

Tips to avoid nerve injury in elbow arthroscopy

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Conflict-of-interest statement: Hilgersom NFJ, Oh LS and Flipsen M have no conflicts of interest or financial ties to disclose. Eygendaal D has received travel expenses from the ESSKA board and fees for serving as a consultant for Lima Elbow System and as a speaker for the AO foundation. van den Bekerom MPJ has received an enabling grant from Smith and Nephew for research in rotator cuff surgery and research funding from Tornier.

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Manuscript source: Invited manuscript

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Received: September 14, 2016

Peer-review started: September 18, 2016

First decision: October 21, 2016

Revised: November 10, 2016

Accepted: November 27, 2016

Article in press: November 29, 2016

Published online: February 18, 2017

Abstract

Elbow arthroscopy is a technical challenging surgical procedure because of close proximity of neurovascular structures and the limited articular working space. With the rising number of elbow arthroscopies being performed nowadays due to an increasing number of surgeons performing this procedure and a broader range of indications, a rise in complications is foreseen. With this editorial we hope to create awareness of possible complications of elbow arthroscopy, particularly nerve injuries, and provide a guideline to avoid complications during elbow arthroscopy.

Key words: Elbow; Arthroscopy; Complications; Nerve injury; Education; Preventive strategies

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Core tip: Elbow arthroscopy is a technical challenging surgical procedure because of close proximity of neurovascular structures and the limited articular working space. With the rising number of elbow arthroscopies being performed nowadays due to an increasing number of surgeons performing this procedure and a broader range of indications, a rise in complications is foreseen. With this editorial we hope to create awareness of possible complications of elbow arthroscopy, particularly nerve injuries, and provide a guideline to avoid complications during elbow arthroscopy.

Hilgersom NFJ, Oh LS, Flipsen M, Eygendaal D, van den Bekerom MPJ. Tips to avoid nerve injury in elbow arthroscopy. *World J Orthop* 2017; 8(2): 99-106 Available from: URL: <http://www.wjgnet.com>

INTRODUCTION

A small working space and close by neurovascular structures are the main reasons elbow arthroscopy is a technical challenging surgical procedure^[1-12]. Advantages over open surgery may be less scar tissue, decreased risk of infection, less postoperative pain, fast return to work and sports and better visualization of intra-articular pathology^[13-17]. Nowadays arthroscopy of the elbow is performed more frequently for an increasing range of indications; loose bodies, primary degenerative and rheumatoid arthritis, posttraumatic contractures, lateral/medial epicondylitis, osteochondral defects, posteromedial impingement, synovial disorders, fractures of the radial head, capitellum and coronoid, and debridement of osteophytes^[2,18-22]. With the rising number of elbow arthroscopies being performed nowadays due to an increasing number of surgeons performing this procedure and a broader range of indications, a rise in complications is foreseen.

A range of complications has been described after elbow arthroscopy, such as: Transient neuropraxia^[3,6,13,23-45], permanent nerve injury^[28,41,46-55], complex regional pain syndrome^[31], delayed wound healing^[31], superficial wound infection^[28,32,37,42,43,56-58], deep wound infection^[32], limited range of motion^[28,44,59], synovial fistula^[28,37], ganglion cyst at portal site^[32], granuloma of portal scar^[39], heterotopic ossifications^[23,32,43] and triceps tendon ossification^[32]. One of the most devastating complications is nerve injury^[19,60] of which the majority is fortunately transient^[13,32].

Recently Desai *et al.*^[60] conducted a survey among the member of the American Society for Surgery of the Hand to determine which nerves and what kind of nerve injuries were treated after elbow arthroscopy over a five-year period; 222 nerve injuries were identified, an estimated 1.2% occurrence rate. In half of the patients additional surgical intervention was needed; 77%-80% had either partial or no recovery. This seems contradictory with the only 13 cases on permanent nerve injury after elbow arthroscopy published in current literature^[28,41,46-55]. Desai *et al.*^[60] stated that in view of the high number of elbow arthroscopies performed these days permanent nerve injury is probably under-reported. In current literature the ulnar nerve seems most susceptible for nerve injury during elbow arthroscopy^[60-62].

The goal of this current concepts review is to raise awareness of possible complications of elbow arthroscopy, in particular nerve injuries, and provide a practical guideline that can help to avoid nerve complications during elbow arthroscopy.

HOW TO AVOID NERVE COMPLICATIONS IN ELBOW ARTHROSCOPY?

A general necessity is thorough knowledge of the

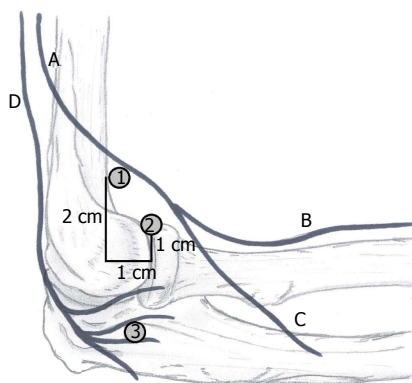


Figure 1 Proximity of nerves and portals: Lateral side view. A: Radial nerve; B: Superficial branch; C: Deep branch; D: Posterior antebrachial cutaneous nerve; 1: Proximal lateral portal; 2: Anterolateral portal; 3: Midlateral portal.

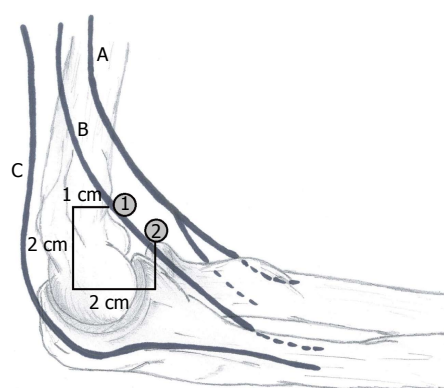


Figure 2 Proximity of nerves and portals: Medial side view. A: Median nerve; B: Medial antebrachial cutaneous nerve; C: Ulnar nerve; 1: Proximal medial portal; 2: Anteromedial portal.

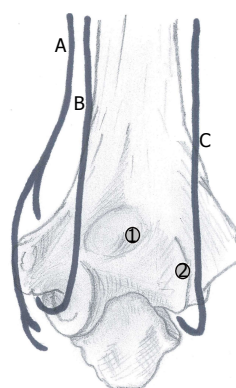


Figure 3 Proximity of nerves and portals: Posterior side view. A: Medial antebrachial cutaneous nerve; B: Ulnar nerve; C: Posterior antebrachial cutaneous nerve; 1: Transtricipital portal; 2: Posterolateral portal.

anatomy of the elbow in order to comprehend the spatial relation among neurovascular structures and portals and be able to safely perform elbow arthroscopy (Figures 1-3).

Work up

Avoiding peri-operative complications starts with a proper work-up. Firstly, there has to be a valid indication for surgery, which starts with patient complaints, history



Figure 4 Osteophytes can cause changed anatomy, for example posteromedial osteophytes could push the ulnar nerve out of its groove.

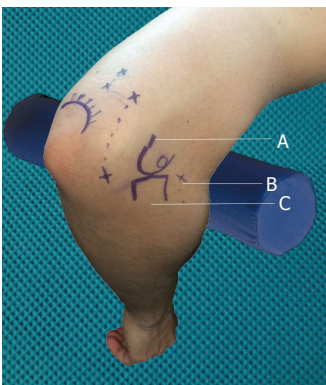


Figure 5 Marking of anatomical structures and portals: Lateral side view. A: Lateral epicondyle; B: Anterolateral portal; C: Radial head.

taking and physical examination. Setting a valid indication prevents unnecessary surgery and subsequently prevents neurological complications. A history of trauma, previous elbow surgery or rheumatoid arthritis, or burns, skin grafts, a subluxing ulnar nerve or congenital deformity of the elbow on physical examination can be complicating factors for surgery due to alteration of the anatomy; for example nerves can be adhered to the capsule^[63], the capsule may have less distension capacity and scar tissue may make identifying nerves and vessels difficult. Additional imaging studies (CT, MRI or ultrasound) might be needed to confirm the diagnosis or for careful planning of surgery when expecting changed or difficult anatomy (Figure 4)^[25]. For example, a subluxing or previously transposed ulnar nerve. The incidence of a subluxing ulnar nerve is reported to be 11%-21%^[64,65] and not recognizing its presence preoperatively may lead to iatrogenic ulnar nerve injury. Dodson *et al.*^[19] suggested that arthroscopic surgery should be avoided if the patient had undergone previous ulnar nerve transposition. In order to prevent missing a not physiological ulnar nerve course it is recommended to routinely report if patients had a ulnar nerve transposition or are diagnosed with a subluxing ulnar nerve during physical examination in the outpatient setting.

Preoperative preventive measures

Prior to incision and distension of the joint, preoperative

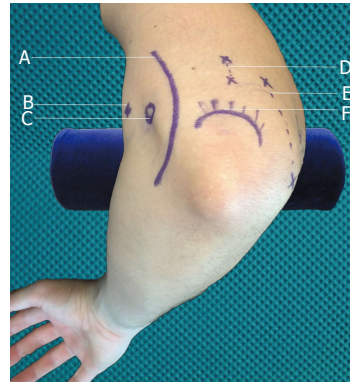


Figure 6 Marking of anatomical structures and portals: Medial side view. A: Ulnar nerve; B: Proximal medial portal; C: Medial epicondyle; D: Transtricipetal portals; E: Posterolateral portals; F: Olecranon.

examination under anesthesia, marking of anatomic landmarks and portal sites, and palpation of the course of the ulnar nerve are of great importance to obtain good orientation and avoid complications^[3,18,28,66] (Figures 5 and 6). In cases with changed ulnar nerve anatomy a possible safe anteromedial approach depending on with what certainty the course of the ulnar nerve can be determined is described by Sahajpal *et al.*^[66]. If the course is unequivocal a safe anteromedial approach is possible by placing the portal 1cm from the nerve, if the course is equivocal portal placement should be 1 cm from the nerve by mini-incision, or by open approach *via* an incision of 2- to 4-cm in order to identify the nerve and subsequently place the portal if localization of the nerve is impossible. However, in the opinion of the authors the safest approach of an elbow with a subluxing or transposed ulnar nerve is an immediate open approach and starting elbow arthroscopy after identifying the ulnar nerve. Whenever establishing or re-entering the portal the ulnar nerve should be fixated posteriorly of the medial epicondyle.

Anesthesia

Most surgeons prefer general anesthesia with total muscle relaxation because of patient comfort and the disabling of unexpected patient movement, and it allows for supine positioning^[2,18]. Some surgeons prefer to add regional anesthesia, for optimal reduction of postoperative pain. However, in a randomized controlled trial performed by Wada *et al.*^[67] no additional pain relief was observed using a supplemental axillary nerve block over general anesthesia alone. In addition, regional anesthesia has a small risk for nerve injury with an incidence of 3:10000 based on two large prospective studies^[68-70].

Patient positioning

Several alternatives are available in positioning of the patient: The most common are the lateral decubitus position and the supine-suspended position with the use of a limb positioner (Figure 7). An advantage of the lateral decubitus position over the supine-suspended position

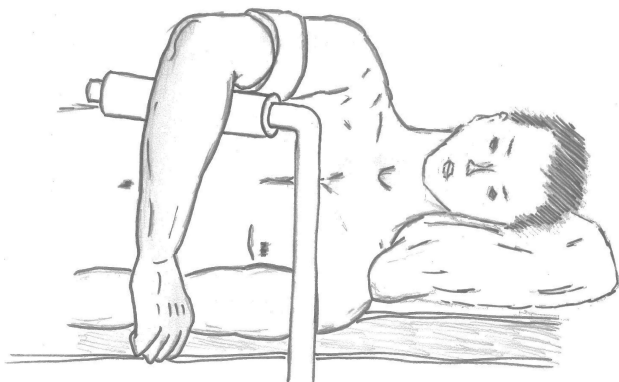


Figure 7 Lateral decubitus position.

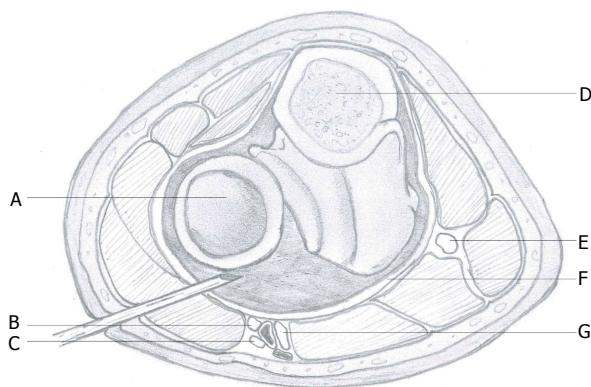


Figure 9 Distended joint. A: Head of radius; B: Radial nerve; C: Lateral antebrachial nerve; D: Cross-section of olecranon; E: Ulnar nerve; F: Capsule; G: Median nerve.

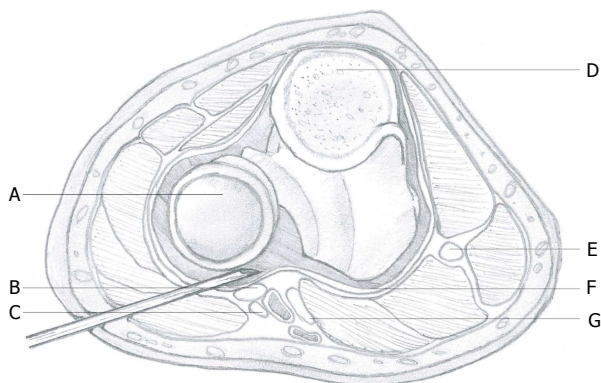


Figure 8 Non-distended joint. A: Head of radius; B: Radial nerve; C: Lateral antebrachial nerve; D: Cross-section of olecranon; E: Ulnar nerve; F: Capsule; G: Median nerve.

is that gravity assists in displacing the neurovascular structures away from the anterior capsule and from the anterior working field. Furthermore, the lateral decubitus position facilitates easy access to all compartments. A stable and comfortable patient position can be achieved by use of vacuum beanbag immobilizer.

Joint distension

When proper orientation of the surgical landmarks and patient positioning has been acquired, the next step is fluid distension (20-30 mL) of the joint *via* the midlateral soft spot or *via* a posterior approach. The latter approach is preferred by the authors because of the absence of cartilage in addition to the absence of nerves. Fluid distension of the elbow joint space moves the neurovascular structures away from the surgical field by expanding the joint capsule^[3-5,10,45,71-75] (Figures 8 and 9). It is very important to realize that the nerve-to-capsule distance does not increase with joint distension, but only nerve-to-portal distance and the nerve to osseous structures distance^[3,5,75,76]. Therefore, joint distension probably reduces the chance of nerve injury during joint entry *via* the portals and during intra-articular surgical procedures, but not during performance of capsular procedures. Since the capsule may rupture at pressures below 50 mmHg, it is advised to use gravitational force

only, and avoid pressurized infusion, to keep the joint distended. Higher pressures occurring in fluid pumps cause fluid to flow extra-articular decreasing joint visibility^[76,77]. Saline-infusion of 5 mL or less indicates a decreased displacement of neurovascular structures and less working space, for example in elbow contractures, making surgery more complicated^[1]. Successful joint insufflation of the elbow with fluid will cause an extension movement.

Elbow positioning

It is advised to flex the elbow to 90 degrees as it displaces the brachial artery and the anterior nerves anteriorly^[4,9], maximizing the distance between the joint capsule and the brachial artery, and the nerve-to-capsule distance^[3,73]. The distance between the portals and the medial and radial nerves is doubled solely by elbow flexion, in combination with the aforementioned joint distension this distance even triples^[72]. Furthermore, capsular capacity is maximized by flexion, increasing arthroscopic working space and minimizing the chance of neurovascular complications^[1,3-5,73,78]. Disorders as rheumatoid arthritis, stiff and posttraumatic elbows may compromise the distension capacity of the capsule, thus raising the risk of neurovascular complications^[1,3,5,13,38,52]. For maximal range of flexion, compression of the flexion crease due to supportive arm holders should be avoided.

Portal placement

Portal placing can cause nerve injury^[13,18,46,62]. The above-mentioned preventive measures are meant to minimize the risk of neurovascular injury during the placing of portals. Mini-incision of the skin, avoiding incision of subcutaneous tissue, and the use of a blunt trocar or clamp are the first two preventive measures to avoid injury to the antebrachial nerves^[9,75]. Furthermore, recognize that portals placed proximally of the joint have the tendency of being safer^[9,79]. Pronation (in addition to flexion) of the elbow protects the posterior interosseous nerve when placing lateral portals. The elbow should be in midpronation at least. This way the nerve is brought

Table 1 Recommendations in short

Step	Phase	Recommendations
1	Work-up	Determine a valid indication. Identify possible complicating factors. If needed obtain additional imaging studies for careful planning of surgery Routinely report a subluxing or previously transposed ulnar nerve for all patients in the outpatient clinic setting previous of elbow arthroscopy
2	Preoperative preventive measures	Critical assessment of CT-studies to determine if osteophytes compress or mobilize the nerves (Figure 4) Examination under anesthesia (ROM) Marking of anatomic landmarks and portal sites (Figures 5 and 6) Palpation of the ulnar nerve course
3	Anesthesia	General anesthesia is recommended because of patient comfort and disabling unexpected patient movement
4	Patient positioning	Lateral decubitus position is recommended because of additional gravitational displacement of nerves away from the anterior capsule and easy access to all compartments (Figure 7) Use a bean bag for stable patient positioning
5	Joint insufflation	Increases nerve-to-portal distance by expanding the joint space en pushing the neurovascular structures away from the surgical field. Recognize that joint insufflation does not increase nerve-to-capsule distance (Figures 8 and 9)
6	Elbow positioning	Elbow flexion increases distension capacity of the joint and increases nerve-to-portal distance Supportive arm holders should not compress the flexion crease
7	Portal placement	Portals proximal to the joint tend to be safer Mini-incision of the skin only and the use of a blunt trocar or clamp prevents injury to the antebrachial nerves Pronation and flexion of the elbow protects the posterior interosseous nerve when placing lateral portals Avoid use of the posteromedial portal as the posterolateral and midposterior portals are good alternatives when inspecting the posterior compartment
8	Use of instruments	Always visualize the tip of the instrument Avoid suction when in the vicinity of a nerve or against the capsule Use a retractor to lift the capsule away from the debriding instrument, particularly in compartments at risk The use of hooded burrs instead of unhooded burrs is recommended as it help prevent the burr tangling up in the soft tissues No suction while shaving Availability of different shaver sizes during surgery

more anteromedial and the portal-to-nerve distance has increased^[4,78,80]. When assessing the anterior compartment of the elbow it is advised to start with an anteromedial portal subsequently placing a lateral portal using the camera because this possibly reduces the risk of radial nerve, *i.e.*, posterior interosseous nerve (PIN), injury^[7,9,10,12]. The proximal medial portal might even be a superior alternative compared to the anteromedial portal due to greater distance to the medial antebrachial nerve and no difference in arthroscopic view^[9,81]. When placing the proximal medial portal stay anterior of the medial intermuscular septum to keep the ulnar nerve posterior of the portal and avoid ulnar nerve injury^[9,82]. A method to reduce neurovascular injury when placing the proximal medial portal is by using a blunt hemostat or clamp after the usual mini-incision of the skin and place it on the anterior aspect of the humerus and aim it at the coronoid. By sliding downward over the humerus the capsule will be reached with small chance of injuring the median nerve, medial antebrachial nerve or brachial artery^[81]. When assessing the posterior compartment of the elbow avoid using the posteromedial portal as it brings risk for ulnar nerve injury; posterolateral and midposterior portal are good alternatives^[81].

Use of instruments

Once safe entry to the joint has been established it is

important to always keep your instrument tips within sight even under hard conditions and keep clear of using suction when working in the proximity of a nerve or the capsule to prevent within-out- injury^[75]. Never use suction while shaving. Another way of preventing within-out injury is using a retractor, *via* a separate portal, to keep the capsule away from a debriding instrument^[75]. This particularly applies to the posteromedial and the anterolateral compartment because of limited distance to the ulnar nerve and radial nerve respectively. Other advantages of using a retractor, aside from preventing within-out injury, are better visualization and exposure of the elbow joint. Lastly, to prevent a burr from getting entangled in the surrounding soft tissues and causing damage to an adjacent nerve hooded burrs are advised. Availability of different sizes of shavers during surgery is obligatory, so you can adjust the shaver size to the specific circumstances and avoid within-out-injury due to usage of a too large shaver.

All aforementioned recommendations are summarized in Table 1.

DISCUSSION

Thorough knowledge of the anatomy of the elbow in health and various diseases, handling of arthroscopic instruments and number of performed elbow arthroscopies

are of influence on one's arthroscopic expertise^[13,20,31,83,84]. There still is no consensus on the minimal number of elbow arthroscopies that has to be performed to become an experienced arthroscopist. However it is apparent that elbow arthroscopy has a long(er) learning curve. Savoie^[20] states that a minimal number of 100 performed elbow arthroscopies is necessary to become an experienced elbow arthroscopist. After the first 15 arthroscopies Kim *et al*^[84] observed a significant decrease in surgical time in elbow arthroscopy.

It is common sense that with more experience comes a decreased complication rate. This seems to be confirmed when comparing the study of Claessen *et al*^[83] with the studies of Marti *et al*^[31] and Elfeddali *et al*^[28]. Claessen *et al*^[83], observed a 30% complication rate in portal placement by novice surgeons whom were trained by a single didactic lecture and a single cadaveric training and found the complication rate significantly higher when compared to studies in current literature by experienced elbow arthroscopists. Marti *et al*^[31] found 6 minor complications (5%) in a series of 100 elbow arthroscopies done by 1 fellowship trained surgeon with only previous cadaveric experience, however no correlation could be found between the complication rate and the learning curve. Elfeddali *et al*^[28], found a 7.5% complication rate in 200 elbow arthroscopies over 8 years all performed by a single surgeon; due to the sample size it was not possible to detect any significant learning effect.

Following out of the aforementioned studies is that inexperienced surgeons are more likely to cause iatrogenic complications during elbow arthroscopy. A "young" surgeon should undergo extensive training with as much hands-on exposure as possible, comprehending guidance by an experienced elbow arthroscopist, computer-simulated hands-on courses, pre-clinical hands-on cadaveric courses preferably yearly and in line with the current opinion of arthroscopy experts and Claessen *et al*^[83] fellowship training.

In current literature the prevalence of neurologic injury after elbow arthroscopy, transient and permanent, is reported to range between 0% and 14%^[8,13,14,32,34,42,45,63,85-88]. As stated by Desai *et al*^[60] the reported prevalence is probably underreported. Possible causes of nerve injury underreporting after elbow arthroscopy are; the lack of a national registration for nerve injuries like there is for orthopedic implants, loss-to-follow-up due to the diagnosis and treatment of nerve injury by another specialty, and the possible reluctance or fear of the consequences when reporting iatrogenic nerve injury.

The goal of this editorial is to make one aware of the complications that can occur when performing elbow arthroscopy and more importantly stress the difficulty of performing elbow arthroscopy. The abovementioned instructions are to be a general guideline in order to help avoid complications during elbow arthroscopy. We believe a proper and thorough work-up and awareness of the possible severe complications throughout all steps of the procedure is the key for a successful elbow arthroscopy.

No matter the experience of an elbow arthroscopist, for

every indication a surgeon should assess if he is capable to perform the procedure as a surgeon's experience is directly related to the incidence of complications^[20].

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P- Reviewer: Ertem K, Guerado E, Ohishi T S- Editor: Ji FF
L- Editor: A E- Editor: Lu YJ





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