoulder surgeons in Poland, including limited funding and long waiting lists. However, there is no official channel for the society to cooperate with policymakers, such as the Polish Parliament or the Ministry of Health. This lack of engagement with the political process limits the society's ability to advocate effectively for the necessary changes in healthcare funding and access.

Conclusions and future directions

The Polish Shoulder and Elbow Society, despite its relatively small size, is playing a crucial role in advancing shoulder surgery in Poland. The society's focus on education, research, and integration has helped to improve the professionalism of the field. However, the impact of the society on political and economic changes remains limited. There is a pressing need for more structured involvement in healthcare policy, particularly in advocating for increased funding and improved access to shoulder surgeries.

While Poland's healthcare system has made significant strides since the political transformation of 1989, it still faces challenges, particularly in the funding and accessibility of specialized care. The society's continued efforts to raise awareness, promote research, and collaborate with other organizations will be crucial in ensuring that shoulder surgery receives the attention and resources it deserves.

In conclusion, despite the limitations imposed by the healthcare system and political constraints, shoulder surgery in Poland continues to progress. This progress is largely due to the enthusiasm and collaboration of dedicated surgeons and healthcare professionals who are committed to improving the field. The future of shoulder and elbow surgery in Poland depends on continued advocacy, both within the medical community and in the broader political arena, to ensure that patients have access to high-quality care. Yet, we do have major tasks as community to improve, get involved in health care policies and see the medical profession beyond operating theater.

Acknowledgments

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Przykład:

Elhassan, B., Bishop, A., Shin, A., Spinner, R. (2010), *'Shoulder tendon transfer options for adult patients with brachial plexus injury.'* J Hand Surg Am., 35 (7), pp. 1211–1219.

Artykuł z czasopisma:

Elhassan, B., Bishop, A., Shin, A., Spinner, R. (2010), *'Shoulder tendon transfer options for adult patients with brachial plexus injury.'* J Hand Surg Am., 35 (7), pp. 1211–1219.

Książki:

Rang, H. P., Dale, M. M., Ritter, J. M., Moore, P. K. *Pharmacology.* 5th Ed. Edinburgh: Churchill Livingstone, 2003.

Phillips, S.J., Whisnant, J.P. *Hypertension and stroke.* In: Laragh JH, Brenner BM, Editors. Hypertension: pathophysiology, diagnosis, and management. 2nd Ed. New York: Raven Press; 1995. pp. 465–478.

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