

Arthroscopic versus open surgery and therapeutic options of Kienböck's Disease

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Abstract

Introduction. The goal of this study was to compare the two surgical procedures (arthroscopic versus open surgery) in the treatment of Kienböck disease (KD) and all therapeutic options depending on the stage of disease. **Materials and Methods.** Various electronic databases were used to search for articles on this topic. This review aims to evaluate and summarise the various surgical interventions and their outcomes in KD. **Results.** Many treatments for KD are described, various surgical options are available based on the stage of disease. The surgical procedure including radial shortening osteotomy, capitate shortening osteotomy, total wrist arthrodesis, proximal row carpectomy, scapho-trapezio-trapezoid arthrodesis, vascularized bone grafting, excisional arthroplasty are the most commonly used. In the study there were included a number of 190 patients in different stages (Lichtman) of KD. They have undergone to surgical interventions (arthroscopic and open surgery) by following the same things in each group; decreasing pain, increasing range of motion (ROM) and grip strength, also earlier return to unrestricted daily activities. Patients were follow-up for a long period (between 1 year and 10 years postoperative). **Conclusions.** 1. For each stage of KD, there are several therapeutic options. 2. Preoperative arthroscopic evaluation of cartilage damage can inform treatment decisions. Arthroscopic surgery resulted in shorter operating time, shorter hospital stay and earlier return to unrestricted daily activities.

Key words: *Kienböck disease, wrist surgery, rehabilitation for kienböck disease*

Introduction.

Arthroscopy is the minimally invasive alternative to the classical surgical technique. The procedure appeared at the end of the 19th century, developed in the 20th century, and today most of the surgeries in sport traumatology are performed arthroscopically [1]. At the beginning arthroscopy was used as a mean of exploration and diagnosis, which is still happening today (an articular cartilage is much better visualized and arthroscopically explored in real time than by any other imaging means). Arthroscopic intervention allows the diagnosis to be very accurate, and most of the times, the solution for the orthopaedic condition. Thus arthroscopy has evolved over time from a method of exploration and diagnosis to being also a treatment one. The advantages of the method to open surgery consists in shorter hospital stay of the patient, less pain and complications (infections or arthrofibrosis) and shorter rehabilitation time [1]. This is why it is widespread in sports medicine.

The overtime development of arthroscopy has allowed the majority of such procedures to be performed in outpatients, with daily hospitalization and under different types of anesthesia, from local, regional to general, depending on the joint on which they are working, the patient's preferences and the knowledge of the anesthetist. The widest arthroscopic pathology that is successfully performed, is on the

knee and on the shoulder, the broad joints on which the approach can be performed comfortably. Some of the ankle and the elbow disorders can be treated arthroscopically, and when it comes to the wrist, the arthroscopy represents the gold standard for the diagnosis of intra-articular pathology: removal of loose body, arthroscopic debridement in case of chondral defects, synovectomy, degenerative arthritis or septic arthritis [1].

Kienböck's disease (KD) was discovered by the Austrian radiologist Robert Kienböck in 1910 and although it has been over 100 years since then, the pathogenesis of the disease has not been fully elucidated even today [2]. KD is an avascular necrosis of the lunate bone, manifested by collapse, sometimes with bone fragmentation caused by the poor nutrition of the lunatum due to rupture of ligaments and blood vessels following a single strong trauma (contusion, sprain, and subluxation) or a minor repetitive trauma. It seems that the lunate bone geometry plays an important role in triggering of the disease, therefore patients with negative ulnar variance are more liable to the disease, because a shorter ulna increases the forces that pass across the radiolunate joint, generating a high risk of osteonecrosis. The disease is manifested by pain of the dorsum of the wrist and chronic dysfunction in latest stages. KD affects

commonly men between the ages of 20 and 40 and occurs very rarely bilaterally [3,4].

Materials and methods

The materials used are clinical trials conducted over the last 25 years and 95% come from the electronic database "Pubmed". The aim of this article is to evaluate and summarize the therapeutical options for treatment depending on the stages of KD as well as the advantages of one or the other of the two surgical procedures: arthroscopy or open surgery. In the study were included a number of 190 patients in different stages (Lichtman). They have undergone to different type of surgical interventions (arthroscopic and open surgery), by following the same parameters for each type of operation: decreasing pain, increasing range of motion (ROM), improvement of grip strength and early return to daily activities. The patients were followed up for a long period (between 1 year and 10 years postoperative).

In choosing the treatment of KD three method are taken into account: the stage of the disease, the ulnar variance and the presence or absence of osteoarthritic changes. In the medical literature, there are several classifications but the most used is Lichtman classification, that includes four stages with two subdivisions of the stage III.

Stage I is noticeable by the absence of visible changes, or sometimes it may appear a fine line of fracture, barely visible on plain radiograph. The patient in stage I of the disease required a magnetic resonance imaging (MRI) [3,4].

Stage II The radiography shows a high lunate bone intensity associated often with fracture lines. Sclerotic changes are seen in the lunate but its height is preserved. The clinical symptom of the patient is synovitis [3,4].

Stage III A. It is obvious the collapse of lunate bone, but with maintaining the alignment and the height of the first row of carpal bones. The radiography in lateral view shows an enlargement of dimensions in anteroposterior plane of the lunate. The clinical symptom included stiffness.

Stage III B. There is a flattening of lunate with loss of carpal height, appears the scaphoid rotation (ring sign), proximal migration of capitate bone with/without ulnar deviation of the triquetrum. The clinical symptoms take to joint instability [3,4].

Stage IV. Severe collapse with degenerative disease at mid-carpal joint, radio-carpal joint or both. Clinical

symptomatology included swelling, pain and limiting movements in the wrist joint [3,4].

The treatment of KD uses the prolonged wrist splinting (between 6 and 12 weeks) which is possible only in the first stage of the KD, but otherwise included in the rest of the stages surgical procedures divided into three major categories.

A. Uploading the lunate bone from the forces that act upon it

B. Lunate revascularization

C. Salvage procedures (in the latest stages of the KD). *Surgical interventions in Early Stages (Lichtman Stages I, II, IIIA), the carpal bones maintained the alignment and height.*

We currently have a lot of surgical procedures; the most important factor to take into account is the ulnar variance. There are three types of ulnar variance: negative, neutral and positive.

Patients with negative ulnar variance (ulna is shorter than the radius) need bone levelling procedures (radius shortening or ulna lengthening).

Patients with neutral and positive ulnar variance are suitable for the procedures of shortening (adjusting) the capitate bone, with/without capito-hamate arthrodesis or the radial wedge osteotomy.

Stages II and IIIA with neutral or positive ulnar variance: Treatment is identical with the only mention that in stage II the lunate bone is nonvascularized, but without collapse, so it can be performed the lunate bone revascularization procedure which includes transfer from the pisiform, transfer of a segment from the distal radius into a vascularized pedicle bone graft harvesting from the pronator quadratus or transfer of the primary, secondary or tertiary branches of the dorsal metacarpal arteries. The most recent vascularized bone grafts include harvesting both the bone and the vascular pedicle from the same site (the same fragment) [3].

Other treatment options besides revascularization include radial wedge osteotomy and shortening of the capitate bone with/without capito-hamate fusion.

Stage II and IIIA with negative ulnar variance: Radial shortening osteotomy is required to decrease the forces exerted on the lunate.

Surgical interventions in Late Stage patients, manifested by collapse with or without fragmentation of the lunate, changing the alignment and height of the carpal bones (Lichtman IIIB and IV).

Stage IIIB is characterized by scaphoid hyperflexion, the surgical procedure obtaining the correction of the scaphoid and achieving the normal 45 degree flexion position, as well as the fusion between its trapezium and trapezoidal bones (STT) or its fusion with the capitate bone (SC fusion) decreasing the forces with is exerted on the radio-lunate joint, thus preventing the collapse of the carpal row and also stabilizing the mid carpal joint.

A recent comparison between the scapho-trapezium-trapezoidal fusion (STT) and the proximal row carpectomy, both in stopping bone degradation, showed that there were no difference between the two procedures when it comes to grip strength, pain relief or range of motion, all these being similar in both of the cases.

Radial osteotomy also showed better outcome on a long-term (over 5 years of follow-up) compared to STT fusion.

In stage IIIB the collapse and the lunate bone fragmentation causes a synovial reaction. The lunate excision added to a fusion process would drastically decrease pain. Some authors additionally use the tendon of palmaris longus muscle to fill the dead space resulting from the lunate excision. Others use a titanium implant instead of lunate bone. This in time leads to the increase of grip strength and the improvement of ROM. [3,4].

Stage IV. Salvage procedures, such as proximal row carpectomy or total wrist fusion, are indicated. In case of severe arthrosis of the head of capitate bone, the above mentioned procedure is not indicated. When performing the row carpectomy, it is excised a 1 cm segment from a posterior interosseous nerve (PIN) right inside from the dorsal 4th compartment, to reduce the post-operative wrist pain. When it is impossible to perform the proximal row carpectomy as the ultimate salvage procedure, the total wrist fusion is used, with the price of limiting the range of motion, but preserving the muscle force. In fact, choosing one or the other procedure is done by taking into account the type of activity the patient does. When we have a patient whose basic occupation does not involve the use of an intense strength force, but rather fine, precise movements (writing or computer work) we choose the proximal row carpectomy, an operation in which the patient partially loses the strength force by cutting some ligaments, but maintains the ability to perform fine movements in a painless joint. On the other hand, the people who

carry out hard work (construction workers, woodcutters, etc.), for whom muscle strength is mandatory, we choose the radiocarpal arthrodesis that completely blocks the wrist movement, but allows the normal use of the fingers, forearm in the elbow joint and the arm, keeping the entire force generated by the upper limb muscles.

In the study 190 people participated, aged 16 to 74, most of whom were in stages IIIA and IIIB of KD. 89 patients, meaning 56.84% of the total were in stage IIIA and 68 patients, meaning 35.78% in stage IIIB. All patients experienced pain in the wrist joints, decreased grip strength and reduction of ROM (flexion, extension, abduction, and adduction). A much smaller number, meaning 27 patients representing 14.21% of the total, were in stage II. All of those included in the study have undergone a number of surgical procedures following the same parameters for each type of operation, namely:

- a.) decreasing of pain
- b.) improving ROM
- c.) increasing grip strength

In 7 of the patients in stages IIIA and IIIB arthroscopic debridement was performed. Intraoperative, cartilage with osteoarthritic changes have been visualized, lunotriquetral and scapholunate ligaments showed partial (at 2 patients) or complete (at 5 patients) rupture. Also, a local synovitis has been found. All patients were followed up postoperative on an average of 19 months, and there was a decrease in pain (till the total disappearance of the pain) in the wrist joint, although towards the end of the follow-up period at 3 of the patients there was a radiological progression of the disease [5].

Therefore, arthroscopy allows direct visualization and accurate assessment of radiocarpal pathology. The arthroscopic debridement of the necrotic lunate bone allows for (a short or medium period) an increase in articular functionality, increase the ROM, lack of pain and improve the quality of life [5].

To compare the reasons for and against the use of the arthroscopic procedures in treatment of patients in stages IIIA and IIIB of KD, a study was conducted on 16 patients divided into two equal groups. In group 1, open surgery of scaphocapitate arthrodesis and lunate bone revascularization was performed. Group 2 benefited from arthroscopic scaphocapitate fusion with capitate pole excision. Patients were follow-up a period of 36 months.

| Results | Group 1 | Group 2 |
|---------------------------------|-------------|------------|
| Operating time | 153 minutes | 99 minutes |
| Hospital stay | 3,6 days | 2,3 days |
| Return to daily activities | 15 weeks | 5,8 weeks |
| Healing time (radiographically) | 7,25 weeks | 9 weeks |
| Rehabilitation | Good | Good |

Also the study was conducted on a small group of patients (16) representing only 8.42% of all operated patients, the results of arthroscopy are better in many points of view as the open surgery, so the procedure deserves further study because the results obtained favor the faster re-integration of the patient into work field [6].

Of the many surgical procedures applicable in the above stages of KD is the vascularized bone graft compared to radial osteotomy (shortening) with scaphocapitate arthrodesis. A number of 71 patients (37.3%) in the two stages IIIA and IIIB of KD were undergone the two surgical procedures following to each group the same parameters: pain, grip strength, range of motion (ROM). Those who benefited by vascularized bone graft, have registered a slight improvement of ROM, relieve pain and increasing of grip strength compared to a decrease of flexion – extension after radial osteotomy [7].

A salvage procedure applicable in advanced stages of KD is proximal row carpectomy (PRC), a compromise solution which means to remove the proximal row of carpal bones. By cutting off the ligaments of extracted bones, it partially decreases the muscle strength but the wrist pain disappears and the ROM is maintained within decent limits. Attempts to improve this surgical procedure through dorsal capsule interposition between radius and the capitate bone after removal of scaphoid, lunate and triquetrum in order to increase joint functionality and to earn some degrees of mobility, proved to be unsuccessful. In all 30 patients with PRC (15.7%) from which 14 without capsule interposition and 16 with capsule interposition the postoperative outcomes were similar [8,13]. Because they are compromise solutions, PRC for decreasing muscle strength with maintaining the ROM within decent limits and wrist arthrodesis for total immobilization of the wrist joint with maintaining the muscle strength, this surgical procedures must be carefully chosen because once performed these are definitive and irreversible.

Radius osteotomy proved to be, according to Masahiro et al. study, a long-term procedure in

treatment of patients in the stages IIIA and IIIB of KD. All 18 patients (9.47%) from which 14 with positive ulnar variance to whom it has been performed radial wedge osteotomy as well as those 4 with negative ulnar variance to whom radial shortening osteotomy was worked on, presented improving all three of the tracked parameters. In addition the benefits achieved postoperatively in terms of pain, grip strength and ROM were maintained after 10 years, period during which patients were followed up [9].

A new treatment strategy in stages II and III of KD was the one attempted by Takeshi et al. through combining the bone marrow transfusion with low-intensity pulsed ultrasound therapy and external fixation [10].

Of the 18 patients (9.47%) undergone this type of treatment, immediate results did not show any improvement regarding the wrist joint flexion and extension, grip strength did not change postoperatively, but the lunate intensity showed improvement after 1,5 years and maintained after 10 years [10].

Results and Discussion:

For all patients studied, only 2 (1.05%) were in stage I of KD, in which the recommended treatment is splinting for a 6 to 12 weeks [7].

In the stage II 27 patients (14.21%) have possible variants arthroscopy [6], if the bone is intact but sclerotic the vascularized bone graft can be done [4] or the last strategy would be the bone marrow transfusion combined with low-intensity pulsed ultrasound and external fixation [10].

The highest number of procedures can be performed in patients in the stages IIIA and IIIB, (89 and 68 patients), meaning 46.84% and 35.78% respectively, starting with vascularized bone graft [4,12], radial shortening osteotomy [4], radial wedge osteotomy [4,11], proximal row carpectomy [11,13,14], intracarpal arthrodesis [13].

For patients in stage IV meaning 2.1% remain only the salvage procedures, PRC or total wrist fusion [4,8]

Postoperatively, in all patients, the same parameters were tracked down till the lack of pain, the restoration of ROM and the increasing of grip strength.

The latest researches into rehabilitation after PRC in stage IIIB of KD, present the importance of the starting the immediate postoperative rehabilitation protocol (right after the next day) without the

immobilization period. If a few years ago, the rehabilitation protocol included splinting for 1 to 6 weeks, with the beginning of gradual rehabilitation after the splint removal. It used to begin with passive wrist movements and fingers, isometric contractions in immobilized joint and exercises in free joints; then from the next week after splint removal retrograde massage of the edema area was started, as well as light circular massage around the wound, active progressive kinesiotherapy in forearm, wrist and fingers. Electrostimulation (TENS) for relieving the pain for 30 minutes per day, then kinesiotherapy with active movements against resistance and increasingly difficult daily exercises. After 3 months the hand could be used in any activity [15].

Currently the rehabilitation protocol begins immediately the next day postoperatively with active finger movements, lymphatic drainage, raising the arm. For pain prevention, cold packs are applied several times a day, TENS technique. After two weeks isotonic exercises are performed, but without weight. From the third week begins the massage with cream, range of motion, grip strength tested to the maximum, exercises with small and large ball [16]. Muscle wrist strength is measured at 3 and 6 weeks postoperatively with the dynamometer. ROM are evaluated at 3 and 6 months for passive and active flexion, passive and active extension, ulnar and radial deviation as well as the arc of motion which sums up a flexion and a maximum extension [16]. The immediate start of postoperative recovery does not harm the patient, does not increase complication rate, on the contrary, it helps to improve ROM, grip strength and by these speeds up the patient's return to daily activities [16].

Conclusions

1. For each stage of KD there are several therapeutic options. The optimal method is chosen based on the correct staging (Lichtman), ulnar variance, the existence or non-existence of a preoperative arthroscopic evaluation, the surgeon's experience and last but not least the patient's preference.

2. Preoperative arthroscopic evaluation of cartilage lesions helps us to choose the treatment option. Arthroscopic surgery has the advantages of shortening operating time, shortening hospital stay, and allowing the patient to return more quickly to daily activities. To get the most benefit, do not forget to start the early rehabilitation protocol (right after the next day postoperative).

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