Endoscopic cubital tunnel decompression – Review of the literature

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Abstract
Cubital tunnel syndrome is the second most common compressive neuropathy of the upper limb. Endoscopic cubital tunnel decompression has gained popularity in recent years as this enables surgeons to achieve decompression of the ulnar nerve along its course using a small incision. This article describes the technical peals in performing endoscopic cubital tunnel decompression. In conditions which anterior transposition of the ulnar nerve is needed, subcutaneous transposition can be performed under endoscopic guidance. In addition, current literature is reviewed, and outcomes are presented. While short term results are encouraging, further prospective randomized study with longer follow-up is recommended.

Keywords
anterior transposition, cubital tunnel decompression, cubital tunnel release, cubital tunnel syndrome, elbow, endoscopic decompression, peripheral nerve entrapment, ulnar nerve, ulnar nerve entrapment, ulnar nerve subluxation

Introduction
Cubital tunnel syndrome is the second most common compressive neuropathy of the upper limbs, following carpal tunnel syndrome. It has an incidence of 25 cases per 100,000 person per year.1 It is a compressive neuropathy of the ulnar nerve around the medial aspect of the elbow, with the potential sites of compression being (from proximal to distal): Arcade of Struthers (8–10 cm proximal to medial epicondyle), medial intermuscular septum (especially if the nerve is needed for transposition), osteophytes of medial epicondyle, cubital tunnel retinaculum (also known as Osbourne’s ligament), anomalous anconeus epitrochlearis muscle, and the deep fascia of the flexor carpi ulnaris muscle (which may extend to 6–8 cm distal to medial epicondyle)2 (Figure 1).

Surgical intervention for cubital tunnel syndrome is indicated if the patients maintain to have persistent symptoms after a period of conservative treatment or if they present with severe motor or sensory deficit. Open decompression and anterior transposition of the ulnar nerve used to be the gold standard for the treatment of cubital tunnel syndrome.3 Yet, four prospective randomized studies4–7 comparing decompression and anterior transposition with open decompression in situ, showed that both techniques had similar recovery and functional outcomes. In addition, with the decompression in situ group5,6 revealing significant lower complication rate, the trend has shifted from open decompression and anterior transposition to open decompression in situ.8–10

In recent years, endoscopic cubital tunnel release has gained popularity.11 It allows surgeons to decompress the ulnar nerve along its route of all potential sites of compression under endoscopic guidance, with a smaller incision...
than that used in open decompression in situ (i.e., 2 cm as opposed to 4 cm)\textsuperscript{12}.

Currently there are different instruments which are dedicated for cubital tunnel release in the market. It can be classified into 2 types: the use of specialized dissecting equipment: Storz instruments (Karl Storz, Tuttingen, Germany)\textsuperscript{13,14} (Figure 2), and Agee device (3M, Orthopedic Products, St Pauls, MN, USA)\textsuperscript{15,16} and the use of cannula (Integra LifeSciences, Plainsboro, NJ, USA)\textsuperscript{17,18} (Figure 3). In this article, we are going to describe the technique of using Storz instruments in the endoscopic cubital tunnel release in situ as well as anterior transposition.

### Endoscopic cubital tunnel decompression in situ

#### Indications

- Symptomatic idiopathic cubital tunnel syndrome who are unresponsive to conservative care, preferably confirmed by nerve conduction study.

#### Contraindications

- The presence of mass or space occupying lesion around the elbow, leading to ulnar nerve compression.
- Patient with concomitant condition necessitating open surgery, e.g., humeral malunion or non-union.
- Patient with severe elbow contracture.
- Patient with previous trauma or surgery to the ulnar nerve.
- Patient in which ulnar nerve decompression and anterior transposition is more indicated (refer to below: Indication for endoscopic ulnar nerve decompression and anterior transposition).
- Patients with hypermobile ulnar nerve (refer to below: Hypermobility of ulnar nerve).

### Figure 1. Potential sites of ulnar nerve compression in cubital tunnel syndrome (copyright Professor Greg Bain and Mr Max Crespi).

### Figure 2. Endoscopic view of distal release using endoscope and specialized dissection equipment. Inlet: instrument used (copyright Professor Greg Bain).

### Figure 3. Illustration of endoscope and cannula in place (copyright Dr Tyson Cobb).
Hypermobility of ulnar nerve

Hypermobility of ulnar nerve remains to be a constant factor for debate on whether anterior transposition is needed. Conventionally, in the presence of ulnar nerve subluxation, concomitant ulnar nerve transposition at the time of surgical decompression is recommended. Interestingly Bartels et al. who randomized 152 patients suffering from cubital tunnel syndrome into either simple decompression and anterior subcutaneous transposition, irrespective of the mobility of their ulnar nerve, demonstrated that there was no significant difference in clinical outcomes between two groups at 1 year follow-up. There was no significant increase in persistent symptoms and recurrence. These findings were substantiated by the findings of Cobb et al who found that post-operative resolution rates of pain ($p = 0.69$), numbness and tingling ($p = 0.53$) and satisfactory ($p = 0.37$) were not affected by the presence of preoperative ulnar nerve subluxation.

Nevertheless, recurrence of cubital tunnel syndrome in the presence of ulnar nerve subluxation remains to be a concern for some authors. Krogue et al. demonstrated that subluxation of the ulnar nerve was one of key factors for patients to undergo a revision surgery after simple ulnar nerve decompression. Meanwhile Cobb et al studied recurrence following endoscopic cubital tunnel release in 104 cases and found a recurrence in one case only (0.96%; 95% confidence interval 0.02–5.24). Recurrence rate following endoscopic release were not found to be higher than that of literature controls following open cubital tunnel release.

Among our authors, TKC only performs anterior transposition for instability if the instability is clinically symptomatic, while GB and MWM Fok perform anterior transposition if gross instability is found either preoperatively or intra-operatively.

Surgical techniques

An 1.5–2 cm incision is first made at the retro-condylar groove, between the medial condyle and olecranon. After dissecting through the subcutaneous tissue, the ulnar nerve is usually identifiable distal to the cubital retinaculum. It is important to avoid injuring the medial antebrachial cutaneous nerve in the subcutaneous plane as this may result in numbness around the surgical incision and the medial aspect of forearm. The cubital retinaculum is cut open under direct vision to decompress the ulnar nerve. A dissecting forceps is then used to develop a subcutaneous tunnel between subcutaneous tissue and fascia along the route of ulnar nerve (proximal extent: 10–12 cm proximal to the medial epicondyle; distal extent: 8–10 cm distal to the medial epicondyle). The surgeon should not encounter much resistant during this procedure and force should not be needed in the tunnel preparation.

During the decompression, the ulnar nerve should be kept under direct vision at all times. The ulnar nerve can be released from the Arcade of Struthers proximally (8–10 cm proximal to the medial epicondyle) and to the distal extent of the deep fascia of the branching of ulnar nerve to the flexor carpi ulnaris muscle (about 6–8 cm distal to the medial epicondyle). When the decompression is completed, the stability of the ulnar nerve is checked by taking the elbow in full range of movement. If the nerve is found to be subluxatable or dislocatable during elbow flexion, anterior transposition is recommended by GB and MWM. Prior to wound closure, hemostasis is obtained with long bipolar forceps. This is especially important in the presence of tourniquet use

Pitfalls

- There is a learning curve in mastering endoscopic techniques. It is recommended for surgeons to familiarize with all the instruments and tissue manipulation in a cadaveric lab.
- A small incision may cause difficulty in visualization, which in turn result in iatrogenic injuries to either ulnar nerve proper or cutaneous nerves. It is recommended to use a larger incision especially in the first few cases and in overweight patients, until the surgeon is comfortable with the procedure.
- Injury to either the ulnar nerve proper or one of its branches may be resulted during decompression of the fasciae. It is important to keep the ulnar nerve in view at all times. Dissecting scissors is used to separate the nerve from the deep fasciae (i.e. 'nick and spread' technique) prior to the incision of the fasciae. If the endoscopic field is clouded (e.g. by blood) and cannot be cleared, convert to an open procedure should be considered.
- Aggressive dissection and forceful insertion of the endoscopic instruments may lead to soft tissue damages and bleeding. If resistance is encountered during the insertion of the endoscope, all the instruments should be retrieved, and the subcutaneous tunnel should be checked.
- One of the recognized complications of endoscopic cubital tunnel release is hematoma formation (Tables 1 and 2). Tourniquet with no Esmarch is recommended for the procedure, as small vessels can be identified and be cauterized proactively. Long bipolar cautery is used (Figure 4). If needed, low suction can be used to clear out the smoke generated. If the endoscopic view is obscured by blood, one may need to extend the incision or convert it to an open procedure.

Endoscopic cubital tunnel decompression + anterior transposition

Indications

In conditions which anterior transposition is needed, e.g. the presence of hostile bed, ulnar nerve hypermobility
| First Author | Technique | Cases | Severity | Follow-up (mths) | Results | Complications |
|--------------|-----------|-------|----------|-----------------|---------|---------------|
| Tsai 1989<sup>19</sup> | Cannula | 76 | Dellon 1: 33 Dellon 2: 35 Dellon 3: 17 | 32 | Bishop: excellent: 36 (42%) good: 38 (45%) fair: 9 (11%) poor: 2 (2%) | Hematoma with infection: 4 Thrombophlebitis: 1 Recurrence: 3 |
| Hoffmann 2006<sup>13</sup> | Storz | 76 | Dellon 1: 5 Dellon 2: 52 Dellon 3: 19 | Not mentioned | Bishop: excellent: 46 (60.5%) good: 25 (33%) fair: 4 (5%) poor: 1 (1%) | Hematoma: 4 CRPS: 1 Hypoesthesia (MABC nerve): 9 |
| Ahsan 2007<sup>20</sup> | Storz | 36 | McGowan 1: 4 McGowan 2: 21 McGowan 3: 11 | 14 | All complete/partial improved | |
| Yoshida 2009<sup>31</sup> | Cannula | 35 | McGowan 1: 3 McGowan 2: 14 McGowan 3: 18 | 26 | All but I had complete/partial improvement | No |
| Stadie, 2010<sup>16</sup> | Agee | 27 | McGowan 1: 5 McGowan 2: 16 McGowan 3: 6 | 26 | Improved McGowan Grade: 22 (81%) Subjective improvement: 70% | |
| Flores 2010<sup>27</sup> | Storz | 13 | Dellon 1: 1 Dellon 2: 4 Dellon 3: 7 | 6 | Bishop: excellent: 13 (76.9%) good: 3 (22.9%) | Hematoma: 4 |
| Cobb 2010<sup>17</sup> | Cannula | 104 | Dellon 1: 7 Dellon 2: 43 Dellon 3: 54 | 25 | Bishop: excellent: 78 (75%) good: 20 (19%) fair/poor: 6 (6%) | Recurrence/CRPS: 1 Reoperations: 2 |
| Oertel 2010<sup>32</sup> | Storz | 23 | McGowan 1: 4 McGowan 2: 9 McGowan 3: 13 | 9 | McGowan’s grade: Improved 17 (77%) Satisfaction: 17 (77%) | Nerve subluxation – convert to open I |
| Mirza, 2011<sup>33</sup> | Cannula | 52 | Not mentioned | 5 | Not mentioned | Hematoma: 1 Medial epicondylectomy I Anterior transposition: I Nil |
| Barlaan 2011<sup>34</sup> | Storz | 6 | Dellon 2: 3 Dellon 3: 3 | 6 | Bishop: excellent: 2 good: 4 | Hematoma: 2 |
| Martin 2014<sup>35</sup> | Storz | 55 | Not mentioned | 24 | Bishop: excellent 56.4% good: 32.7% fair: 9.1% poor: 1.8% Subjective outcome better: 72.7% same: 20% worse: 9.3% | |
| Sautier 2017<sup>36</sup> | Storz | 53 | Dellon 1: 8 Dellon 2: 29 Dellon 3: 16 | 17 | Bishop: excellent: 32 (60.4%) good: 13 (24.5%) fair: 6 (11.3%) poor: 2 (3.8%) | Delayed wound healing: 1 CRPS: 2 Nerve instability: 1 Recurrence: 1 |
| Zengin 2017<sup>37</sup> | No special retractor | 29 | Dellon 1: 3 Dellon 2: 14 Dellon 3: 12 | 16 | Bishop: excellent: 21 (72.4%) good: 4 (13.8%) fair: 3 (10.3%) poor: 1 (3.4%) | Hematoma: 2 |

(continued)
Contraindications

Similar to endoscopic cubital tunnel release in situ. In addition, as this is a subcutaneous anterior transposition, in conditions like severe elbow contracture, previous trauma or surgery causing abundant scar around the elbow and in thin patients who predispose to ulnar nerve irritation, necessitating submuscular transposition, this technique is contraindicated.

Surgical techniques

In the initial stage of procedure, the ulnar nerve is decompressed in the usual manner, as described in the above section. Furthermore, the previously identified medial intermuscular septum (MIMS) during proximal dissection must be excised. MIMS has been known to be a potential site of impingement along the new course of the ulnar nerve if it is left intact.

An anterior subcutaneous space anterior to the medial epicondyle which the ulnar nerve will be placed after the transposition is developed by dissecting forceps or spatula. Then an additional subcutaneous volar portal, about 1 cm in length, is created just distal to the medial epicondyle (Figure 5). A nylon tape is introduced into this portal in order to aid the mobilization of ulnar nerve. The tape looped over the ulnar nerve, and its accompanied vessels. By having an assistant to pull on the tape gently, the nerve can be mobilized from the loose aerolar tissue under endoscopic guidance.

Once the ulnar nerve is positioned into its ‘new’ course, anterior to the medial epicondyle, the entire course of the ulnar nerve is inspected again to ensure that there was no new site of compression or kinking of the nerve. A proximally based fascial sling from the flexor pronator muscle complex can be raised. By retracting the ulnar nerve anteriorly, i.e. between the fascial sling and the muscle bed, and suturing the sling onto the adjacent subcutaneous tissue, the nerve is being secured in its new course. Alternatively the subcutaneous tissue can be sutured to the rasped medial epicondyle in order to prevent the ulnar nerve from subluxing posteriorly during elbow movement. The stability of the nerve is checked again by taking the elbow to its full range of motion. Hemostasis is needed prior to the closure of the incisions to prevent the development of hematoma.

Pitfalls

- Due to the close proximity of the ulnar nerve to the MIMS, nerve injury may be resulted during MIMS excision. An additional proximal incision can be made to retract the ulnar nerve from the MIMS prior to the excision (Figure 5).
- Surgeons may devascularized the ulnar nerve by skeletonized the nerve from its accompanied vessels during the mobilization. This may affect the nerve recovery. It is recommended to mobilize the nerve together with its vessels.
- Traction injury to the ulnar nerve may be resulted if the assistant retracts the nerve, by pulling on the nylon tape with excessive force. It is important to remind assistant to lift up, instead of pulling on, the nylon tape, which wraps around the nerve and accompanied vessels, with minimal force. The accompanied vessels would be engorged proximally if excessive force is applied. Cadaveric practice may be beneficial for new assistants.
- New site of compression may be noted after transposition. It is important to inspect the new route for potential compression site and its stability.

Review of the current literature

Cubital tunnel decompression is a common procedure of which more than 50,000 were performed per year in United States.\textsuperscript{8} It comprises of different techniques including open and endoscopic decompression, with and without

| First Author | Technique         | Cases | Severity \textsuperscript{3, 41, 42} | Follow-up (mths) | Results                                                                 | Complications |
|--------------|-------------------|-------|--------------------------------------|-----------------|------------------------------------------------------------------------|---------------|
| Spies 2018\textsuperscript{38} | Optischer Dissektor | 51    | Not mentioned                       | 82              | Grip strength: 25 improved Paresthesia: 20 improved DASH 20.82 Patients opinion: excellent 26 (51%) good: 14 (27%) satisfactory: 3 (6%) not improved: 8 (16%) | Hematoma: 1   |

\textsuperscript{a}Wilson and Krout rating system, modified by Heithoff 1990.\textsuperscript{54}
Complex regional pain syndrome – CRPS.
Medial antebrachial cutaneous nerve – MABC.
| Author          | Study Type                  | Techniques (cases)                                      | Severity              | Follow-up (mths) | Outcomes                                      | Complications                                                                 |
|-----------------|-----------------------------|--------------------------------------------------------|-----------------------|------------------|-----------------------------------------------|------------------------------------------------------------------------------|
| Watt 2009<sup>24</sup> | Retrospective study         | Endoscopic (19) Open (15)                              | All levels           | 12               | Satisfaction: endoscopic 79% open 60%; p = 0.229 | General complication: Endoscopic: 11% (new elbow pain and hematoma) Open: 40% (new elbow pain, scar tenderness, MABC) p = 0.044 |
|                 |                             |                                                        |                       |                  | VAS satisfaction: Endoscopic 90 Open 60, p = 0.022 | Not mentioned                                                                 |
|                 |                             |                                                        |                       |                  | Employment and recreation status: work: p = 0.68 | Open: numbness over MABC: 14 (23.7%) Scar sensitivity: 4 (6.7%) Wound infection: 1 (1.7%) Endoscopic: Hematoma 2 (3.6%) Ulnar nerve subluxation: 4 (7.2%) |
| Saint-cyr 2013<sup>39</sup> | Retrospective study        | Endoscopic (12) Open (58) Submuscular transposition (24) Subcutaneous transposition (19) | All levels           | 14 (2 days–139 mths) | Bishop score: p = 0.77 Return to work: p = 0.512 | | |
| Dutzmann 2013<sup>40</sup> | Retrospective study         | Endoscopic (55) Open (59)                              | All levels           | 24               | Bishop: excellent/good: Endoscopic: 89.1% Open: 78% p = 0.52 Time to return to work (within 2–7 days): Endoscopic: 76.4% Open: 18.6% p < 0.001 Duration of post-operative pain: Endoscopic: 67.3 Open: 45.8% p = 0.04 | | |
|                 |                             |                                                        |                       |                  | *Similar results are obtained if 34 cases are paired and matched based on demographics and severity of ulnar nerve neuropathy | | |
| Cobb 2014<sup>25</sup> | Prospective cases vs retrospective cohort | Endoscopic (172) vs. Anterior transposition (15) (including nerve subluxation) | All levels           | 12               | Return to work: Endoscopic: 7 days anterior transposition: 71 days p < 0.001 | | |
|                 |                             |                                                        |                       |                  | | Endoscopic: 7 (4%) (hematoma and cellulitis) Persistent/recurrence: Endoscopic 4 (2%) Scar pain: Endoscopic: 1 Recurrence: Open: 1 submuscular transposition: 5 |
| Bacle 2014<sup>41</sup> | Retrospective, multicentre study | Endoscopic (95) vs. open (44) vs. submuscular transposition (82) vs. subcutaneous transposition (154) | All levels mainly McGowan I and IIA | 92 (9–144) | All had > 90% subjective improvement/cure p > 0.05 | | |

(continued)
| Author          | Study Type                  | Techniques (cases)       | Severity          | Follow-up (mths) | Outcomes                                                                 | Complications                  |
|-----------------|-----------------------------|--------------------------|-------------------|------------------|---------------------------------------------------------------------------|-------------------------------|
| Bolster 2014    | Prospective study          | Endoscopic (20) Open (22)| All levels        | 6                | Tourniquet time: Endoscopic: 42 min Open: 32 min, p = 0.04 VAS: Endoscopic: 2.9 Open: 2.2, p = 0.75 DASH: Endoscopic 24 Open: 17, p = 0.74 Bishop excellent/good: endoscopic 91% open: 93%, p = 0.63 Satisfaction: endoscopic: 80% open 86%, p = 0.58 | Infection: Endoscopic: 1 Recurrence: Open: 1 |
|                 |                             |                          |                   |                  |                                                                          |                               |
| Schmidt 2015    | Prospective, randomized    | Endoscopic (29) Open (27)| All levels (McGowan Level II and III except 1 patient) | 24               | Numeric analogue scale score (Pain): 3 months: p = 0.84 12 months: p = 0.84 Bishop score: 3 months: p = 1.9 12 months: p = 0.47 | Wound pain: p = −0.56 Post-operative electrophysiological findings: p = 0.62 Hematoma: endoscopic: 7 open: 1, p = 0.05 Persistent/Recurrence Endoscopic: 3 open: 5, p = 0.46 |
|                 | study                       |                          |                   |                  |                                                                          |                               |
| Krejci 2018     | Prospective, randomised    | Endoscopic (22) Open (23)| All levels        | 12               | Operation time: Endoscopic: 35 min Open: 30 min, p = 0.011 Bishop: 3 months: p = 0.176 12 months: p = 0.191 Return to work p > 0.05 Scar satisfaction: endoscopic vs. open p < 0.0005 Patient’s satisfaction: 12 months: p = 0.140 | Post-operative pain: p > 0.05 Chronic pain from scarring: 3 months: Endoscopic: 0 Open: 8, p = 0.011 12 months: Endoscopic: 0 Open: 5, p = 0.082 |

MABC: medial antebrachial cutaneous nerve.

VAS – Visual analogue scale score.
transposition, and medial epicondylectomy. Endoscopic cubital tunnel decompression was first described by Tsai et al in 1995. By using a 30° endoscope, ulnar nerve can be identified and released along its route, while preserving the vascularity of the ulnar nerve. Out of 112 patients, Tsai reported 87% excellent and good outcomes (Table 3), with short return to work time, low recurrence and complication rate. Subsequent case series also showed similar results. Comparative studies and meta-analysis between endoscopic cubital tunnel decompression and open decompression

Numerous studies comparing endoscopic cubital tunnel decompression with open decompression were available in the literature (Table 2). Both the operative time and the tourniquet time were noted to be significantly longer (of an average of 5–10 min) for the endoscopic decompression as compared with the open decompression, likely due to the additional need of endoscopic equipment preparation and in some cases limited experience. The latter is suggested by the findings of Cobb et al who reported on 172 cases of endoscopic cubital tunnel release with a mean tourniquet time of 10 min (range 3–23). While there was no significant

| Table 3. Bishop rating system. |
|--------------------------------|
| Bishop Rating System | Points |
| Satisfaction |  |
| Satisfied | 2 |
| Satisfied with reservation | 1 |
| Dissatisfied | 0 |
| Improvement |  |
| Better | 2 |
| Unchanged | 1 |
| Worse | 0 |
| Severity of residual symptoms (pain, paresthesia, dysesthesia, weakness, clumsiness) |  |
| Symptomatic | 3 |
| Mild-occasional | 2 |
| Moderate | 1 |
| Severe | 0 |
| Work status |  |
| Working or able to work at previous job | 1 |
| Not working secondary because of ulnar neuropathy | 0 |
| Leisure activity |  |
| Limited | 0 |
| Unlimited | 1 |
| Strength |  |
| Both grasp and pinch strength 80% or greater, compared with other hand | 2 |
| Either grasp or pinch (but not both) less than 80% | 1 |
| Both grasp and pinch less than 80% | 0 |
| Sensibility (static two-point discrimination) |  |
| Normal (<5 mm) | 1 |
| Abnormal (>5 cm) | 0 |
| Total | 12 |

| Bishop rating | Bishop Score |
|---------------|--------------|
| Excellent | 10–12 |
| Good | 7–9 |
| Fair | 4–6 |
| Poor | 1–3 |

**Figure 4.** The use of bipolar cauter to achieve haemostasis (copyright Professor Greg Bain).

**Figure 5.** Additional portal for anterior transposition for ulnar nerve mobilization (copyright Professor Greg Bain).
difference in Bishop score and patients’ subjective satisfaction between the two groups, the duration of postoperative pain and scar satisfaction were significantly in favour for endoscopic cubital tunnel decompression. There was no significant difference in the time to return to work for endoscopic and open decompression. Yet there was a significant difference in the time to return to work when endoscopic decompression was compared with anterior subcutaneous transposition, i.e. 7 days vs. 71 days. The overall complication rate for endoscopic cubital tunnel decompression was low compared with open cubital tunnel decompression. Nevertheless, post-operative haematoma remained to be a significant complication in endoscopic cubital tunnel decompression and care should be taken to achieve good haemostasis intraoperatively.

Only one long-term multicentre study was available with an average follow-up of 92 months (range: 9–144 months), comparing endoscopic decompression with other techniques namely open decompression, anterior subcutaneous transposition and submuscular transposition. The majority of these patients suffered from mild to moderate ulnar nerve palsy i.e. McGowan I and II. There was no significant difference in subjective improvement between different techniques. Submuscular transposition appeared to have more recurrence (i.e. 5 out of 82 patients) compared with other techniques (i.e. 1 out of 44 patients in open decompression), but the number was too small to reach a statistically significant difference.

Numerous systematic reviews and meta-analysis comparing endoscopic cubital tunnel decompression and open decompression have been published in recent years (Table 4). Similar clinical outcomes could be achieved with the two techniques. Yet there were more overall complications associated with open decompression. Scar tenderness and injuries to the medial antebrachial cutaneous nerve were

**Table 4.** Systematic review and meta-analysis of endoscopic cubital tunnel decompression with other techniques.

| First Author     | Type                     | Studies  | Patients  | Outcomes                                  | Complications                      |
|------------------|--------------------------|----------|-----------|-------------------------------------------|------------------------------------|
| Aldekhayel 2016  | Systematic Review/       | 20 studies| Endoscopic| Bishop: Excellent/Good endoscopic: 82%    | Endoscopic: 9% Hematoma, MABC Open: 12% MABC; scar sensitivity Reoperation: Endoscopic 1.6%, Open: 2.8% Overall Complications: RR = 0.88; p = 0.85 |
|                  | Meta-analysis            |          | Open 425  | Open: 80% p > 0.05                        |                                    |
| Ren 2016         | Systematic Review/       | 6 studies| Endoscopic| Bishop: RR = 0.99; p = 0.88 Patients’ satisfaction: RR = 0.98; p = 0.70 |                                    |
|                  | Meta-analysis            |          | Open 244  |                                            |                                    |
| Toirac 2017      | Systematic Review/       | Clinical results: 8 studies | Endoscopic 344 | Bishop: Excellent/ good: Endoscopic: 92%  |                                    |
|                  | Clinical results         |          | Open 150  |                                            |                                    |
|                  |                          |          |           | Open: 82.7%                               |                                    |
|                  |                          |          |           |                                            |                                    |
| Buchanan 2018    | Systematic Review/       | 5 studies| Endoscopic 226 | Bishop: Excellent/good: endoscopic: 85%   | Complications: Endoscopic vs. open OR = 0.28; p = 0.002 Scar tenderness: Open more p = 0.002 Hematoma: Endoscopic more p = 0.003 Reoperation: endoscopic: 4.9% (hematoma or persistent/recurrent symptoms); open: 4.1% (persistent/recurrent symptoms only) |
|                  | Meta-analysis            |          | Open 429  | open: 82%; p > 0.05 VAS p > 0.05          |                                    |
|                  |                          |          |           |                                            |                                    |
| Byvaltsev 2020   | Systematic Review/       | 8 studies| 582 patients | No difference in Bishop score, VAS reduction and satisfaction | No different in hematoma and reoperation rate |
|                  | Meta-analysis            |          |           |                                            |                                    |

MABC: medial antebrachial cutaneous nerve.
VAS – Visual analogue scale score.
Results described as more, are significantly more.
Satisfaction is post-operative satisfaction.
Only statistically significant results are presented.
associated with the open decompression while haematoma was associated with endoscopic decompression.\textsuperscript{28,29}

\textbf{Endoscopic decompression and anterior transposition}

There are only a few case series illustrating the outcome (up to 24 months) after endoscopic cubital tunnel decompression and anterior transposition (Table 5). Only Martin et al.\textsuperscript{35} described the subjects of their study as patients with preoperative elbow discomfort or recurrence, requiring anterior transposition. The short term outcomes of endoscopic cubital tunnel decompression and anterior transposition was promising, with at least 75\% achieving either good or excellent outcome.\textsuperscript{35,52,53} Though the complication rate was low, hematoma and injury to the medial antebrachial cutaneous nerve remained to be the main complications.\textsuperscript{35}

\textbf{Conclusion}

Endoscopic decompression appears to be a promising technique in the management of cubital tunnel syndrome. It can achieve, comparable or superior clinical outcome as with open decompression and is associated with low complication rate and recurrence rate. Yet, there is a lack of well-designed study, preferably an adequately powered, double blinded, randomized controlled trial to compare endoscopic decompression with open decompression.

With the need of using endoscopic equipment, endoscopic decompression is associated a higher operative cost than open decompression.\textsuperscript{11} Currently there is no study examining the cost effectiveness in open and endoscopic cubital tunnel decompression. If endoscopic decompression is associated with early return to work and low complication rate, an increase in the initial surgical cost may be justified.

Endoscopic decompression and anterior transposition is a relatively new concept. It is useful in cases which the native bed of the ulnar nerve is hostile, or the ulnar nerve is subluxatable. Yet, further study is needed to compare its outcome with different conventional anterior transposition.

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\textbf{References}

1. Mondelli M, Giannini F, Ballerini M, et al. Incidence of ulnar neuropathy at the elbow in the province of Siena (Italy). J Neurol Sci 2005; 234(1–2): 5–10.

2. Damert H-G, Altmann S, Infanger M, et al. Operative decisions for endoscopic treatment of cubital tunnel syndrome. In: Harwin SF (eds) Orthopedics 2013; 36(5): 354–359.
3. Lee Dellon A. Review of treatment results for ulnar nerve entrapment at the elbow. J Hand Surg Am 1989; 14(4): 688–700.
4. Bartels RHMA, Verhagen WIM, van der Wilt GJ, et al. prospective randomized controlled study comparing simple decompression versus anterior subcutaneous transposition for idiopathic neuropathy of the ulnar nerve at the elbow: part 1. Neurosurgery 2005; 56(3): 522–530.
5. Gervasio O, Gambardella G, Zacccone C, et al. Simple decompression versus anterior submuscular transposition of the ulnar nerve in severe cubital tunnel syndrome: a prospective randomized study. Neurosurgery 2005; 56(1): 108–117.
6. Biggs M and Curtis JA. Randomized prospective study comparing ulnar neurolysis in situ with submuscular transposition. Neurosurgery 2006; 58(2): 296–304.
7. Keiner D, Gaab MR, Schroeder HWS, et al. Comparison of the long-term results of anterior transposition of the ulnar nerve or simple decompression in the treatment of cubital tunnel syndrome – a prospective study. Acta Neurochir (Wien) 2009; 151(4): 311–316.
8. Soltani AM, Best MJ, Francis CS, et al. Trends in the surgical treatment of cubital tunnel syndrome: an analysis of the national survey of ambulatory surgery database. J Hand Surg Am 2013; 38(8): 1551–1556.
9. O’Grady E, Power D and Tan S. Current attitudes regarding surgical treatment of cubital tunnel syndrome in the UK. J Hand Surg Eur Vol 2017; 42(9): 959–960.
10. Yahya A, Malarkey AR, Eschbaugh RL, et al. Trends in the surgical treatment for cubital tunnel syndrome: a survey of members of the American Society for surgery of the hand. Hand (N Y) 2018; 13(5): 516–521.
11. Law TY, Hubbard ZS, Chieng LO, et al. Trends in open and endoscopic cubital tunnel release in the medicare patient population. Hand (N Y) 2017; 12(4): 408–412.
12. Said J, Frizzell K, Heimur J, et al. Visualization during endoscopic versus open cubital tunnel decompression: a cadaveric study. J Hand Surg Am 2019; 44(8): 697.e1–697.e6.
13. Hoffmann R and Siemionow M. The endoscopic management of cubital tunnel syndrome. J Hand Surg Br 2006; 31(1): 23–29.
14. Hoffmann R and Lubahn J. Endoscopic cubital tunnel release using the Hoffmann technique. J Hand Surg Am 2013; 38(6): 1234–1239.
15. Bain GI and Bajhau A. Endoscopic release of the ulnar nerve at the elbow using the Agee device: a cadaveric study. Arthroscopy 2005; 21(6): 691–695.
16. Studie AT, Keiner D, Fischer G, et al. simple endoscopic decompression of cubital tunnel syndrome with the Agee system. Oper Neurosurg 2010; 66(1): 325–332.
17. Cobb TK, Sterbank PT and Lemke JH. Endoscopic cubital tunnel recurrence rates. Hand (N Y) 2010; 5(2): 179–183.
18. Cobb T. Endoscopic cubital tunnel release. In: Lee DH and Nevisier RJ (eds) Operative techniques: shoulder and elbow surgery. Amsterdam: Elsevier, 2011, pp. 891–903.
19. Tsai TM, Bonczar M, Tsuruta T, et al. A new operative technique: cubital tunnel decompression with endoscopic assistance. Hand Clin 1995; 11(1): 71–80.
20. Staples JR and Calfee R. Cubital tunnel syndrome: current concepts. J Am Acad Orthop Surg 2017; 25(10): e215–e224.
21. Bain G and Fok MWM. Endoscopic ulnar nerve decompression and transposition. In: Bain G, Eygendaal D and van Riet RP (eds) Surgical techniques for trauma and sports related injuries of the elbow. Berlin, Heidelberg: Springer, 2020, pp. 739–744.
22. Matzon JL, Lutsky KH, Hoffler CE, et al. Risk factors for ulnar nerve instability resulting in transposition in patients with cubital tunnel syndrome. J Hand Surg Am 2016; 41(2): 180–183.
23. DeGeorge B Jr and Kakar S. Decision-making factors for ulnar nerve transposition in cubital tunnel surgery. J Wrist Surg 2018; 8(2): 168–174.
24. Watts AC and Bain GI. Patient-rated outcome of ulnar nerve decompression: a comparison of endoscopic and open in situ decompression. J Hand Surg Am 2009; 34(8): 1492–1498.
25. Cobb TK, Walden AL, Merrell PT, et al. Setting expectations following endoscopic cubital tunnel release. Hand (N Y) 2014; 9(3): 356–363.
26. Krogue JD, Aleew AM, Osei DA, et al. Predictors of surgical revision after in situ decompression of the ulnar nerve. J Shoulder Elbow Surg 2015; 24(4): 634–639.
27. Flores LP. Endoscopically assisted release of the ulnar nerve for cubital tunnel syndrome. Acta Neurochir (Wien) 2010; 152(4): 619–625.
28. Aldekhayel S, Govshievich A, Lee J, et al. Versus open cubital tunnel release. Hand (N Y) 2016; 11(1): 36–44.
29. Buchanan PJ, Chieng LO, Hubbard ZS, et al. Endoscopic versus open in situ cubital tunnel release: a systematic review of the literature and meta-analysis of 655 Patients. Plast Reconstr Surg 2018; 141(3): 679–684.
30. Ahcan U and Zorman P. Endoscopic decompression of the ulnar nerve at the elbow. J Hand Surg Am 2007; 32(8): 1171–1176.
31. Yoshida A, Okutsu I and Hamanaka I. Endoscopic anatomical nerve observation and minimally invasive management of cubital tunnel syndrome. J Hand Surg Eur Vol 2009; 34(1): 115–120.
32. Oertel J, Keiner D and Gaab MR. Endoscopic decompression of the ulnar nerve at the elbow. Neurosurgery 2010; 66(4): 817–824. Discussion824.
33. Mirza A, Reinhart MK, Bove J, et al. Scope-assisted release of the cubital tunnel. J Hand Surg Am 2011; 36(1): 147–151.
34. Barlaan PI and Ip JW-Y. Our early experience in surgical and clinical outcome on endoscopic cubital tunnel release: a preliminary result. ISRN Orthop 2011; 2011(1): 427403–427405.
35. Martin KD, Dützmann S, Sobottka SB, et al. Retractor-endoscopic nerve decompression in carpal and cubital tunnel syndromes: outcomes in a small series. World Neurosurgery 2014; 82(1–2): e361–e370.
36. Sautier E, Neri T, Gresta G, et al. Endoscopic neurolysis of the ulnar nerve: retrospective evaluation of the first 60 cases. J Shoulder Elbow Surg 2017; 26(6): 1037–1043.
37. Zengin Ç, Tahta M, Güntürk Ö, et al. Results of endoscopically-assisted cubital tunnel release without using any specific instrument. Acta Orthop Traumatol Turc 2017; 51(2): 138–141.
38. Spies CK, Schäfer M, Langer MF, et al. Functional outcome after endoscopic assisted release of the ulnar nerve for cubital tunnel syndrome: mid-to-long term results. Int Orthop 2018; 42(6): 1331–1337.
39. Saint-Cyr M, Lakhiani C and Tsai T-M. Surgical management of cubital tunnel syndrome: a comparative analysis of outcome using four different techniques. Eur J Plast Surg 2013; 36(11): 693–700.
40. Düttmann S, Martin KD, Sobottka S, et al. Open vs retractor-endoscopic in situ decompression of the ulnar nerve in cubital tunnel syndrome: a retrospective cohort study. Neurosurgery 2013; 72(4): 605–616. discussion 614–616.
41. Bacle G, Marteau E, Freslon M, et al. Cubital tunnel syndrome: comparative results of a multicenter study of 4 surgical techniques with a mean follow-up of 92 months. Orthop Traumatol Surg Res 2014; 100(4 Suppl): S205–S208.
42. Bolster MAJ, Zöphel OT, van den Heuvel ER, et al. Cubital tunnel syndrome: a comparison of an endoscopic technique with a minimal invasive open technique. J Hand Surg Eur Vol 2014; 39(6): 621–625.
43. Schmidt S, Kleist Welch-Guerra W, Matthes M, et al. Endoscopic vs open decompression of the ulnar nerve in cubital tunnel syndrome: a prospective randomized double-blind study. Neurosurgery 2015; 77(6): 960–970. discussion 970–971.
44. Krejčí T, Večeřa Z, Krejčí O, et al. Comparing endoscopic and open decompression of the ulnar nerve in cubital tunnel syndrome: a prospective randomized study. Acta Neurochir (Wien) 2018; 160(10): 2011–2017.
45. Morse LP, McGuire DT and Bain GI. Endoscopic ulnar nerve release and transposition. Tech Hand Up Extrem Surg 2014; 18(1): 10–14.
46. Kleinman WB and Bishop AT. Anterior intramuscular transposition of the ulnar nerve. J Hand Surg Am 1989; 14(6): 972–979.
47. McGowan AJ. The results of transposition of the ulnar nerve for traumatic ulnar neuritis. J Bone Joint Surg Br 1950; 32-B(3): 293–301.
48. Goldberg BJ, Light TR and Blair SJ. Ulnar neuropathy at the elbow: results of medial epicondylectomy. J Hand Surg Am 1989; 14(2 Pt 1): 182–188.
49. Ren Y-M, Zhou X-H, Qiao H-Y, et al. Open versus endoscopic in situ decompression in cubital tunnel syndrome: a systematic review and meta-analysis. Int J Surg 2016; 35: 104–110.
50. Toirac A, Giugale JM and Fowler JR. Open versus endoscopic cubital tunnel in situ decompression: a systematic review of outcomes and complications. Hand (N Y) 2017; 12(3): 229–235.
51. Byvaltsev VA, Stepanov IA and Kerimbayev TT. A systematic review and meta-analysis comparing open versus endoscopic in situ decompression for the treatment of cubital tunnel syndrome. Acta Neurol Belg 2019; 72(2): 90–98.
52. Jiang S, Xu W, Shen Y, et al. Endoscopy-assisted cubital tunnel release under carbon dioxide insufflation and anterior transposition. Ann Plast Surg 2012; 68(1): 62–66.
53. Wong JKF, Hsu CC, Lin CH, et al. Endoscopy-assisted subfascial anterior transposition of the ulnar nerve for the treatment of cubital tunnel syndrome. J Plast Reconstr Aesthet Surg 2016; 69(12): 1704–1710.
54. Heithoff SJ, Millender LH, Nalebuff EA and Petruska AJ. Medial epicondylectomy for the treatment of ulnar nerve compression at the elbow. J Hand Surg Am. 1990; 15(1): 22–29.