Issue Rehabil. Orthop. Neurophysiol. Sport Promot. 2023; 42: 23–31. ISSN 2300-0767
DOI: 10.19271/IRONS-000182-2023-42

REVIEW ARTICLE

ELBOW OSTEOARTHRITIS: PATHOGENESIS, CLINICAL PRESENTATION, WORK-UP

CHOROBA ZWYRODNIENIOWA STAWÓW ŁOKCIOWYCH: PATOGENEZA, OBRAZ KLINICZNY, BADANIE

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ABSTRACT
Degenerative joint disease of the elbow, although much rarer than in lower limbs, affecting about 2% of population, may be the result of primary and secondary etiologies and may significantly affect the quality of life, leading to pain, loss of motion and functional disability.

A detailed medical history combined with physical examination and imaging modalities can help to locate the source of symptoms and choose the appropriate treatment. Nonoperative management is the initial therapy for elbow arthritis and is limited to relief of pain by rest, activity modification, analgesics and nonsteroid anti-inflammatory medications.

When conservative management fails, surgical treatment should be used according to the patient's expectations, age, severity and etiology of elbow arthritis. Patients with posttraumatic and primary elbow osteoarthritis in mild and moderate stage of disease may be treated by arthroscopic osteocapsular arthroplasty which consist of soft tissue and bony debridement, osteophytes and loose bodies removal, synovectomy, capsular release and bony contouring of humerus and ulnae. Total elbow arthroplasty is dedicated to low-demand, elderly patients with rheumatoid, inflammatory, posttraumatic or primary elbow osteoarthritis in severe stage. For younger, high-demand patients with severe osteoarthritis of the elbow which affects the majority of the ulnohumeral articular surface a good option for surgical treatment is interposition arthroplasty with/using auto or allografts.

Keywords: elbow, arthroplasty, osteoarthritis

STRESZCZENIE
Choroba zwyrodnieniowa stawu łokciowego, choć znacznie rzadsza niż w przypadku kończyn dolnych, dotykająca ok. 2% populacji, może być wynikiem pierwotnej i wtórnej etiologii i w istotny sposób wpływać na jakość życia, prowadząc do dolegliwości bólowych, ograniczenia ruchomości i niepełnosprawności funkcjonalnej.

Szczegółowy wywiad połączony z badaniem fizykalnym i badaniami obrazowymi może pomóc w zlokalizowaniu źródła objawów i wyborze odpowiedniego leczenia. Postępowanie nieoperacyjne jest początkowym sposobem leczenia zapalenia stawu łokciowego i ogranicza się do łagodzenia bólu poprzez odpoczynek, modyfikację aktywności, leki przeciwbólowe i niesteroidowe leki przeciwzapalne.

W przypadku niepowodzenia leczenia zachowawczego, należy zastosować leczenie operacyjne w zależności od oczekiwań pacjenta, wieku, stopnia zaawansowania i etiologii zapalenia

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Authors reported no source of funding
Authors declared no conflict of interest

Date received: 25th January 2023
Date accepted: 19 th February 2023

stawu łokciowego. U pacjentów z pourazową i pierwotną chorobą zwyrodnieniową stawu łokciowego w łagodnym i umiarkowanym stadium choroby można zastosować artroskopową artroplastykę, która polega na usunięciu tkanek miękkich i kości, usunięciu osteofitów i ciał obcych, synowektomii, uwolnieniu torebki stawowej i obrysowaniu ramiennej i łokciowej. Całkowita artroplastyka stawu łokciowego jest dedykowana dla pacjentów o niskim zapotrzebowaniu, starszych, z chorobą reumatoidalną, pourazową lub pierwotną chorobą zwyrodnieniową stawu łokciowego w ciężkim stadium. Dla młodszych, wymagających pacjentów z ciężką chorobą zwyrodnieniową stawu łokciowego, która dotyczy większości powierzchni stawowej stawu łokciowego, dobrą opcją leczenia operacyjnego jest artroplastyka interpozycyjna z wykorzystaniem auto- lub alloprzeszczepów.

Słowa kluczowe: łokieć, artroplastyka, choroba zwyrodnieniowa stawów

Introduction

Elbow osteoarthritis is commonly classified by etiopathogenesis as primary or secondary, although clinical presentation and treatment are similar. Among the secondary causes of elbow osteoarthritis (OA), the most common is post-traumatic OA. Even though primary osteoarthritis is less common than posttraumatic arthritis of the elbow, both conditions lead to pain, loss of motion, and functional disability. Osteoarthritis is much rarer in the elbow than in the shoulder or lower limbs, affecting about 2% of the population (Stanley,1994; Adla *et al.* 2011).

This paper will review the etiology, pathogenesis, clinical presentation with imaging investigations of both primary and posttraumatic arthritis of the elbow. The principles and goals of non-surgical treatment will be presented as well as indications for surgical treatment and choice of surgical method.

Etiology

The etiology of primary elbow OA is still unclear, although combinations of environmental and genetic factors have been discussed.

The prevalence of symptomatic elbow osteoarthritis is 2%. Osteoarthritis was found to be more common in men and in workers who did heavy manual labor and was very uncommon in women (Stanley, 1994). In particular, there are a number of studies that have suggested heavy and repetitive work to be important factor especially in coal miners, truck drivers, stone quarry workers who operated chipping hammers, rock drills and patients using tools with higher vibration frequencies. OA also affects athletes, in particular weightlifters, MMA fighters, javelin throwers etc. (Lawrence *et al.* 1955; Sakakibara *et al.* 1993).

OA of the elbow is also recognized in patients with ambulatory problems, requiring prolonged use of crutches. In this group, the dominant extremity is involved in approximately 80% to 90% of patients (Morrey B. 2008). Different types of traumatic injuries of the elbow joint may ultimately result in specific forms of post-traumatic elbow joint degeneration.

Pathogenesis

Primary Osteoarthritis

The first noticeable degenerative changes in the elbow joint are osteophytes formed at the tips of olecranon and coronoid processes as well as their respective fossae within the distal humerus. Accordingly, the most common complaint of patients with early stages of primary osteoarthritis of the elbow is pain at terminal flexion and extension, as the osteophytes of the coronoid and olecranon engage their fossae. Over time, the degenerative process of the cartilage progresses, and the majority of articular surface involvement is confined to the ulnohumeral joint. The process of cartilage degeneration is accompanied by

pain and reduced range of motion in flexion and extension (Wysocki *et al.* 2011).

Isolated primary osteoarthritis is uncommon within the radiocapitellar articulation. In addition to the loss of cartilage and the formation of osteophytes, osteoarthritis of the elbow is characterized by the formation of loose bodies which contribute to impingement and joint contracture as the capsule becomes abnormally thickened and fibrotic (Tsuge *et al.* 1994; Suvarna *et al.* 2004).

Posttraumatic Osteoarthritis

Various elbow injuries may ultimately result in specific forms of posttraumatic arthritis to the elbow. The risk of developing this pathology depends on injury extent, gravity and on the way the trauma is provoked. Intra-articular distal humerus or olecranon fractures, for example, are frequently associated with degenerative joint, which is symptomatic during flexion and extension (O'Driscoll S.1993). Radiocapitellar incongruity may result following malunion of an intraarticular radial head fracture, which is manifested by pain and crepitus exacerbated during rotation of the forearm. Although malalignments in the geometry of the articular surface change contact pressures and accelerate the development of arthritis, ligamentous instability around the elbow may also result in abnormal joint kinematics and the potential for degenerative changes. Heterotopic ossifications are common in posttraumatic elbow osteoarthritis, which is rare in primary.

Clinical presentation

Physical examination

The most common complaints of patients with either primary or posttraumatic arthritis of the elbow are pain, loss of motion and mechanical blockage caused by loose bodies.

Morrey described normal and functional range of motion of the elbow as follows: ROM – flexion 150, extension 0, pronation – 75, supination 85. Functional ROM – flexion 130, extension – 30, pronation and supination – 50 (Morrey *et al.* 2000).

Mild phase

The patient reports posterior pain at the end point of extension. An associated contracture of some degree is almost invariably present. This posterior impingement can be confirmed with confidence on physical examination using the extension impingement test and arm bar test. Patients frequently have a near normal range of motion (ROM), although, when a deficit is present, it is usually a fixed flexion deformity of less than 30° (O'Driscoll *et al.* 2010).

Moderate phase

In this stage, there is a progressive deterioration of ROM, with episodes of locking and acute pain. Patients often describe locking of the joint, which requires trick movements to 'unlock' the elbow. A reduction in ROM to less than 30° of full extension to 120° flexion is often present. The elbow may be swollen, with tenderness over the posterior and anterior aspects (Biswas *et al.* 2013).

Severe phase

In severe disease, there is significant reduction in the ROM and the pain is more constant.

On examination, there is an increase in the elbow contracture measured by the arc of motion from 30 to 60 degrees and crepitus throughout the ROM is frequently noted. The pain occurs not only during the work but also at rest and patients usually require regular painkillers.

Ulnar neuropathy

Ulnar neuropathy is often observed in OA of the elbow. Kashiwagi reported an incidence of 40% in patients with elbow OA (Kashiwagi *et al.* 1985). The irritation of the nerve is considered to be a result of osteophytes, loose bodies or ganglions arising from the elbow joint. Worsening symptoms of ulnar nerve neuropathy should suggest compression by a ganglion or a free body and are an indication for USG or MRI of the elbow (Kato *et al.* 2002).

Rating Systems for Evaluation of the Elbow
Many scoring systems have been used to rate functional aspects in elbow disorders. However, only a few of these have been validated. The most common evaluating system is MEPS – Mayo Elbow Performance Score (80.7%), followed by quick DASH (22.9%), DASH – The Disabilities of the Arm, Shoulder and Hand (15.7%) and m-ASES – modified American Shoulder and Elbow Surgeons Score (7.2%) (Jeffrey *et al.* 2021).

The Mayo Elbow Performance Score (MEPS) analyses four categories: pain, range of motion, stability and daily function. Each category has a series of questions, the answers of which are marked with a score. The sum of all the scores can be correlated with an index of functionality ranging from excellent to poor.

Diagnostic imaging
Radiographs
The basic imaging examination in elbow diseases are plane radiographs, which include anterior-posterior and lateral projections. They demonstrate hypertrophic bony spurs, loose bodies, joint space narrowing. In post-traumatic elbow, radiographs help to assess malalignment, incongruency of the ulno-humeral or radiocapitellar joints, or the development of heterotopic ossification. A recent radiographic study showed that the most common features in elbow OA were olecranon osteophytes (96%), followed by osteophytes of the coronoid process (90%), radial head (86%) and coronoid and radial fossae (64%) (Dalal *et al.* 2007).

The stage of osteoarthritis can be assessed using the Broberg and Morrey and the Hastings and Rettig classification. The BM classification is divided into: Grade 1 – slight joint space narrowing with minimal osteophyte formation; Grade 2 – moderate joint space narrowing with moderate osteophyte formation; and Grade 3 – severe degenerative change with gross destruction of the joint. The Hasting and Rettig classification (HR), on the other hand, divides osteoarthritis into the following classes:

Class I – degeneration in the margins of the ulnotrochlear joint with the presence of coronoid and olecranon spurring and absence of degenerative changes within the radiocapitellar joint; Class II – class I with mild joint space narrowing within the radiocapitellar joint, without subluxation of the radial head; and Class III – class II with radiocapitellar subluxation (Broberg *et al.* 1986; Rettig *et al.* 2008).

Both the BM and HR classification systems demonstrated substantial reliability in evaluating the radiographic severity of post-traumatic *arthritis* (PTA) and *OA*. They are important before planning the treatment of patients with osteoarthritis of the elbow (Amini *et al.* 2015).

Computed tomography
CT-3D – Computed tomography with three-dimensional surface rendering provides excellent imaging of the bony pathology. The individual bones can be isolated from each other and spun around in three dimensions, demonstrating the location and structures of each osteophyte and loose body. CT-3D scan study of 22 patients with elbow OA, to map the osteophyte distribution, confirmed that in 95% of patients the osteophytes involved the ulnohumeral joint, whereas radiohumeral osteophytes were only found in 59%. The anterocoronoid region was predominant region where this cohort of patients tended to get osteophytes (Lim *et al.* 2008).

CT-2D: Two-dimensional sagittal, coronal and axial reconstruction are also necessary because they reveal the fine details not available in the three-dimensional images: nonunited fractures, the original floors of the fossae, small loose bodies embedded in the cartilage surface.

MRI, USG
MRI – magnetic resonance imaging has a very limited role in diagnosis of the elbow OA but helps to find noncalcified loose bodies and assessing the articular cartilage; posttraumatic instability and osteochondritis dissecans (Brunton *et al.* 2006).

USG-Elbow ultrasonography is of limited use in elbow osteoarthritis, mainly to assess the presence of loose bodies and to examine the ulnar nerve – thickness of the nerve, site ofcompression and presence of other lesions such as ganglions.

Treatment

Conservative treatment

Nonoperative management remains the mainstay of initial treatment for both primary and posttraumatic arthritis of the elbow and is limited to relief of pain by rest, activity modification, analgesics and nonsteroidal anti-inflammatory medications (O'Driscoll *et al.* 2010). For early-stage primary arthritis, symptoms are strongly associated with specific activities (weightlifting, boxing, etc.), patients are advised to avoid elbow aggressive terminal flexion and to use stretching extension exercises. In order to limit the pain and reduce inflammation, an elbow splint can be used in patients with OA. In the event of failure of NSAIDs consideration may be given to the use of steroid/viscosupplement injections. A study series of 19 patients with post-traumatic elbow OA, who received three intra-articular sodium hyaluronate injections at regular intervals over 4 weeks, showed minimal improvement in pain at 3 months, and no improvement at 6 months (van Brakel *et al.* 2006).

Platelet-rich plasma (PRP) and MSC injections are used in the treatment of osteoarthritis of the lower limb. PRP is used in elbow pathologies in order to help regenerating soft tissue through releasing the cytokines which are able to modulate inflammatory responses, but there is no literature confirming a positive effect in elbow osteoarthritis (Kwapisz *et al.* 2018).

Surgical treatment

When conservative management fails, patients with elbow osteoarthritis should be qualified for surgical treatment. These can be divided into open or arthroscopic techniques, all of which aim to reduce pain and achieve some improvement in ROM. The decision on the choice of method depends on the stage of presentation and the surgeons' skill and the familiarity with different techniques. Factors, such as severity of degeneration, age of the patient and level of physical activity, need to be taken into account, considering which kind of procedure is most suitable for every patient (Noticewala *et al.* 2017).

Open techniques

Posterior approach (*open ulnohumeral arthroplasty*)

The Outerbridge– Kashiwagi procedure. The procedure is performed through a posterior triceps splitting approach with fenestration of the olecranon fossa (1 cm to 1.5 cm) being performed to gain access to the anterior aspect of the elbow. The osteophytes on the olecranon and the coronoid process are excised (Kashiwagi *et al.* 1985). Minami *et al.* reviewed the results of this arthroplasty in 44 elbows followed for 8 years to 16 years. They reported 61% patients had slight or no pain at final review but noted 10% deterioration in ROM, when the same group was compared at 5 years and 12 years after initial surgery (Minami *et al.* 1985). Complication that may occur after open arthroplasty of the elbow is ulnar nerve entrapment, anterior interosseus nerve palsy, superficial wound infection, hematoma myositis ossificans and triceps rupture (Vingerhoeds *et al.* 2004).

Posteromedial approach

Wada *et al.* described a posteromedial approach for debridement of the arthritic elbow. Wada advocated this approach for patients with degenerative arthritis who also had ulnar nerve symptoms requiring decompression (Wada *et al.* 2004).

Posterolateral approach

Tsuge and Mizuseki described an extensive debridement arthroplasty through a posterolateral approach. The ulnar nerve was decompressed, the triceps and periosteum of the olecranon reflected, and the joint dislocated

by dividing the lateral collateral ligament. Pain was relieved in all cases, although some patients complained of dull aching on firm gripping. Impingement in flexion and extension was noted at 5 years and most patients returned to their former occupation (Tsuge *et al.* 1994).

Interposition arthroplasty or Arthrodesis
For younger high-demand patients with inflammatory arthropathy or severe post-traumatic or primary arthritis which affects the majority of the ulnohumeral articular surfaces and who have failed nonoperative management, good option for surgical treatment is interposition arthroplasty or elbow arthrodesis. Interposition arthroplasty uses autograft or allograft material to resurface the elbow articular surface, mainly by introducing a cushion of thick and hard tissue between the bones. A review of the literature regarding elbow interposition arthroplasty shows the different types of allo and autografts used for the operation: autografts- cutis, triceps fascia, anconeus interposition, fascia lata; allografts- Achilles tendon, fascia lata (Cheung *et al.* 2008; Nadeem *et al.* 2021).

Elbow arthrodesis is a rarely used procedure, which can relieve pain but is difficult to achieve and has dramatic implications on function of the upper limb. Elbow arthrodesis and total elbow allografts are considered only in salvage situations (Gallo *et al.* 2008).

Total elbow arthroplasty TEA
Total elbow arthroplasty is a good option for the low-demand elderly patients (> 60 year-old) with rheumatoid, inflammatory, post-traumatic, or primary elbow osteoarthritis in severe stage. Total elbow prostheses have evolved over the years and now include the linked, unlinked, and convertible types. Out of more than 10 different types of prostheses of the elbow, Kwak *et al.* distinguished four popular implant system (Kwak *et al.* 2019).

Unlinked Design (Kudo Type 5 System)
The Kudo prosthesis is one of the most popular unlinked TEA designs used to treat end-stage RA of the elbow. Theoretically, unlinked TEA has no mechanical connection between the humeral and ulnar components and is appropriate only for patients with limited bone loss or limited deformity and good ligament function. The primary stabilizers of nonconstrained TEA are the medial and lateral collateral ligaments, the posterior capsule and surrounding muscles function as secondary stabilizers (Iwamoto *et al.* 2018).

Linked Semiconstrained Design (Coonrad-Morrey)
The Coonrad-Morrey Total Elbow is a second-generation linked semiconstrained design featuring a central cylindrical bearing and two side bearings. The linked semiconstrained implant is one of the most frequently used devices for TEA. This design has been used to treat conditions including RA, degenerative arthritis, and trauma reconstruction, and satisfactory outcomes have been reported with long-term follow-up (Aldridge *et al.* 2006).

Semiconstrained Condylar-Bearing Design (Discovery Elbow System)
It is a hemispherical linked prosthesis designed to decrease complications associated with a semiconstrained prosthesis, especially bushing wear. Minimally constrained design allows a close match of the articular surfaces, avoids the use of a true hinge, and anatomically reproduces the axis of elbow motion (King *et al.* 2019).

Convertible Design (Latitude System)
This **more** recently, convertible system (Latitude Tornier implant system) allows surgeons to choose between a nonconstrained and semiconstrained prosthesis. If the surgeon has concerns regarding collateral ligament insufficiency or implant stability, a semiconstrained hinge can be created by applying a modular component to the ulnar prosthesis (de Vos *et al.* 2016).

Despite promising clinical outcomes for pain relief, restoration of function and range

of motion after total elbow arthroplasty, this procedure is associated with a high complication rate. The complication rate was 19.1% (at 5.9 years) for the linked prosthesis and 26.5% (at 8.2 years) for the unlinked prosthesis (Welsink *et al.* 2017).

Linked arthroplasties require more revisions due to polyethylene wear, while unlinked prostheses require revisions due to instability and dislocations. An increased risk of complications is seen in patients with young age, obesity, smoking, and high comorbidity. The most common complications after TEA are: periprosthetic joint infection (with reported rates ranging from 1% to 12.5%), aseptic loosening, periprosthetic fracture, triceps insufficiency, bushing wear, wound breakage, especially round the olecranon, ulnar nerve lesions (Ting *et al.* 2017).

Arthroscopic techniques

Arthroscopic techniques for treating elbow osteoarthritis include debridement of osteophytes and removal of loose bodies, capsular release and arthroscopic osteocapsular arthroplasty. Osteocapsular arthroplasty (OCA) combines soft tissue and bony debridement, osteophytes/loose bodies removal, synovectomy, capsular release and bony contouring of the humerus and ulna. It is a complex procedure requiring a high level of experience in elbow arthroscopy for its safe and effective performance.

Shawn ODriscoll proposed that the osteocapsular arthroplasty of the elbow is best performed in a stepwise sequence (get in and establish a view, create a space in which to work, bone removal, capsulectomy), starting posteriorly and completing the work in the gutters before going anteriorly (O'Driscoll *et al.* 2010).

Arthroscopic treatment of elbow osteoarthritis significantly improved 6-month clinical results for functional scores, pain, strength and range of motion (Carlier *et al.* 2019).

Although technically demanding, arthroscopic osteocapsular arthroplasty is a good option to restore elbow mobility in treatment of primary and posttraumatic elbow osteoarthritis if conservative methods fail. After early deterioration one week post operation, elbow mobility gradually improved, reaching the maximum ROM 6–12 months after the surgery (similar, but never better than intraoperatively) (Lubiatowski *et al.* 2018).

Other procedures

Most authors recommend simple decompression of the ulnar nerve, although anterior transposition is advisable in patients with a fixed flexion deformity of > 60, and when a space-occupying lesion, such as a ganglion in the cubital tunnel is present (Kato *et al.* 2002). Other procedures, to reduce elbow pain have been described, although these have not been widely adopted. Bateman described denervation of the elbow in a small group of patients with elbow pain and reported improvement in pain in most patients (Bateman *et al.* 1948).

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