Elbow Arthroscopy: Difficult Cases and Ulnar Nerve Preservation

63

L.A. Pederzini, F. Di Palma, F. Nicoletta, and E. Tripoli

63.1 Introduction

Arthroscopy has been increasingly used to diagnose and treat elbow pathologies, even though the elbow has always been considered a difficult joint to be arthroscopically explored [20, 27, 32, 33, 37, 40]. An increase in arthroscopy knowledge and skills as well as technological advances in the last few years has allowed a standardization of techniques and a better definition of indications.

In the 1980s Andrews and Carson, Hempfling and Lindenfeld published the first indications, techniques and notions on elbow arthroscopy [3, 16, 22].

Elbow arthroscopy becomes a very difficult technique when an alteration of the anatomy can determine vessel and nerve displacement. This can happen in contracted elbow joint. Furthermore because the contracted joint cannot distend normally with inflow, neurovascular structures around the elbow may not be safely displaced after saline injection.

In 1981, Morrey et al. determined that the elbow functional motion ranged from 30 to 130° of flexion [20, 25, 26]. However, many daily activities performed at work or while doing physical exercise require extension past 30° [20, 25, 26]. As a matter of fact, for sportsmen and manual workers even a small decrease in ROM, together with slight symptoms of pain and inability to perform specific tasks, can be unacceptable and, hence, interfere with their daily work or sporting activities. For these reasons, there has been an extension of indications for treatment of stiff elbows. In 1992 O'Driscoll and Morrey presented 72 cases of elbow arthroscopy, and in 2001 they published a review of 473 cases in which they analysed the complications related to this procedure [29]. The previous year, Reddy et al. published a review of 172 cases in which patients had undergone arthroscopic elbow surgery with a 7-year follow-up [35].

The indications for elbow arthroscopy has grown over the past years and today includes osteochondritis dissecans (OCD), plica syndrome, synovitis, lateral epicondylitis, loose body removal, osteoid osteoma and stiff elbows related to degenerative or post-traumatic causes [2, 10, 14, 23, 27, 30, 32, 44, 45, 47]. Recently, Conso et al., Schubert et al. and Salini et al. published results comparing elbow pathology (including stiffness) treated by either arthroscopic or open procedures [8, 38, 42].

Stiff elbow, presence of osteoid osteoma into the olecranon fossa and osteochondral autologous transplantation are complex pathologies and procedures that can be treated arthroscopically.

L.A. Pederzini (✉) • F. Di Palma • F. Nicoletta
E. Tripoli
Orthopaedic – Traumatologic Department, New Sassuolo Hospital, Via Ruini 2, Sassuolo 41049, Italy
e-mail: gigiped@hotmail.com

P. Randelli et al. (eds.), *Arthroscopy: Basic to Advanced*, DOI 10.1007/978-3-662-49376-2_63

63.2 Stiff Elbow

In this cases indications for arthroscopic surgery include failure of at least 6 months of conservative treatment (mobilization, splinting and physical therapy) [24, 29, 30, 43], absence of important anatomical deformity, reduction in ROM, disability or inability to perform sport or occupation.

Relative contraindications are cerebral palsy, muscle spasticity, burns, previous surgery with anatomical deformity, heterotopic ossification, myositis ossificans, chronic regional pain syndrome (CRPS), articular instability and sepsis-related stiffness.

63.3 Surgical Procedures

The main arthroscopic procedures in our department have been:

- Isolated removal of loose bodies
- Anterior and posterior capsulectomy
- Anterior and posterior osteophytes removal
- Radial head resection
- Partial or total synovectomy
- Mosaicplasty from homolateral knee to elbow for osteochondritis dissecans

All these arthroscopic surgeries have increased the range of motion.

63.4 Surgical Technique

The anaesthetic procedure begins with the identifications of the appropriate nerve trunks with electrostimulation, and a catheter is placed without injecting anaesthetic. Patients then receive general anaesthesia. After waking up a neurological evaluation is performed, and a peripheral block is done.

After the induction of anaesthesia, ROM is carefully assessed and a complete assessment of ligamentous stability is performed. A well-padded tourniquet is placed proximally around the arm. The limb is exsanguinated and the tourniquet insufflated to approximately 250 mmHg. The patient is then placed prone but can also be placed in the lateral or supine position depending on the surgeon's preference and experience, with the shoulder abducted 90°, the elbow flexed to 90° and the arm held up by an arm holder secured to the operating table. A sterile field is set up and posterior, superior anteromedial and superior anterolateral arthroscopic portals are marked.

The risk of nerve injury, including posterior interosseous nerve and ulnar nerve injury, is real in these stiff elbows and should be considered by the operative surgeon before undertaking arthroscopic management.

Because the contracted joint does not distend normally with inflow, neurovascular structures about the elbow may not be safely displaced after N saline injection.

Except in cases with full ROM, an ulnar nerve neurolysis is always performed through a 2 cm skin incision. Ulnar nerve intraneural pressure increases as the elbow proceeds from full extension to full flexion. Beyond 90° of flexion, the intraneural pressure raises more than the extraneural pressure. In fact, at 130° of elbow flexion, the intraneural pressure is 45 % greater than the extraneural pressure [13, 39].

So if ROM is less than 100° of flexion, a neurolysis of the ulnar nerve is necessary before any arthroscopic procedures.

An 18-gauge needle is then inserted into the elbow through the "soft spot" in the middle of the triangular area demarcated by the lateral epicondyle, the radial head and the olecranon. The contracted joint does not distend normally with inflow (15 %, less fluid 3–9 ml at 85°). The joint is then distended as possible by injecting N saline solution. This aids in shifting neurovascular anterior structures away while introducing the trocar. Five portals (three posterior and two anterior) are always used. Posterior compartment arthroscopy is performed first by introducing a 4.5 mm 30° arthroscope through the posterolateral portal (soft spot). A second portal is then established 1.5 cm proximal to the first portal. These two portals allow the use of the scope and the shaver at the same level of the posterior portion of the radial head. Joint distension is maintained with a pump set at 35–50 mmHg.

Once a complete view of the proximal radio-ulnar joint (posteriorly) is obtained, a third posterior portal is placed in the olecranon fossa, close to the medial border of the triceps and 2–3 cm proximal to the olecranon tip. A complete debridement of the olecranon fossa and its lateral wall can be performed. If present, removal of loose bodies from the lateral side of the olecranon and humerus may be performed to allow better gliding of the articular surfaces.

In stiff elbows despite of anatomical changes, the medial epicondyle and medial intramuscular septum in most cases are used as a guide for anterior portal placement.

The proximal anteromedial portal is generally made in an outside-in manner and kept superiorly and also posterior to the brachialis muscle.

We use different approaches on the posteromedial side depending on the size of the osteophytes and because of the proximity of the ulnar nerve. After inserting the arthroscope through the most proximal portal, we evaluate the size of the osteophytes. If they are small, we protect the ulnar nerve by positioning a retractor in an accessory portal slightly posterior to the ulnar nerve, and we resect the osteophytes arthroscopically. If they are large, we prefer to remove the osteophytes by performing a small arthrotomy at the end of the procedure, thus avoiding fluid extravasation during arthroscopy. The medial approach is always used after ulnar nerve neurolysis, which is the first surgical step of the procedure. This is necessary to prevent overstretching of the nerve during flexion and extension testing in surgery.

Hypertrophy or contractures may have bound the posterior interosseous nerve, increasing the risk of a damage while performing a lateral portal. Using an inside-out technique with an anterior superior lateral portal decreases the risk of injury to this structure. Unlike a normal elbow, portal establishment in a contracted elbow joint requires careful placement of a cannula, not only through the skin but during joint entrance to prevent misdirection by the hypertrophied tissue with resultant soft tissue injury. In severe cases, it may be necessary to develop the tissue plane between the brachialis muscle and the capsule and secondarily incise and then excise the capsule.

The anterolateral portal is so created using an inside-out technique and placing a Wissinger rod 2 cm proximal and 1 cm anterior to the lateral epicondyle. A plastic cannula is introduced over the rod. The rod is then removed and a shaver inserted through the cannula and the anterior debridement carried out (removal of loose bodies, anterior osteophytes and synovectomy).

During the capsular release and excision, the surgeon must remember the relationship of the capsule to the neurovascular structures.

In the anterior compartment, the brachialis muscle lies between the capsule and the anterior neurovascular structures (median nerve, radial nerve and brachial artery). Thus, arthroscopic capsular release and excision should be continued from within the joint until brachialis muscle fibres are visible but no further. Shaver blades and cutting instruments must be kept in close proximity to the humerus at all times to avoid being too far anteriorly and potentially into the neurovascular structures by brachialis muscle penetration. Using accessory anterior portals to place protective retractors to hold the brachialis muscle and anterior neurovascular structures away from the operative field is helpful in preventing potential complications.

On the lateral aspect of the elbow, the radial nerve courses between the brachioradialis and brachialis muscles. It divides into the superficial radial nerve and the posterior interosseous nerve at the level of the elbow joint. The posterior interosseous nerve runs distally and laterally to the brachialis muscle and becomes immediately adjacent to the anterior joint capsule in the distal half of the elbow. Scar tissue and hypertrophied joint capsule from injury to this area may tether the posterior interosseous nerve and allow damage to it during release. In these cases, the nerve should be identified and retracted before continuing the excision distally.

Until the location of the nerve is identified, extension of the capsular excision should remain proximal to the radial head.

Posteriorly, the ulnar nerve should be identified and protected throughout the procedure.

In several cases, due to the presence of a thick capsule (post-traumatic causes), an anterior capsulectomy may be required. We start by trimming the proximal humeral capsule with a shaver, but a complete anterior capsulectomy is performed with a basket device, at about 1 cm proximal to the apex of the coronoid, firstly in a lateral to medial direction and then in a medial to lateral direction.

After capsulectomy is performed just anterior to the radial head, it is possible to palpate the branch of the radial nerve. This can be useful in order to avoid neurological complications particularly if we are treating radial head problems.

After arthroscopy, ROM is assessed. One or two suction drains are positioned in the joint, arthroscopic portals are sutured and a splint holding the joint in full extension is applied.

On day 1 after surgery, our rehabilitation protocol begins with very slow continuous passive motion (CPM), four times a day for 40 min with the help of two suction drains and a perinervous anaesthetic catheter. On day 2, CPM is performed four times a day for 40 min, plus 60 min of physiokinesiotherapy and self-active movements four times a day for 30 min. The third day the neuro-catheter is removed and CPM is continued, together with physiokinesiotherapy and self-active movements. On day 4, the drains are removed and CPM, physiokinesiotherapy and self-active movements continue. On day 5, once discharged, the patient goes back home with a 20 day re-educational programme combined with indomethacin for 15 days. The splint is removed after 20 days. After 1 month patients attend their first follow-up visit. The rehabilitative programme continues for 3–5 months [32, 33].

63.5 Technical Tricks

From the technical point of view, we believe it is mandatory to have a perfect view of both the compartments; the lack of range of motion can lead to anatomo-pathological changes both anteriorly and posteriorly in the long run. The use of retractors is important in every stage of the surgery because it minimizes any risk of damage to vascular and nervous structures. During posterior debridement, the medial olecranon osteophyte removal should be carefully considered: a retractor can help, but in some cases due to big osteophytes close to the ulnar nerve, arthroscopic surgery is not recommended. The previous isolation of the ulnar nerve enables open surgery, avoiding risks. Posterior debridement and olecranon osteophyte removal allow an extension improvement that, together with the surgical procedures above-mentioned, increases total ROM. Also anterior capsulectomy allows an extension improvement. On the contrary, flexion is favoured by posterior capsulectomy and removal of anterior hypertrophic coronoid or humeral osteophytes. During anterior capsulectomy, it is important to pay attention to the brachialis muscle which is visible once the capsule is removed. This is necessary not only because of the proximity of the humeral artery but also to avoid muscle bleeding, which can lead to possible calcifications. We have found that brachialis muscle in stiff elbows is frequently thinner than in normal elbows, due to muscle's atrophy.

63.6 Osteoid Osteoma

Osteoid osteoma (OO) is a benign neoplasm that is generally smaller than 1 cm in diameter. Osteoid osteoma at the elbow is rare [48].

Clinical symptoms include nocturnal pain that is relieved by nonsteroidal anti-inflammatory drugs (NSAIDs) [21], as well as limited motion caused by pain or synovitis [48]. Diagnosis can be made on plain radiography (Fig. 63.1a), but a computed tomography (CT) scan (Fig. 63.1b) and/or MRI is usually helpful [17]. Optimal surgical treatment comprises complete excision of the OO.

Percutaneous destruction with the use of a laser or radiofrequency is reportedly effective, with a 91 % rate of success [19]. Thermocoagulation is responsible for a spherical bone necrosis of about 1 cm around the area on which it is placed. With thermocoagulation it is not always possible to conduct a pathologic examination so it is not indicated in patients with unprecise diagnosis. Rosenthal [36] reported nondiagnostic findings in 27 % after

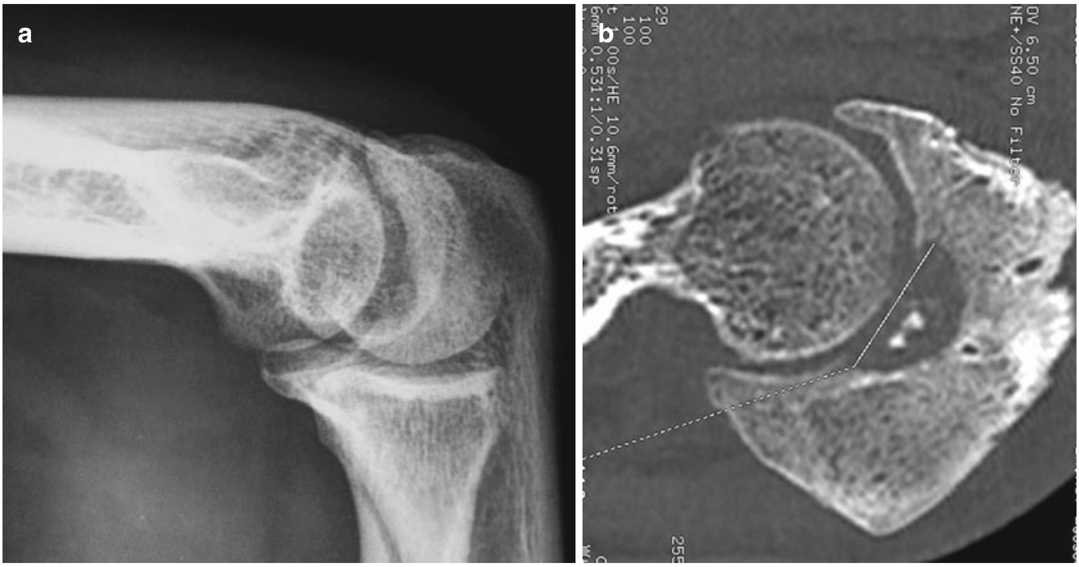

Fig. 63.1 (**a**) Diagnosis can be made on plain radiography (**a**), but a computed tomography (CT) scan (**b**) and/or MRI is usually helpful. (**b**) Diagnosis can be made on plain radiography (**a**), but a computed tomography (CT) scan (**b**) and/or MRI is usually helpful

needle biopsy. The electrode must be at least 1 cm away from a main nerve to prevent nerve injury. This technique may be dangerous for patients with specific localization as near nerve structures or cartilage.

Operative excision (i.e. en bloc resection and curettage) is the recommended treatment for patients with OO of the elbow [48]. Excision of the lesion usually permits complete elbow motion recovery and pain relief.

In our experience the most frequent difficult localization to treat is along the trochlear notch (Fig. 63.2) and coronoid fossa or olecranon fossa. In trochlear notch localization, arthroscopic treatment is performed with the patient under general anaesthesia and in a lateral decubitus position. A direct lateral approach through the soft point (or proximal) is used for the scope. The lesion is removed with a curette through a medial approach after ulnar nerve neurolysis. The hyperemic aspect is identified and totally removed. Excision is performed under arthroscopic visual control. The bony fragment is sent for pathologic testing (Fig. 63.3a, b).

Use of shavers can make pathologic diagnosis difficult because of mechanical artefacts [18]. So before using a shaver, a bony biopsy must be performed first.

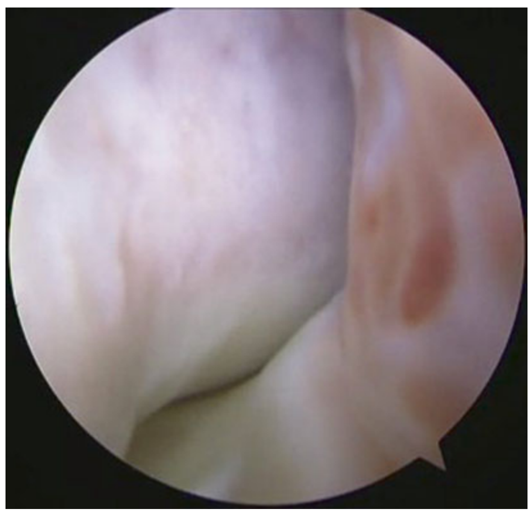

Fig. 63.2 Arthroscopic view of osteoid osteoma along olecranon trochlear notch

With CT scan post-op, we can check the complete resection of the OO (Fig. 63.4).

Patients report total pain relief and complete elbow motion. After 6–8-months follow-up,

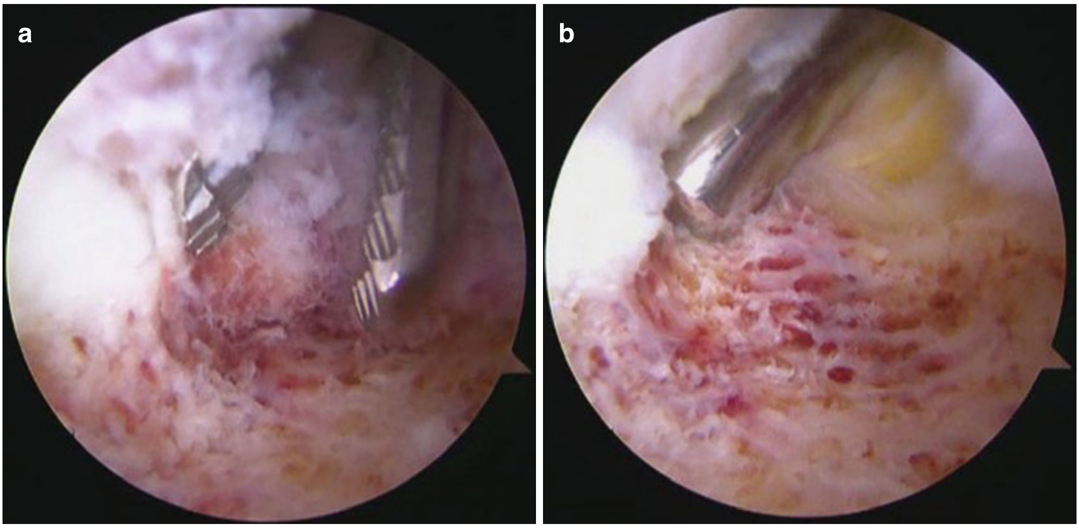

Fig. 63.3 (**a**, **b**) The lesion is removed with a curette through a medial approach after ulnar nerve neurolysis. The hyperemic aspect is identified and totally removed. Excision is performed under arthroscopic visual control. The bony fragment is sent for pathologic testing

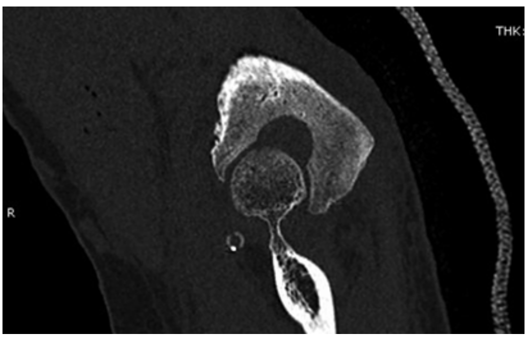

Fig. 63.4 CT scan post osteoid osteoma resection

patients generally have no recurrence of elbow limitation or pain.

In coronoid or olecranon fossa localization, arthroscopic treatment is performed with the patient in the same position. We perform arthroscopic OK procedure by drilling the lesion up to healthy bone.

Advantages of arthroscopy include reduced post-operative pain related to minimal incisions, few wound problems, wider intraoperative vision, less invasive surgery without peripheral muscle and ligament damage, outpatient surgery and early return to full activity [46].

63.7 Osteochondritis Dissecans (OCD)

OCD is an osteochondral focal lesion that generally involves the capitellum, characterized by recurring pain, progressive functional impotence with secondary contracture in flexion of the elbow of approximately 15°, joint swelling and clinical improvement after a resting period.

The causes are vascular deficiency of unknown origin or secondary to direct joint trauma with consequent local vascular lesion and secondary bone necrosis [5, 9, 12].

Osteochondritis dissecans occurs most commonly in overhead-throwing athletes and in gymnasts between the ages of 13 and 16 years [6, 31–33]. It typically affects the young adolescent athlete involved in high-demand, repetitive overhead or weight-bearing activities. The most commonly associated sports are baseball, gymnastics, racquet sports, football and weightlifting [5, 9, 12, 33].

OCD can be a cause of painful elbow with limited ROM. These young patients, usually athletes complaining pain and dysfunction, limit their activity becoming unable to participate in sport. Although lesions have been reported in the trochlea, radial head and olecranon, the most common site of OCD of the elbow is in the capitellum [3, 5, 9, 12, 34].

Radiographs reveal radiolucency or fragmentation of the anterolateral capitellum. MRI has become the standard imaging for identifying OCD, and it can provide an accurate assessment of the size, extent and stability of the lesion.

Determination of lesion stability and integrity of the articular cartilage cap is really important regarding the decision to prescribe nonoperative treatment or proceed with the surgery [8, 32–34].

Panner's disease, most common between 4 and 8 years of age, should not be confused with true OCD because it involves the entire ossification centre, while only the anterolateral capitellum is involved in osteochondritis dissecans of capitellum [5, 6, 31].

Treatment for stable, early-stage OCD lesions consists in avoiding repetitive stress of the elbow and observation. If the lesion has not resolved in 3–6 months, then consideration of surgical management is made.

Surgical management is the treatment of choice for unstable lesions, lesions that have failed nonoperative management and loose bodies. Lesions that are unstable have a tendency to remain symptomatic even if no loose body is present, therefore leading to surgery [5, 6].

Multiple operative procedures have been described for treating OCD. Surgical treatments include drilling of the lesion, fragment removal with or without curettage of the residual defect, fragment fixation by a variety of methods (pull-out wiring, Herbert's screw, bone peg grafting, etc.), reconstruction with osteochondral autograft and autologous chondrocyte implantation [5, 32].

Several studies report different results with open procedure, but more recently arthroscopy has been employed with encouraging scores in the treatment of capitellar OCD [5, 6, 9, 15].

Baumgarten and colleagues report excellent results in a group of 17 patients whose elbows were treated with arthroscopic debridement with a complete return to sport activities at the pre-injury level in 82 % of cases [6].

Reports of arthroscopic treatment of OCD of the capitellum with removal of loose bodies, debridement and abrasion chondroplasty describe overall improvements in pain and range of motions with variable return to pre-injury level of sporting activity [6, 31, 32].

A grading system based on absence, partial or total detachment of the bone plug has been developed by Baumgarten et al. [6] to aid in decision-making during elbow arthroscopy. The recommendation presented for grade 1 lesions is either observation or arthroscopic drilling of the lesion. Grade 2 lesions were treated with debridement of the cartilage to healthy tissue. Grade 3 lesions were treated with loosening of the fragment to create a grade 4 lesion, which was then resected. Grade 5 lesions were treated with a diligent search for the loose bodies [6].

We prefer arthroscopic evaluation and treatment for lesions requiring operative management.

Removal of the bone plug and microfracture is mandatory in order to eliminate catching and popping while the possibility to bone graft the lesion is still controversial [15, 32, 33].

In some cases we have performed an arthroscopic mosaicplasty taking the graft from the homolateral knee putting the patient in lateral decubitus and extrarotating the hip performing knee arthroscopy (Fig. 63.5). The 6.5 mm cylinder graft token from the lateral knee trochlea was inserted in the elbow lesioned area carefully checking the angle of the drilling and of the insertion of the bony cartilaginous cylinder (Fig. 63.6). Arthroscopically the perpendicular insertion of the cylinder allows a complete coverage of the OCD area. A 4-month post-operative MRI shows a nice bone incorporation of the graft (Fig. 63.7). Post-operatively CPM is started the second day post-op and passive exercises in day 4 post-op. Patients are back to normal activity in 4 months [32, 33].

63.8 Ulnar Nerve-Associated Treatment

Taking into account the outcomes, we can assert that the ulnar nerve-associated treatment has always been studied carefully. So far neurolysis has been performed in case of stiffness, with or without neurological disorders.

Fig. 63.5 The mosaicplasty from the knee to the elbow is performed on lateral decubitus positioning the hip in extra-rotation to allow knee arthroscopy for taking the graft from the lateral trochlea

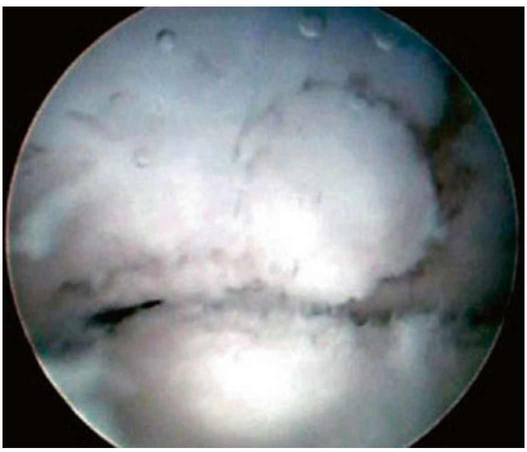

Fig. 63.6 The graft is positioned on the lateral humeral condyle to fill the OCD gap

Fig. 63.7 Four months control MRI shows a good bone incorporation of the osteochondral cylinder

Only when ROM is almost complete and neurological disorders nearly absent, neurolysis is not performed (removal of one to two loose bodies). The case study shows a good pain resolution or improvement. On the contrary, failures are related to a scar around the nerve. Ulnar nerve transposition has never been carried out, except for one case in which the residual scar made it necessary. Neurolysis of the ulnar nerve is nearly always recommended in cases of severe stiffness and where there is a marked ROM recovery. Once isolated, the nerve can be fixed anteriorly in cases of major stiffness, in severe valgus elbow or where a previous surgery prevents the proper positioning in the epitrochlear sulcus. In this study, the release of the ulnar nerve has been performed in more than 90 % of cases.

63.9 Complications

Elbow arthroscopy is a safe and effective technique for the surgical management of a variety of intra- and extra-articular pathologies, but potential complications exist. The most common complications associated with elbow arthroscopy are neurologic injury, heterotopic ossification, infection and post-operative contracture [21, 29, 32, 33].

One of the most serious complications is nerve injury, which has been reported in all forms from neuropraxic to neurotmetic damage. Nerve injury can occur secondary to compression or direct injury from instruments, excessive joint distension, aggressive manipulation or post-operative CPM [21, 32].

Nerves majorly involved in complications are the posterior branch of the radial nerve, the median and the ulnar nerve.

More significant partial or complete nerve damage can also occur and may be caused by direct trauma from portal creation or as a consequence of mechanical or thermal injury from arthroscopic instruments [21, 29, 41].

During arthroscopy of the anterior compartment of the elbow, the posterior interosseous branch of the radial nerve and median nerve are at risk and may be as close as 6 mm to the capsule. The elbow should be insufflated with fluid to distend the capsule and displace the neurovascular structures away from the articulation [21, 32, 40].

Damage to the ulnar nerve can occur in a variety of situations. It is imperative that the surgeon be aware of ulnar nerve hypermobility and subluxation, which can predispose to contusion or laceration when creating anteromedial portals. The ulnar nerve is most at risk during debridement of the medial gutter when performing posterior compartment arthroscopy [21, 41]. It is mandatory during these procedures to identify before the ulnar nerve and use the retractors in order to protect it from the other instruments.

Another risk with elbow arthroscopy is the development of heterotopic ossifications post-operatively.

This can present as a spectrum, from scattered asymptomatic deposition in the surrounding soft tissues to disabling ankylosis requiring open resection. Reported risk factors for the development of heterotopic ossification include recent prior surgery, associated burns and trauma, diffuse skeletal hyperostosis and abnormalities of metabolism.

In high-risk patients, a dose of radiation therapy may be considered as also the use of indomethacin (700 mg a single dose) for 3 weeks [21, 32, 33, 40].

Like all surgery, there exists a risk for superficial and deep infection with elbow arthroscopy. The authors routinely administer a single dose of intravenous antibiotics prior to arthroscopic elbow surgery.

Finally recalcitrant elbow stiffness can occur after arthroscopy. The risk seems highest with surgery for post-traumatic disorders of the elbow, including arthroscopic contracture release and arthroscopic-assisted intervention for fracture [21, 33, 41].

63.10 Discussion

The use of different portals, the ulnar nerve isolation, the use of arthroscopic retractors and the avoidance of an excessive intra-articular joint pressure, are all fundamental elements for an accurate elbow arthroscopy. Post-traumatic and degenerative arthroscopic cases have different features. In post-traumatic cases the articular space is smaller, fibrosis is higher and capsule consistency, when removed by basket forceps, is stronger. In degenerative cases, articular space is larger, fibrosis is lower and capsule consistency weaker. Indications for stiffness arthroscopic treatment are still, in many cases, surgeon dependant. A more advanced learning curve guarantees a wider possibility to address post-traumatic pathologies and degenerative cases.

In 2000 Reddy et al. [35] presented a review of a large number of patients operated by several different surgeons, in different decubitus and by different techniques reporting low rate of minor complications but a complete lesion of the ulnar nerve. As Reddy described [35], we obtain the same low rate of complications using the technique we presented, peculiarly the use of a fine haemostat (after only skin incision) to turn away superficial and deep neurovascular structures.

In 2001 Morrey et al. reported extensive case studies in which they analysed complications following arthroscopic surgery [25]. In some cases, other authors report limited case studies where they compare the outcomes achieved by open techniques with arthroscopic ones [1, 4, 7, 8, 11, 13, 26, 28, 38]. We agree with Reddy [35] that it is impossible to review any large series of elbow arthroscopy without report neurological complications. Despite this we consider that 1.8 % of nervous complications can be defined as a low rate. We also think that 10.8 % of minor complications (synovial leakage through the portals, superficial portal infections) are connected to our aggressive rehabilitative protocol. We still use this protocol because it allows us to obtain a better ROM and result. In case of articular congruence damage, post-traumatic anatomical alterations or previous surgical outcome, arthroscopic indication is not common, while open surgery can be useful and decisive. On the other hand, arthroscopy is used in case of hypertrophy of the olecranon caused by long-standing instability, radial head osteophytes connected to a previous fracture and hypertrophy of the coronoid caused by an intense physical or manual activity.

References

1. Adams JE, Wolff 3rd LH, Merten SM, Steinmann SP. Osteoarthritis of the elbow: results of arthroscopic osteophyte resection and capsulectomy. J Should Elb Surg. 2008;17(1):126–31.
2. Akeson WH, Abel MF, Garfin SR, Woo SL. Viscoelastic properties of stiff joints: a new approach in analyzing joint contracture. Biomed Mater Eng. 1993;3:67–73.
3. Andrews JR, Carson WG. Arthroscopy of the elbow. Arthroscopy. 1985;1(2):97–107.
4. Ball CM, Meunier M, Galatz LM, Calfee R, Yamaguchi K. Arthroscopic treatment of post-traumatic elbow contracture. J Should Elb Surg. 2002;11(6):624–9.
5. Bauer M, Jonsson K, Josefsson PO, et al. Osteochondritis dissecans of the elbow. A long term follow up study. Clin Orthop Relat Res. 1992;(284):156–60.
6. Baumgarten TE, Andrews JR, Satter-White YE. The arthroscopic classification and treatment of osteochondritis dissecans of the capitellum. Am J Sports Med. 1998;26(4):520–3.
7. Bruno RJ, Lee ML, Strauch RJ, Rosenwasser MP. Posttraumatic elbow stiffness: evaluation and management. J Am Acad Orthop Surg. 2002;10(2):106–16.
8. Conso C, Bleton R. Arthroscopy in stiff elbow: report of 32 cases. Rev Chir Orthop Reparatrice Appar Mot. 2007;93(4):333–8.
9. Duthie RB, Houghton GR. Constitutional aspects of the osteochondroses. Clin Orthop Relat Res. 1981;(158):19–27.
10. Eames MHA, Bain GI. Distal biceps tendon endoscopy and anterior elbow arthroscopy portal. Tech Should Elb Surg. 2006;7:139–42.
11. Figgie MP, Inglis AE, Mow CS, Figgie HE. Total elbow arthroplasty for complete ankylosis of the elbow. J Bone Joint Surg Am. 1989;71:513–9.
12. Gardiner JB. Osteochondritis dissecans in three family members of one family. J Bone Joint Surg Br. 1955;37–B(1):139–41.
13. Gelberman RH, Yamaguchi K, Hollstien SB, Winn SS, Heidenreich FP, Bindra RR, et al. Changes in interstitial pressure and cross-sectional area of the cubital tunnel and of the ulnar nerve with flexion of the elbow. An experimental study in human cadavera. J Should Elb Surg. 1998;80(4):492–501.
14. Guhl JF. Arthroscopy and arthroscopic surgery of the elbow. Orthopedics. 1985;8:1290–6.
15. Hangody L, Feczkó P, Bartha L, Bodó G, Kish G. Mosaicplasty for the treatment of articular defects of the knee and ankle. Clin Orthop. 2001;391(Suppl):328–36.
16. Hempfling H. Endoscopic examination of the elbow joint from the dorsoradial approach. Z Orthop Ihre Grenzgeb. 1983;121(3):331–2.
17. Jaffe HL. Osteoid osteoma of the bone. Radiology. 1935;45:319.
18. Joyce MJ, Mankin HJ. Caveat arthroscopic extra-articular lesions of bone simulating intra-articular pathology of the knee. J Bone Joint Surg Am. 1983;65:289–92.
19. Khalpchik V, O'Donnell RJ, Glick JM. Arthroscopically assisted excision of osteoid osteoma involving the hip. Arthroscopy. 2001;17:56–61.
20. Kelly EW, Morrey BF, O'Driscoll SW. Complications of elbow arthroscopy. J Bone Joint Surg Am. 2001;83-A(1):25–34.
21. King JW. Elbow arthroscopy complications. In: Elbow arthroscopy, vol. 1. Ed Springer, Berlin, Germany; 2013. p. 103–11.
22. Lindenfeld TN. Medial approach in elbow arthroscopy. Am J Sports Med. 1990;18(4):413–7.
23. Lynch GJ, Meyers JF, Whipple TL, Caspari RB. Neurovascular anatomy and elbow arthroscopy: inherent risks. Arthroscopy. 1986;2:190–7.
24. Mader K, Penning D, Gausepohl T, Wulke AP. Arthrolysis of the elbow joint. Unfallchirurg. 2004;107(5):403–11.
25. Morrey BF. The posttraumatic stiff elbow. Clin Orthop Relat Res. 2005;431:26–35.

26. Morrey BF, Askew LJ, Chao EY. A biomechanical study of normal functional elbow motion. J Bone Joint Surg Am. 1981;63(6):872–7.
27. Nguyen D, Proper SI, MacDermid JC, King GJ, Faber KJ. Functional outcomes of arthroscopic capsular release of the elbow. Arthroscopy. 2006;22(8):842–9.
28. Nirschl RP, Pettrone FA. Tennis elbow: the surgical treatment of lateral epicondylitis. J Bone Joint Surg Am. 1979;61:832–9.
29. O'Driscoll SW, Morrey BF. Arthroscopy of the elbow. Diagnostic and therapeutic benefits and hazards. J Bone Joint Surg Am. 1992;74(1):84–94.
30. Ogilvie-Harris DJ, Schemitsch E. Arthroscopy of the elbow for removal of loose bodies. Arthroscopy. 1993;9:5–8.
31. Pill SG, Ganley TJ, Flynn JM et al. Osteochondritis dissecans of the capitellum. Arthroscopic-assisted treatment of large, full thickness defects in young patients. Arthrosc J Arthrosc Relat Surg. 2003;19(2):222–5.
32. Pederzini LA, Nicoletta F, Tosi M, Prandini M, Tripoli E, Cossio A. Elbow arthroscopy in stiff elbow. Knee Surg Sports Traumatol Arthrosc KSSTA. 2014;22:467–73. Ed. Springer.
33. Pederzini LA, Tripoli E, Tosi M, Nicoletta F, Scuccimarra T. Tricks in elbow arthroscopy. Sport Injures. 2014;2014:1–14.
34. Rahusen FT, Brinkman JM, Eygendaal D. Results of arthroscopic debridement for osteochondritis dissecans of the elbow. Br J Sports Med. 2006;40(12):966–9.
35. Reddy AS, Kvitne RS, Yocum LA, ElAttrache NS, Glousman RE, Jobe FW. Arthroscopy of the elbow: a long-term clinical review. Arthroscopy. 2000;16(6):588–94.
36. Rosenthal DI, Hornicek FJ, Torriani M, Gebbardt MC, Mankin HJ. Osteoid osteoma: percutaneous treatment with radiofrequency energy. Radiology. 2003;229:171–5.
37. Rupp S, Tempelhof S. Arthroscopic surgery of the elbow: therapeutic benefits and hazards. Clin Orthop. 1995;4:140–5.
38. Salini V, Palmieri D, Colucci C, Croce G, Castellani ML, Orso CA. Arthroscopic treatment of post-traumatic elbow stiffness. J Sports Med Phys Fitness. 2006;46(1):99–103.
39. Sahajpal D, Choi T, Wright TW. Arthroscopic release of the stiff elbow. J Hand Surg Am. 2009;34:540–4.
40. Savoie III FH. Guidelines to becoming an expert elbow arthroscopist. Arthroscopy. 2007;23(11):1237–40.
41. Savoie III FH. Complication. In: Savoie III FH, Field LD, editors. Arthroscopy of the elbow. New York: Churchill-Livingstone; 1996. p. 151–6.
42. Schubert T, Dubuc JE, Barbier O. A review of 24 cases of elbow arthroscopy using the DASH questionnaire. Acta Orthop Belg. 2007;73(6):700–3.
43. Scott J, Huskisson EC. Graphic representation of pain. Pain. 1976;2(2):175–84.
44. Sojdjerg JO. The stiff elbow. Acta Orthop Scand. 1996;67(6):626–31.
45. Steinmann SP, King GJ, Savoie III FH. Arthroscopic treatment of the arthritic elbow. Instr Course Lect. 2006;55:109–17.
46. Szendroi M, Kollo K, Antal I, Lakatos J, Szoke G. Intraarticular osteoid osteoma: clinical features, imaging results, and comparison with extraarticular localization. J Rheumatol. 2004;31:957–64.
47. Ward WG, Anderson TE. Elbow arthroscopy in a mostly athletic population. J Hand Surg Am. 1993;18:220–4.
48. Weber KL, Morrey BF. Osteoid osteoma of the elbow: a diagnostic challenge. J Bone Joint Surg Am. 1999;81:1111–9.