



SURGICAL METHODS IN THE TREATMENT OF BASAL THUMB ARTHRITIS – FROM ARTHROSCOPY TO ARTHROPLASTY

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SUMMARY – The first carpometacarpal joint is the second most common joint affected by degenerative arthritis. The prevalence of the first carpometacarpal joint arthritis increases with age, especially in postmenopausal women. Ligamentous laxity or injury of the first carpometacarpal joint is thought to be the starting point of development of degenerative changes, accompanied with altered biomechanics of the thumb. As the disease progresses, the joint is destroyed and the thumb and hand function are deteriorating. Although many patients, in different stages of disease, experience pain relief with conservative treatment, surgery is often needed. Decision on the type of surgical procedure depends on the age of the patient, functional demands, and stage of the disease. In early stages of the disease, stabilization of the first carpometacarpal joint, extension osteotomy of the first metacarpal and arthroscopic procedures are used. These are joint-preserving procedures, and they slow down progression of the disease and reduce symptoms. In late stages of the disease, joint arthroplasty procedures and first carpometacarpal arthrodesis are performed. In recent years, late stages of the disease can also be treated arthroscopically. This paper describes different surgical methods, their advantages and drawbacks, with respect to different stages of the disease.

Key words: *Hand; Thumb; Rhizarthrosis; Carpometacarpal joint; Osteoarthritis; Surgery*

Introduction

The thumb has an extremely important role in the function of the hand. That function is enabled by a large range of motion of the thumb, dominantly in its basal joint, the first carpometacarpal joint (1st CMC). Due to that large mobility, the thumb is more susceptible to injury, development of overuse syndromes, and degenerative changes. Osteoarthritis of the 1st CMC joint is also known as basal thumb

arthritis, trapeziometacarpal osteoarthritis and rhizarthrosis. After the knee, 1st CMC is the second most common joint affected by osteoarthritis¹. Women are more susceptible to develop basal thumb arthritis due to increased ligamentous laxity in postmenopausal period². Genetic factors, age, obesity, overuse, intraarticular fractures and ligamentous injuries of 1st CMC joint and systemic diseases such as rheumatoid arthritis also increase the risk of developing basal thumb arthritis³⁻⁶. Although many patients experience pain relief with conservative treatment options, such as activity modification, nonsteroidal anti-inflammatory medications, splints or corticosteroid and hyaluronic acid injections, operative treatment is often needed. In

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this paper, we present a variety of surgical techniques available for the treatment of basal thumb arthritis, their advantages and drawbacks.

Anatomy and Mechanism of Disease

The thumb rests in pronated position, flexed approximately 80° relative to the plane of the palm, which allows opposition towards the fingertips and more complex motions such as grasping. The radius of the first metacarpal base curvature is by 34% bigger than the one of the trapezoid, which allows a wider range of motion but may predispose to joint incongruity and instability⁷. This disproportion is more expressed in women who also have thinner trapezium cartilage^{8,9}. Because of bony instability of the 1st CMC joint, 16 surrounding ligaments help stabilize it. The most important one is the volar oblique ligament ('beak' ligament) which acts as a pivot point and limits extreme range of motion, as well as the dorsal radial ligament¹⁰. It is postulated that pathologic ligamentous laxity because of chronic synovitis, overuse or injury of the beak ligament increases the risk of degenerative changes seen in the 1st CMC joint of the thumb due to destabilization of the joint¹⁰. In the course of disease, ligaments that normally reinforce the ulnar side of the 1st CMC joint (anterior oblique, ulnar collateral and intermetacarpal ligaments) become weak and partially ruptured due to chronic synovitis. These ligaments are no longer able to resist the prevailing, radially directed forces that naturally occur with a thumb pinch. Subsequently, the patient develops a deformity where the base of the first metacarpal slides radially, or dorsoradially relative to the trapezium¹¹. In the area of high contact, shear stress forces can damage articular cartilage and cause progression towards osteoarthritis¹². Compensatory hyperextension may occur in the metacarpophalangeal joint with dynamic collapse while pinching¹³.

Clinical Presentation

Patients often complain that activities requiring pinch grip such as opening jars, using a key or remote control cause severe pain in basal thumb joint. Stiffness, pain at rest, and joint deformity are usual indicators for late-stage disease. Point tenderness at the carpometacarpal joint and pain with axial compression of the thumb followed by circumduction (grind test) are pathognomonic signs for basal thumb

arthritis¹⁴. Symptoms should be differentiated from first extensor compartment tenosynovitis (de Quervain disease), carpal tunnel syndrome, carpal fractures, osteoarthritis of nearby joints, Preiser disease, and stenosing tenosynovitis of the thumb flexor tendon. Standard radiographic evaluation that includes posteroanterior and lateral views of the hand have to be supplemented with two additional projections, true anteroposterior (Roberts) view and true lateral (Betts) view of the thumb, where the 1st CMC joint is best visualized¹⁵. Magnetic resonance imaging (MRI) is helpful especially in early stages of the disease, as it shows cartilage wear, ligament injuries, synovitis, and loose bodies. In 1973, Eaton and Littler¹⁴ introduced a widely accepted radiographic staging system for thumb CMC arthritis (Fig. 1).

Methods of Surgical Treatment

A variety of surgical procedures are described in the literature for pain relief and improvement of hand function. The type of operation depends on patient age, functional demands, and stage of the disease.

Operative Treatment in Early Stages of Basal Thumb Arthritis – Joint Preserving Procedures

In early stages of the disease (Eaton stage 1 and 2), joint-preserving procedures are used. Their goal is to stabilize the CMC joint and reduce inflammatory process in order to slow progression of the disease and reduce its symptoms.

Stabilization of 1st CMC joint

Eaton *et al.*¹⁶ describe the method in which half of the flexor carpi radialis tendon was proximally separated from the muscle and then passed through the volar to dorsal tunnel across the base of the first metacarpal bone, parallel to the trapeziometacarpal joint, in order to stabilize the 1st CMC joint by reconstructing beak ligament (Fig. 2A). The advantage of this technique is that trapezium is preserved, so the patients have good pinch and grip strength. Disadvantage of this procedure is that flexor carpi radialis tendon is used, which may be required for future treatment in case of disease progression. In early stages with dorsal subluxation of the 1st CMC joint, simple imbrication of the dorsoradial capsule can provide joint stability¹⁷. Advantage of this procedure is that it is a much simpler procedure that does not require tendon grafts, but it



Fig. 1. Eaton and Littler Classification¹⁴: (A) stage I – slight joint space widening (pre-arthritis); (B) stage II – slight narrowing of first carpometacarpal (CMC) joint with sclerosis, osteophytes <2 mm; (C) stage III – marked narrowing of first CMC joint with osteophytes >2 mm; (D) stage IV – pantrapezoidal arthritis (scaphotrapezotrapezoidal joint involved).

may not be sufficient to support the 1st CMC joint if volar beak ligament is insufficient. It can be used as an additional procedure for stabilizing the 1st CMC joint.

First metacarpal extension osteotomy

First metacarpal extension osteotomy (Fig. 2B) is performed one centimeter distal from the 1st CMC joint¹⁸. A 20- to 30-degree bone wedge is removed from the radial side of the metacarpal bone. The site of osteotomy can be fixed with tension bend wires or with 'T'-plate and screws or staples. The rationale of this operation is to move the load force from the damaged, volar part of the joint dorsally, thereby reducing pain and slowing progression of the disease. First CMC joint laxity is also decreased during pinch because more metacarpal flexion is needed, which

causes tightening of the dorsal radial ligament¹⁹. Disadvantage is a higher percentage of infections and revision surgeries because of hardware removal, non-unions, tendon irritation, and tendon ruptures²⁰. This procedure is not suitable for patients with fixed dorsal subluxation of the 1st CMC joint, hyperlaxity and joint hyperextension.

Arthroscopy for early basal thumb arthritis

Arthroscopy of the basal thumb joint in early stages of osteoarthritis allows visualization of the entire joint and appropriate treatment (Fig. 2C). Arthroscopic classification of 1st CMC osteoarthritis was introduced by Badia²¹. In stage 1, cartilage damage and synovitis are treated with debridement and synovectomy, and removal of loose bodies^{22,23}. In the presence of dorsal

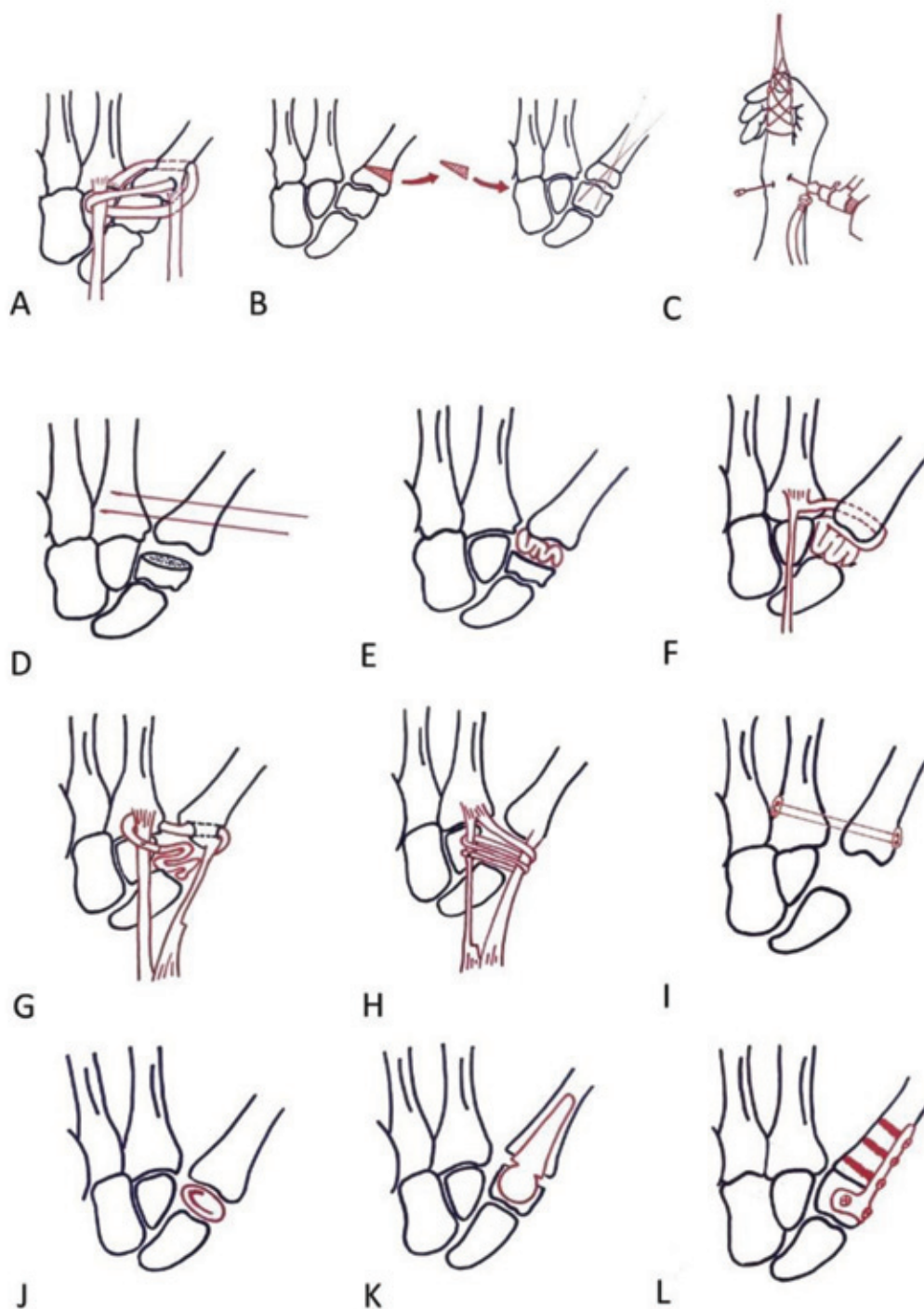


Fig. 2. Schematic presentation of operative procedures for basal thumb arthritis: (A) stabilization of first carpometacarpal (CMC) joint with flexor carpi radialis tendon; (B) first metacarpal extension osteotomy; (C) arthroscopy of first CMC joint; (D) hematoma distraction; (E) tendon interposition arthroplasty; (F) ligament reconstruction and tendon interposition with flexor carpi radialis tendon; (G) ligament reconstruction and tendon interposition with abductor pollicis longus tendon; (H) Weilby's suspensionplasty with a strip of flexor carpi radialis tendon wound around abductor pollicis longus and rest of flexor carpi radialis tendon; (I) suture-button suspensionplasty with mini Tight-Rope; (J) pyrocarbon interposition arthroplasty; (K) prosthetic arthroplasty of first CMC joint; (L) arthrodesis of first CMC joint.

subluxation, arthroscopic stabilization of the 1st CMC joint is performed by electrothermal heating and shrinkage of volar ligaments and joint capsule with monopolar radiofrequency probe, followed by immobilization²⁴. For stage 2, it is recommended to add first metacarpal extension osteotomy to arthroscopic procedure²⁵. Advantages of arthroscopic procedures are a minimally invasive approach and less scar tissue, direct visualization and treatment of joint pathology. Disadvantages are inability to reconstruct 1st CMC ligaments and danger of thermal injuries to the cartilage.

Operative Treatment in Late Stages of 1st CMC Osteoarthritis – Joint Arthroplasty Procedures

Progression of the disease (Eaton stage 3 and 4) leads to the development of significant degenerative changes, primarily on the trapezium, with loss of the cartilage cover and development of large osteophytes. Because of that, in later stages of basal thumb arthritis, partial or complete removal of the trapezium bone (trapeziectomy) combined with different joint stabilization procedures are the methods of choice. The main technical pearl, whether partial or complete removal of the trapezium is performed, is complete removal of osteophytes on the trapezium between the first and second metacarpal bone. That will enable reposition of the first metacarpal bone, eliminate pain, and improve function of the thumb.

Hematoma distraction

Good results with minimal complications shows a technique called 'hematoma distraction'²⁶ (Fig. 2D). After complete or partial trapeziectomy, metacarpal bone is fixed with Kirschner wire in a slightly overcorrected position, without tissue interposition or ligament reconstruction, in order to prevent proximal migration until hematoma is stiffened. Kuhns *et al.*²⁶ report excellent results with this operative technique. Initially, this technique offers a pain-free and good range of thumb motion but subsidence and instability of first metacarpal can occur, and patient can start to feel pain and loose strength. Also, over time, cranial migration of metacarpal bone (subsidence) can cause impingement with the scaphoid.

Interposition arthroplasty

In order to prevent subsidence, in 1970, Froimson²⁷ described a technique of tendon interposition following trapeziectomy (Fig. 2E). Upon careful dissection and excision of the trapezium, the flexor carpi radialis tendon (FCR) was split and half of it was used as an interpositum in the place created by trapezial excision in order to prevent metacarpal migration. In similar manner, the abductor pollicis longus tendon (APL) can be used as interpositum. Due to increasing number of younger and highly active patients that need not only surgical treatment but also faster rehabilitation, various allogeneic materials such as silicon²⁸⁻³⁰, polytetrafluorethylene (Gore-Tex)²², polyurethane (Artelon)³¹, acellular matrix (Graftjacket)³², and titanium³³ were developed for interpositum because of their strength, but with time, instability of the implant and its wear resulted in inflammatory synovitis and recurrence of pain³⁴. Pyrolytic carbon implants are used as nonanatomic implants after partial or complete trapeziectomy³⁵ (Fig. 2J). It has elasticity comparable to cortical bone, and should be used in patients without subluxation of trapeziometacarpal joint and without scaphotrapeziotrapezoidal joint involvement³⁶. Pyrocarbon implants provide good grip strength and range of motion, and can be used for revision procedures. The main problem concerning pyrocarbon is subluxation of the implant described in several studies, and need of revision³⁷. Therefore, more long-term studies are still needed to evaluate this implant.

Ligament reconstruction – suspensionplasty

In 1986, Burton and Pellegrini³⁸ described surgical technique that combined ligament reconstruction, similar to the technique of Eaton *et al.*¹⁶, and tendon interposition, similar to the technique of Froimson²⁷. Half or whole tendon of flexor carpi radialis is harvested and then passed through the previously made hole in the base of metacarpal bone in order to reconstruct ligamentous complex (Fig. 2F). The remaining tendon is interpositioned and sutured to the capsule between the scaphoid and first metacarpal bone. The goal of this procedure is to create suspension of the first metacarpal like a hammock that would stabilize the first metacarpal. Tomaino *et al.*³⁹ report on excellent pain relief in 95%

of operated patients during long-term follow up. There are several modifications of this technique reported, such as the use of interfering screw for fixation of the FCR tendon in the first metacarpal bone in order to achieve early mobilization and faster recovery⁴⁰. This is the most popular procedure for treatment of 1st CMC osteoarthritis and generally provides very good results but subsidence can still occur over time because of rupture or attrition of the FCR tendon. Tendon can also be injured intraoperatively, especially during removal of the trapezium, and it should be recognized during surgery. If tendon injury is not severe, it can be reinforced with suture, but if there is severe injury of the tendon, different procedure should be performed.

However, it has been reported by some authors that the use of the FCR for basal thumb arthritis is associated with weakness in wrist flexion and torsion⁴¹. Because of that, Thompson⁴² has described the 'suspensionplasty' technique using a slip of the APL (Fig. 2G). The idea was not to reconstruct volar beak ligament but to recreate the intermetacarpal ligament. After trapeziectomy, he used a distally based strip of the APL, made a tunnel in the base of the first and second metacarpal bone, and then suspended the base of the first metacarpal to the second metacarpal. The remaining tendon was used as an interposition. Reporting on 50 suspensionplasties over an 8-year period, using tendon interposition to fill the space of the trapezium, Thompson describes "generally excellent" outcomes, with pain reduction and improved mobility and strength⁴². Disadvantages of suspensionplasty techniques include possible injury to the superficial radial nerve and a cosmetically unappealing bump. Sigfusson and Lundborg⁴³ modified Thompson's technique so that it did not require bone tunnel in second metacarpal. They passed the APL tendon around the FCR tendon and sutured it back to itself on insertion on the first metacarpal.

Weilby⁴⁴ has published an alternative 'suspensionplasty' technique that also does not require bone tunnel creation at the base of the first metacarpal bone (Fig. 2H). In this procedure, the trapezium is removed, after that approximately one third of the FCR tendon is harvested and mobilized to its insertion on the second metacarpal base. Subsequently, the harvested tendon graft is used as a sling to wind together the abductor pollicis longus tendon and the remaining two thirds of the FCR tendon as a suspension and interposition arthroplasty.

Recently, suture-button suspensionplasty with mini Tight-Rope (Arthrex) was introduced and it is becoming more and more popular⁴⁵ (Fig. 2I). Suture-button system is made of sutures looped across two titanium buttons. After trapeziectomy and reposition of first metacarpal, bone tunnel is made through first and second metacarpal in oblique manner, from dorsoradial border of first metacarpal into proximal diaphysis of second metacarpal. Suture-button system is passed through that tunnel and buttons are placed on both metacarpals, and suture is tensioned and secured. Oblique position of the tunnel is thought to be better in preventing subsidence. Some authors place two suture-button systems to provide more secure stabilization of first metacarpal⁴⁶. The advantage of this procedure is that it allows early mobilization and fast recovery because it does not need time to heal. It can also be good solution for revision cases. Drawbacks are some subsidence, cost of implant(s), and possible nerve injury and metacarpal fracture⁴⁷.

Arthroscopy for late basal thumb arthritis

As technology continues to evolve, new advances in arthroscopy give us a possibility to achieve good strength of the thumb and pain reduction even in late stages of basal thumb arthritis. With camera control, hemitrapeziectomy can be done in a manner of producing contour of smooth flat surface by removing all osteophytes and loose bodies⁴⁸. After that, thermal capsulodesis, with or without addition of Kirschner wire, can be done in order to stabilize the joint¹⁷. There is no published paper on arthroscopically done ligament reconstruction yet, but suspensionplasty, as mentioned before, can be achieved by the use of Mini Tight-Rope⁴⁵. Finally, allogeneic or autogenous material can be placed as interpositum to avoid metacarpal subsidence. The advantage of this procedures is that capsule is intact and there are reduced chances of damage to radial sensory nerve branch. Disadvantage is that these procedures are technically demanding and could require longer operation time and use of fluoroscopy to confirm complete removal of osteophytes and adequate removal of trapezium.

Prosthetic arthroplasty

Total joint arthroplasty was also introduced as a method of treatment for basal thumb arthritis (Fig. 2K). First total joint endoprosthesis was done back

in 1979 by de la Caffiniere and Aucouturier⁴⁹. Over time, more prosthetic implants have been developed. They all had very good short-term results, better than trapeziectomy and arthrodesis, but over time they showed poor survival rate and high loosening rate of 44%⁵⁰. The main complications were hardware failure (including dislocation, subsidence and loosening of the components), persistent pain, neurologic damage, inflammation of the surrounding tissues, and peri-implant fractures. Among all, the most frequent is hardware failure because of the really small implant dimensions and thinness of the cortical bone of the joints involved. Although there are some studies that show good long-term results for certain types of prosthesis, with good strength and mobility of the thumb, literature review does not show that total arthroplasty is superior to trapeziectomy. Complications of prosthetic arthroplasty that are much higher and more difficult to manage and significant cost of implant are the drawbacks of this procedure⁵¹.

Arthrodesis

Trapeziectomy, whether it is a single or combined with any other described techniques, never provides enough strength for high-demanding patients. First CMC arthrodesis should be a reasonable procedure if strength is crucial (Fig. 2L). It is to be noted that in arthrodesis, postoperative thumb function depends on increased mobility of surrounding joints to compensate for the lack of motion at the fused trapeziometacarpal joint. Because of that, in stage 4 of basal thumb arthritis where degenerative changes are extended to the surrounding joints, arthrodesis is contraindicated. Muller⁵² described technique in 1949. The thumb is fixed with screws or plate and screws in a position of 30–40° palmar abduction, 35° of radial abduction, 15° of pronation and 10° of extension. Surgery creates a pain-free, strong, stable thumb at the expense of full range of motion⁵³. The possible complications are more postoperative infections and pseudarthrosis. Also, as in other arthrodesis, degenerative changes will in time spread to the surrounding joints, or hyperextension of MCP joint can develop⁵³. The advantage of this procedure is that in exacerbation of disease, you can still perform simple trapeziectomy combined with other procedures mentioned above.

Treatment of Hyperextension of First Metacarpophalangeal Joint

Adduction deformity of first metacarpal in advanced stages of disease can cause hyperextension and instability of the first metacarpophalangeal (1st MCP) joint, 'zigzag' deformity of the thumb¹³. If this deformity is not corrected with treatment of the 1st CMC joint, it will cause weak pinch of the thumb, and intercalated instability of first metacarpal which will regain adducted posture in order to stabilize 1st MCP joint. That adducted posture will then put an excessive stress on 1st CMC arthroplasty. For this reason, it is mandatory to treat hyperextension deformity of the 1st MCP if it is greater than 30°¹³. It can be treated with volar plate capsulodesis or transfer of extensor pollicis brevis along with temporary transfixation of MCP joint with K wire in semiflexion^{54,55}. If the joint is grossly unstable or arthritic, MCP joint arthrodesis is the best solution.

Conclusion

There are many different techniques for the treatment of 1st CMC osteoarthritis to achieve the best possible functional results if conservative treatment fails. In early stages of the disease, ligament laxity or rupture and cartilage wear with synovitis are the main problem, and arthroscopy, metacarpal osteotomy and 1st CMC stabilization are performed to address specific pathology. Late stages include severe degenerative changes with large osteophytes, especially in the first intermetacarpal space, and they need to be removed with partial or complete trapeziectomy. Additional procedure such as interposition arthroplasty, ligament reconstruction and suspensionplasty, is usually performed to achieve stability of the 1st CMC joint and to prevent subsidence of first metacarpal. Total joint arthroplasty theoretically has the best predisposition to accomplish stable joint with good range of motion but more long-term studies are needed. First CMC arthrodesis is still preferred if the patient needs to be very active with high loads on his hands. The surgeon needs to be familiar with several different methods in order to provide appropriate treatment for each patient, and to be able to perform revision procedures or treat intraoperative complications.

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Sažetak

OPERACIJSKE METODE U LIJEČENJU ARTROZE PRVOG KARPOMETAKARPALNOG ZGLOBA PALCA
ŠAKE – OD ARTROSKOPIJE DO ARTROPLASTIKE*Z. Sulje, D. Starčević, A. Aljinović i K. Barbarić Starčević*

Prvi karpometakarpalni zglobov je druga najčešća lokalizacija za razvoj degenerativnih promjena. Učestalost artroze prvog karpometakarpalnog zgloba povećava se s dobi, pogotovo u postmenopauzalnom razdoblju. Laksitet ligamenata i ozljede prvog karpometakarpalnog zgloba se smatraju razlogom nastanka degenerativnih promjena, zajedno s promijenjenom biomehanikom palca. Kako bolest napreduje zglobov se uništava i smanjuje se funkcija palca. Iako kod mnogih bolesnika, u različitim stadijima bolesti, konzervativno liječenje dovodi do poboljšanja, često je potrebno operativno liječenje. Odluka o vrsti operativnog zahvata ovisi o dobi bolesnika, funkcionalnim zahtjevima i stadiju bolesti. U ranim stadijima bolesti izvode se stabilizacija prvog karpometakarpalnog zgloba, ekstenzijska osteotomija prve metakarpalne kosti i artroskopija. To su postupci koji čuvaju zglobov i usporavaju razvoj bolesti te smanjuju simptome. U kasnim stadijima bolesti provode se postupci artroplastike prvog karpometakarpalnog zgloba i artrodeze. U novije vrijeme se i kasni stadiji bolesti mogu liječiti artroskopskim postupcima. U ovom radu opisujemo različite kirurške metode, njihove prednosti i nedostatke, s osvrtom na stadij bolesti.

Ključne riječi: *Šaka; Palac; Rizartroza; Karpometakarpalni zglobov; Osteoartritis; Kirurške tehnike*