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REVIEW

Lateral Epicondylitis: Current Concepts in Pathology, Investigation, and Management

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Abstract

Lateral epicondylitis of the elbow is a common cause of elbow pain and a frequent reason for medical consultation. Comprehension of disease pathology, clinical presentation, and taking evidence-based decisions is crucial for providing the optimal care. Therefore, it is paramount that the clinician is well aware and up-to-date with the *leges artis* and the current evidence-based literature. A thorough review of the most recent literature concerning etiology, pathogenesis, patient presentation, physical examination, imaging, and non-operative and operative treatment options was performed. Tennis is no longer considered the main etiological factor. Pain is mainly localized to the lateral elbow epicondyle and may radiate throughout the forearm, worsening with activity. Lateral epicondylitis is currently viewed as a chronic degeneration of the common origin of the forearm extensor muscles, more commonly the extensor carpi radialis brevis tendon. Magnetic resonance imaging and ultrasound are helpful; however, diagnosis is mainly based on clinical findings. Conservative treatment is successful in most cases; however, there is no recommendation for an individual option. Surgical open release versus arthroscopic debridement is comparable in terms of long-term pain and function. Innovative therapies such stem cell and collagen-producing cell therapy are promising. The treatment of lateral epicondylitis does not have a defined algorithm; taking into account the most recent studies, only some recommendations can be made regarding surgical treatment options. Some new therapies have emerged; however, concerns regarding safety are pending investigation. The physician must therefore analyze the current available information to produce an individualized treatment plan.

Keywords Lateral epicondylitis · Elbow pain · Tendinosis · Radiofrequency microtenotomy · Nirschl procedure · Arthroscopic ECRB release

Introduction

Great changes in concept regarding lateral epicondylitis (LE) pathology have been made. Initially considered an inflammatory condition, nowadays, it is considered as a tendinosis, or chronic painful tendon degeneration of the common origin of the extensor muscles of the forearm (extensor carpi radialis brevis, extensor digitorum, extensor digiti minimi, and extensor carpi ulnaris), more commonly affecting the extensor carpi radialis brevis (ECRB) tendon, in the lateral epicondyle of the humerus (Fig. 1) [1].

With an age distribution ranging from 40 to 59 years, no gender predilection has been identified. In the USA, it has an incidence of 1–3% of the general population [2].

Symptoms are mainly localized to the lateral elbow and forearm and worsen with activity. Diagnosis mainly relies on clinical examination and symptoms, and imaging usually takes a secondary, confirmatory role in investigation [3]. This condition is usually manageable with simple pain medication, and most cases are self-limited, with symptoms resolving in a matter of twelve to eighteen months [4, 5]. Patients with persistent symptoms, who failed to respond to conservative treatment methods, are candidates for surgical intervention [2]. Numerous surgical techniques have been proposed [6]. Although the current literature does not present us with one single diagnosis or management algorithm that can be used across a broad patient population, therefore, it is of extreme importance that the clinician is well aware of this disease, and up-to-date with the current *leges artis*

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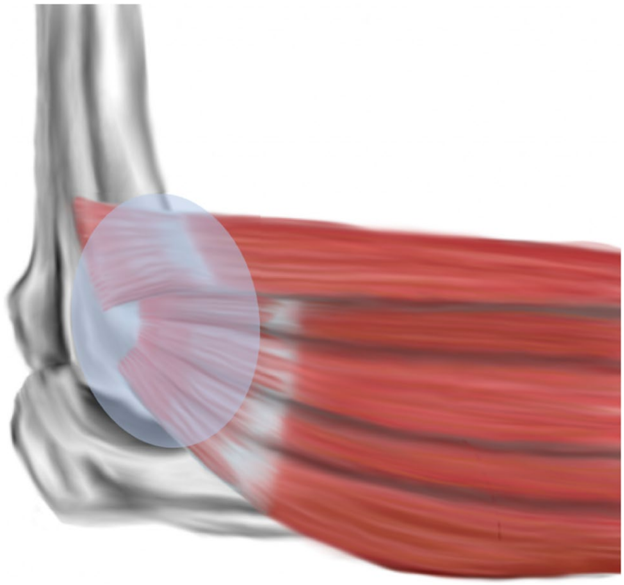

Fig. 1 Common origin of extensor tendons in the lateral epicondyle (light blue shaded area)

and evidence-based studies to guide their treatment plan, providing the patient with the best care possible.

Etiology

While still a matter of debate among the medical community, with no clear underlying cause identified, the term "Tennis Elbow" is a misnomer and should no longer be recognized as the main activity linked to this lesion, as other activities such as repetitive manual work (usually when working with tools heavier than 1 kg, loads heavier than 20 kg more than ten times per day, and repetitive movements for more than 2 h), playing an instrument, or typing can be associated with epicondylitis [7–9]. When related to sports that require the use of the upper extremity, it is usually due to a variety of factors such as incorrect technique, exhaustive playing, overtraining, and racquet size and weight for racquet sports [10].

Therefore, the most accepted etiological factor is repetitive microtrauma due to overuse of the wrist extensor or supinator muscles, either by heavy prolonged workload, overtraining in racquet sports, or incorrect technique while practicing [11].

Pathogenesis and Histology

Considered currently as a tendinosis, without an active inflammatory component, histologically, there is a low level of inflammatory cells such as neutrophils and macrophages, while on the other hand, increase in disorganized collagen deposits, soft-matrix calcification, and fibrosis. Normally, stress or distention to a tendon results in collagen deposition and increased cross-linkage [12]. If this tension exceeds the normal tendon resistance, or shearing as opposed to tensile forces is applied, microtears start to appear, with increased disorganized collagen deposition, with further tendon adaptation to stress until a point where regeneration is difficult. This, in association with the patients' response to pain, results in underuse of the tendon, with muscle atrophy, further diminishing its vascular supply, ultimately leading to what we call a tendinosis, with full tendon degeneration, possible necrosis, and ischemia [11, 13]. Hyperthermic injuries, due to repetitive activities, altered gene expression, and an imbalance of matrix metalloproteinases and growth factors, have also been implicated in the pathogenesis [3, 14].

Ultimately, all of these mechanisms can lead to changes in the peripheral nervous system that can lead to alterations in pain perception, with sensitization and pain exacerbation. This can serve as explanation for why patients with LE sometimes report referred pain, distant from the pathological area. It has been documented that up to 56% of patients with LE have associated pain in the neck [13].

Further studies regarding the exact pathogenesis are required and will eventually aid in future disease management.

Patient Presentation

Clinical symptoms consist in pain on the lateral epicondyle, either anterior to or on the bony prominence, usually radiating to the forearm, following the common extensor muscles. There is tenderness on palpation of the insertion of the common wrist extensor origin or in surrounding areas, hand grip weakness, and pain on counter-resistance dorsiflexion of the wrist. Contraction of the wrist and finger extensors often exacerbates these symptoms [3].

In early/mild cases, pain is maintained at a low level of intensity while performing certain movements during normal daily activities, while in severe cases, constant pain with an impairment of the patient's normal life may be present, even occurring at night, disturbing the normal sleep of the patient [3, 4].

Physical Examination

A careful patient history assessment should be undertaken. Rheumatoid arthritis, cervical radiculopathy (with pain radiating to the forearm), and shoulder pathology should be inquired or assessed and further documented [15, 16].

While inspecting the lateral epicondyle in and early, there are no noteworthy alterations in morphology. However, as the condition evolves, a bony prominence may be present, and this is can be cause either by muscle wasting or by complete rupture of the ECRB tendon. Muscle atrophy and skin alterations can be seen in late-stage disease, the latter usually appearing in patients subjected to corticosteroid injection causing skin depigmentation, and skin atrophy may also be present [3, 10].

Normally, throughout the disease natural course, the range of motion (ROM) is maintained, active, and passive. However, full forearm pronation can reproduce pain, limiting this gesture.

Counter-resistance extension of the wrist in pronation reproduces the typical pain pattern, activating the common wrist extensor mass as a whole [17]. Tests such as Maudsley's test (sensitivity 88%, consisting in resisted third finger extension produces pain, due to selective recruitment of the ECRB tendon), "chair test" (the patient lifts a chair with the forearm pronated, raising stress on the forearm extensors origin), Cozen test (84% sensitivity, consisting in pain during wrist or finger extension against resistance with the elbow flexed at 90º), and Mills test (53% sensitivity, consisting in pain with the elbow in extension and passive wrist extension) can be positive [18, 19]. Diminished grip strength can be reported, but it is not specific to LE, as it can present itself on many other conditions [11].

Posterolateral elbow instability should be ruled out, as there is a common association with epicondylitis. Varus of the cubitus, previous surgical interventions, or dislocations of the elbow should all be assessed.

Imaging and Complementary Tests

Conventional radiographs can show increased radiopacity in the tissues adjacent to the common extensor tendon origin (Fig. 2). They are also useful in the differential diagnosis, distinguishing from pathologies regarding the bone itself, such as fractures, loose intra-articular bodies, osteoarthritis, and osteochondritis dissecans.

Blood tests with inflammatory parameters and autoimmune markers can help investigate other causes of elbow pain, such as local tissue infection, septic arthritis, or rheumatological diseases.

Magnetic resonance imaging (MRI) and ultrasonography (US) are useful when the physical examination is less clear (Fig. 3). US imaging is an outpatient bed-side tool of easy access, useful in characterizing the tendon structure: demonstrating tendon thickening or thinning, intrasubstance degeneration, high-level tendon ruptures or tears, bone-irregularities, and calcium deposits. If a Doppler study is included, then neo-vascularization can also be assessed. If no changes in greyscale ultrasound sonography are found nor is neo-vascularization, then the diagnosis of LE is unlikely [20].

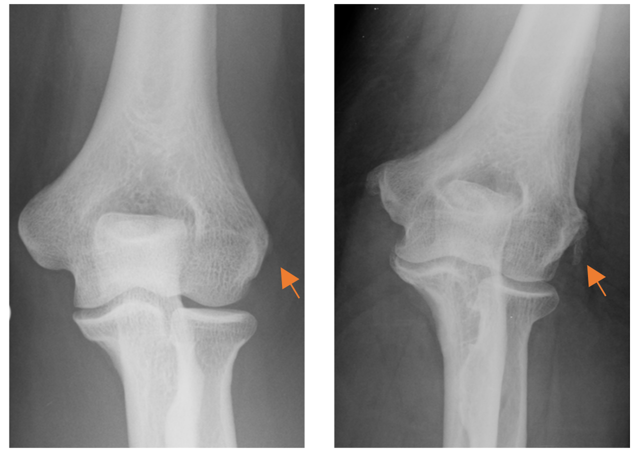

Fig. 2 Radiographs from different patients showing increased radiopacity of the common extensor origin (orange arrows)

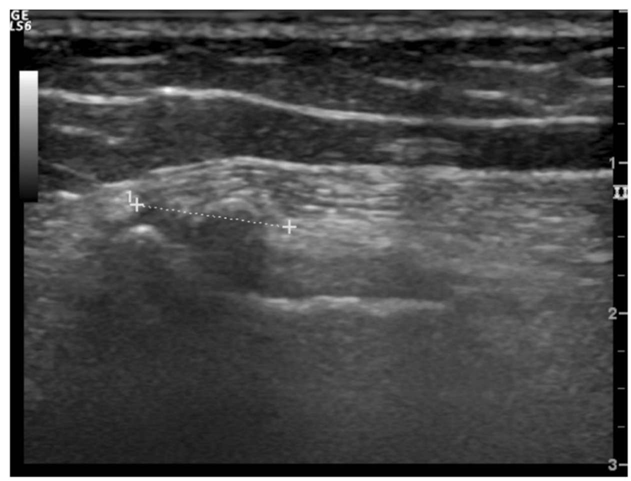

Fig. 3 US showing heterogeneous tendon deformation of the common origin of the extensor tendons

MRI is less subjective than US, with less inter-operator variability. Tendon degeneration or tears at the common extensor origin and underlying capsule are clearly evidenced by this technique. It may also be useful in pre-operative planning and differential diagnosis with degenerative changes (59% of cases of lateral elbow pain refractory to conservative treatment have cartilage alterations in the radiocapitellar joint) because of its capacity to study the entire elbow anatomy (Figs. 4 and 5) [21–23]. It can also be useful in differentiating from inflammation and edema of the anconeus muscle, present in chronic compartment syndrome of the forearm [24], another possible source for lateral elbow pain, especially present during exercise [25].

Computed tomography arthrography, less used nowadays, can help diagnose capsular tears on the deep surface

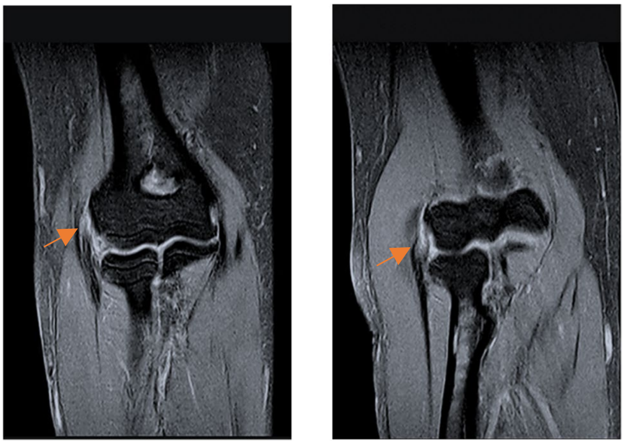

Fig. 4 MRI fat suppressed axial frames showing hypersignal in the common origin the common origin of the extensor tendons (orange arrow)

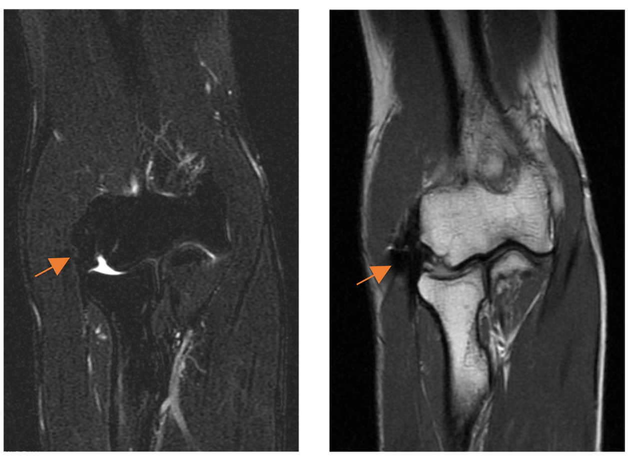

Fig. 5 MRI and T1-weighted (respectively) axial frames showing enlargement of the common origin the common origin of the extensor tendons (orange arrow)

of ECRB, when extravasation of the contrast liquid occurs. It has been demonstrated to be more sensitive than MRI in diagnosing capsular tears [26].

In addition, electrical conductance tests, such as electromyography of the posterior interosseous nerve (PIN) and an anesthetic test with local anesthetic injection just distal to the radial head, can be useful in ruling out posterior interosseous nerve entrapment (radial tunnel syndrome) [27].

In conclusion, the main consideration in the use of most commonly utilized imaging studies is that ultrasonography is an important imaging study that can be used as a screening tool to exclude high-grade tendon tears. If a tear is evident on US, MRI should be considered to evaluate the extent of tendon injury and surrounding structures with precision [28].

Diagnosis is largely based on clinical history and examination, and radiological imaging is not required for diagnosis and does not correlate with patient prognosis.

Treatment

Currently, there is no consensual management protocol or regimen. However, the management of LE can be divided into five main objectives: 1, pain control; 2, range of motion preservation; 3, improvement in function, grip strength, and endurance; 4, return to normal capacity and function; and 5, control of soft tissue microscopic and macroscopic deterioration [3].

Non-Operative

Non-surgical management such as modifications in behavior, corrections in the technique regarding specific sports, avoidance of aggravating or provocative activities, and rest have shown to lead to symptom resolution in many cases [4]. Immobilization or bracing can help manage symptoms. Clasps, orthoses, straps, wrist extension splints, forearm straps, and taping all have some impact on reducing pain while comparing to placebo [29]. Yet, no superiority in regard to which type of contention method/material has been proven confirmed by a recent meta-analysis [5, 30, 31].

Physiotherapy has shown superior results in comparison to "wait and see" management, in reducing pain at 6 weeks, largely due to its effect on maintaining normal ROM and function.

Medication with oral or topical non-steroidal anti-inflammatory drugs (NSAIDs) can improve function at the short term [32, 33].

Corticosteroid (CS) injections are commonly used in the treatment of epicondylitis, and some trials have demonstrated superior results comparing with oral NSAIDs and physiotherapy in the short term (4 weeks) [33]. The exact mechanism of action of CS is not fully understood, but is thought to reside in the anti-inflammatory effect of CS [3]. A randomized trial concluded that multiple injections into multiple areas the tendon ("peppered injections") are superior to a single injection, thought to be due to the effect of penetrating multiples times the degenerated area with a needle, thereby transforming the chronic degenerated fibrotic area into an acute state of inflammation and increasing blood flow [34]. Side effects of CS injection are skin depigmentation (usually the patients' main concern), atrophy, and muscle wasting [35, 36]. However, in the long term, there is no data evidencing any difference between the use of NSAIDs and CS injections. Bisset et al. demonstrated that physiotherapy with elbow manipulation and eccentric exercises is superior in terms of outcome and benefits comparing to CS after 6 weeks, providing a good alternative to injections in the mid to long term [37]. Another study reported no differences between CS injections and saline injections in a 6-month follow-up [38]. The positive short-term outcomes of corticosteroid injection are paradoxically reversed after an average period of 6 weeks; associated with a high symptom recurrence rate, caution should be taken when using this CS injection in the management of tennis elbow [37, 38].

Ultrasound therapy has some advocates in the field. It is thought that the application of mechanical waves on the local painful area is thought to produce mechanical and thermal effects on the target tissue, resulting in vascularization, connective tissue elasticity, cell permeability, and tissue regeneration [39]. The available data suggest that ultrasound therapy provides modest pain reduction in the short to mid-term. However, exercise and physiotherapy appear have greater effect in pain relief when compared to ultrasound therapy [40, 41].

Shockwave therapy, based on generating an intense local energy over the lateral epicondyle in a short period of time, can be beneficial [41–43]. The mechanism of action is not fully known but is theorized to consist of alternate increase in pressure over the affected tissues which in turn increases cellular permeability and microcirculation to the area. With a consequent increase in cellular metabolism, potentiating the healing process, a recent study stated that ultrasound therapy is less effective than radial shockwave therapy, but that both therapies can lead to patient outcome improvement [44].

Low-level laser therapy has also been advocated to clinically reduce pain. The principle is that with laser application, there is a local stimulus to produce collagen and increase deposits within the tendons. Contradictory evidence is presented, with systematic reviews stating no benefit at all regarding laser therapy [45, 46]. However, a recent study found out that success with laser therapy is dose dependent: stating that when administration is carried out, using a low-level wavelength (optimal dose of 904 nm or 634 nm), applied directly to the lateral elbow extensor tendons insertions, seemed to result in short-term pain relief and improvement in functional disability [47]. Further studies should be carried out.

Platelet-rich plasma (PRP) has also been used in the treatment of LE. The technique involves extraction of the patients' blood, centrifugation, and re-injection of the autologous plasma into the lateral epicondyle. The supposed mechanism of action resides in the principle that plasma contains high concentrations of growth factors, which when injected directly to the degenerated area, boosting tendon healing [48]. It was considered a safe and effective tool in reducing symptoms of LE, with concomitant reduction in the need for surgical intervention [49, 50]. Recent evidence stated that regarding pain reduction, PRP injections seem to be effective in managing chronic LE and superior to autologous full blood injections in the short term. However, in terms of functional outcomes, no superiority was demonstrated [50]. Voids in the literature regarding PRP protocols and safety associated with the increasing availability of this type of treatment indicate that more investigations should be conducted in terms of safety and long-term outcomes. Thereby, there is no formal recommendation for these treatments in the meantime due to safety concerns [51].

Acupuncture has shown good short-term results to some extent [52]. Long-term effects are still unclear, and the majority of studies and trials regarding acupuncture are of low methodological quality. Further large-scale trials with a low bias are essential in the future [53].

Botulinum toxin injection can also produce some short-term positive effects in pain relief, by reducing the muscle tone and ECRB tension at its insertion [54]. As opposed, others reported no differences when comparing botulinum toxin injection with saline injection [55, 56]. Importantly, botulinum toxin injections can incur in hazardous side effects, such as weakness of finger extension, experienced by some patients subjected to botulinum toxin injections [56, 57].

Nitrates applied topically (topical glyceryl trinitrate) have shown to be effective in pain reduction [58, 59]. They are thought to act by increasing local blood, thus promoting local healing. However, more long-term studies are needed.

Regarding treatments using stem cells or collagen-producing cells, Tarpada et al. recently produced a review analyzing clinical trials involving these new therapies in humans and animals. They conclude that collagen-producing cell and stem cell therapies have the potential to be more effective for tendon healing, pain management, and restoration of use when compared to the implementation of surgical techniques or conservative treatment options in isolation [51]. Further trials and systematic reviews are needed to back these new forms of therapy.

Operative Treatment

Surgical intervention is reserved for refractory cases that do not respond to conservative measures. Various surgical techniques have been described, and the main surgical principle involves debridement of the degenerated tissue of the ECRB. As so, there are various techniques exist, such as open debridement (classically known as Nirschl procedure) and modifications such as percutaneous release, extensor muscles fasciotomy, V–Y slide of the common extensor tendons, epicondylar resection with ECRB lengthening with anconeus muscle transfer, and decortication, denervation, or perforation of the lateral epicondyle [60–62]. Arthroscopic debridement and open or percutaneous radiofrequency thermal microtenotomy are also common treatment options [63–65].

The Nirschl and Pettrone procedure is described as follows: the patient is positioned in a supine position, with a tourniquet. An oblique incision (4–5 cm) is made anterior to the lateral epicondyle; identification of the interval between the extensor carpi radialis longus (ECRL) and extensor digitorum communis (EDC) tendons is carried out; a small incision is made through this interval, exposing the ECRB tendon directly under the EDC, normally showing signs of degeneration. Excision of the degenerated part and approximately 1 cm of the tendon distally is carried out, with the removal of any adhesions to the EDC tendon. The initial interval is then closed using absorbable sutures, covering the created ECRB defect, and the skin in a layer by layer fashion [3, 60, 66]. In addition to this technique, decortication or perforations can be performed on the lateral epicondyle [60]. ECRB tendon repair with anchors has been described [67].

The percutaneous release of the ECRB, as first described by Baumgard and Schwartz [68], consists of a stab incision over the ECRB insertion, releasing the tendon. This procedure is done with the wrist maximum flexion and forearm pronation; this way the common extensor tendon is under maximum tension [69].

With an increase in popularity over the recent years, arthroscopy has a major role in LE treatment. Arthroscopic debridement and ECRB release (first described by Grifka, Boenke, and Krämer) start by making two outside in portals (anteromedial and anterolateral portals), with joint distention with a saline solution. A thorough inspection of the elbow joint is carried out. Capsule changes, cartilage degeneration, plicas, and other lesions are visible under arthroscopy. Tenodesis of the ECRB origin in the humerus is done using a shaver. Usually the tendon presents some degree of tendinosis, seen as a loss of shiny surface and the observation of disorganized tendon fibers. Further radiofrequency ablation is carried out on and around the tendon footprint, carefully not to damage the lateral collateral ligament complex. Calcifications, adhesions, and tendon remnants are removed from the overlying structures. Further decortication or perforations can be performed on the lateral epicondyle [70, 71].

Radiofrequency (RF) thermal microtenotomy involves the use of a radiofrequency electrode. A small incision is made over the lateral epicondyle, identification of the EDC and ECRL is made, the electrode is introduced in the ECRB to a depth of approximately 3–5 mm, tenotomy of the ECRB is performed, and destruction of the pathological degenerate tissue is carried out. This technique may be performed percutaneously, and ultrasound may be used concomitantly to improve accuracy. Lab tests show that the application of radiofrequency alters the morphology and disrupts the cell structure of tendons, nerves, and other structures. There is a neuromodulation component tied to RF microtenotomy [64]. Still, the complete mechanism of action is not fully understood.

Few randomized studies about RF efficacy exist. Improvement in pain but with no tendon structural changes following RF has been reported [64]. One study found comparable results to arthroscopic debridement during the recovery phase [72]. One study comparing RF to open release shows comparable results between the two in short and medium term, but in the long term, RF results are prone to decline [73]. One advantage of RF to arthroscopy and open procedures is that it can be repeated if pain reappears, as the technique is minimally destructive and can be performed under local anesthesia [3, 64].

Open release has the advantage of full inspection of the lateral epicondyle and surrounding structures and in turn allows for careful separation of the EDC and ECRL from the degenerative tissue of the ECRB [3]. When accurate resection of the degenerated tissue is performed, this technique remains highly successful in the long term [74]. Problems may arise as consequence of excessive debridement, further compromising elbow stability [74].

Arthroscopy has the advantage of joint inspection and is believed to provide an earlier return to the premorbid level of activity compared with open techniques [70, 71]. It is considered a reliable treatment for LE and has a high success rate at a long-term follow-up [64]. But, however, functional outcomes and absenteeism from work or daily life are highly variable throughout studies in regard to arthroscopic release versus open release, with many studies reporting no statistical significance in the difference between arthroscopic release and open release techniques [4, 71, 75–77]. It is noteworthy that there is an increase in average surgery time (comparing with open release), and arthroscopy is also associated with the potential risk of damage to the radial nerve [71, 78].

No advantages were seen in ECRB lengthening or lateral epicondyle decortication or perforation, with the latter having the documented side effect of increased postoperative pain [79, 80].

Although good outcomes were reported with tendon repair with anchors [67], the current literature lacks consistent information comparing tendon repair with simple release.

There is no universal consensus regarding the optimal open surgical technique. We can conclude that both open and arthroscopic techniques are valid and reliable treatment options for patients with persistent lateral epicondylitis.

Both patients submitted to open and arthroscopic surgery are usually discharged the same day as the intervention, in an outpatient protocol manner. Rehabilitation protocols should be instituted, with early passive-assisted motion on the first postoperative day. Strengthening exercises can take place at 6-week post-op. Patients should avoid the pain-triggering gestures and activities for a minimum of 3 months. Usually, patients can expect to return to work within 4 to 12 weeks (for jobs that require manual labor). Desk workers can return to work promptly with modified behavior to enable full recovery [3, 4].

Although surgical intervention has shown good outcomes in the majority of patients (generally nine out of ten patients improve their pain and functional status), the associated risks, such as infection, haematoma, and nerve injury, are not infrequent [3, 4, 78].

In patients with persistent significant symptoms despite exhaustive treatment (conservative and surgical), it is important to consider the possibility of wrong diagnosis or the presence of another associated pathology.

Conclusions

Lateral epicondylitis is one of the most common causes of lateral elbow pain in the general population. It is considered a tendinosis with degeneration of the origin of the common wrist extensors, and is usually a self-limiting entity, with a normal course of 12 to 18 months.

Careful assessment of patient history and a physical examination are crucial for diagnosis; further investigations using MRI or US can be performed, but must not serve as a substitute for clinical evaluation.

Although an innumerable amount of rehabilitation protocols and treatment options exists for LE management, one should start with the less invasive treatment, with behavior modification, eventually following the normal therapeutic scale ladder and medical common sense. In the majority of patients, improvement in pain and function with good results is usually observed with conservative measures. There is still currently no gold standard option in conservative therapy. As no non-operative treatment option has demonstrated clear superiority, none constitutes a solid-specific recommendation for conservative treatment.

In refractory cases, surgical intervention can be indicated. Various techniques are available, and their main surgical act is the debridement of the degenerative tissue of the extensor carpi radialis brevis.

Radiofrequency microtenotomy is the less invasive technique, with fewer risks regarding excessive debridement tied to other techniques, but shows no superiority in terms of function and pain in the short and mid-term, with a greater tendency for poorer outcomes when compared to open release or arthroscopic techniques in the long term.

Arthroscopy has the main advantage of inspection of the elbow joint. Open techniques allow a careful release of the affected tendon, with tissue debridement. In the meantime, both open and arthroscopic techniques are considered useful and reliable treatment options for patients with persistent lateral epicondylitis.

Innovative treatments such stem cell and collagen-producing cell therapy show promising results; however, further investigations should be carried out, addressing the mechanism of action, long-term efficacy, and safety.

Author Contribution Emanuel C. Seiça was responsible for data collection, referencing, interpretation, analysis, conclusions, and text elaboration, being the main author and corresponding author. Alexei Buruian was responsible for reference revision and text proof-reading and corrections. Diogo Gameiro was responsible for reference revision and text proof-reading. Daniel Peixoto was responsible for study orientation, data collection, reference revision, and text proof-reading. Carlos Pereira was responsible for text proof-reading.

Data Availability Not applicable.

Code Availability Not applicable.

Declarations

Ethics Approval Not applicable.

Consent to Participate All clinical and radiographic images utilized were selected from our institutional local archive and utilized with patient's consent.

Consent for publication The author and co-authors consent for publication. The patients whose complementary tests were used consent for publication.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

Competing Interests The authors declare no competing interests.

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