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A new capsulotomy-based dorsal approach to the wrist: a cadaver study

Une nouvelle capsulotomie comme abord dorsal du poignet : étude cadavérique

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1 **A new capsulotomy-based dorsal approach to the wrist: a cadaver study**

3 **Une nouvelle capsulotomie comme abord dorsal du poignet : étude cadavérique**

5 **Abstract**

6 Using a cadaver study, we described a new dorsal approach to the wrist joint using a "U-
7 shaped with proximal base" capsulotomy. Six fresh adult cadaveric wrists were dissected
8 after intra-arterial silicone injection. We did a dorsal approach to expose the dorsal joint
9 capsule. It was then possible to identify the dorsal radiocarpal and intercarpal ligaments, the
10 dorsal radiocarpal and intercarpal arterial arches, the dorsal branch of the anterior
11 interosseous artery and the terminal branch of the posterior interosseous nerve. Wrist
12 arthrotomy was done using our capsulotomy. In each dissected capsular flap, we always
13 found the individual ligament, vascular, and nerve structures, implying they were intact over
14 their trajectories. The mean surface area of the articular exposure was 945 mm² (range 725–
15 1102 mm²) allowing easy access to the carpal bones and the radiocarpal and midcarpal joint
16 spaces. This surgical approach to the wrist is technically feasible and avoids damaging the
17 dorsal extrinsic ligaments fibers. Keeping the vascularization intact could improve capsular
18 healing, while preserving innervation could maintain wrist proprioception.

20 **Résumé**

21 À l'aide d'une étude cadavérique, nous avons décrit un nouvel abord dorsal pour l'articulation
22 du poignet en utilisant une capsulotomie en forme de "U" à base proximale. Six poignets de
23 cadavres adultes frais ont été disséqués après injection intra-artérielle de silicone. Par une
24 voie d'abord dorsale, nous avons exposé la capsule articulaire dorsale. Il a alors été possible
25 d'identifier les ligaments radio-carpien et intercarpien dorsaux, les arcades artérielles
26 radiocarpienne et intercarpienne dorsales, la branche dorsale de l'artère interosseuse
27 antérieure et la branche terminale du nerf interosseux postérieur. L'arthrotomie du poignet a
28 été réalisée à l'aide de notre capsulotomie. Dans chaque lambeau capsulaire disséqué, nous

29 avons systématiquement trouvé les structures ligamentaires, vasculaires et nerveuses
30 individualisées, ce qui implique qu'elles étaient intactes sur leurs trajets. La surface moyenne
31 de l'exposition articulaire était de 945 mm² (range 725–1102 mm²) permettant un accès facile
32 aux os du carpe et aux espaces articulaires radio-carpien et médiocarpien. Cet abord
33 chirurgical du poignet est techniquement réalisable et évite d'endommager les fibres des
34 ligaments extrinsèques dorsaux. Garder la vascularisation intacte pourrait améliorer la
35 cicatrisation capsulaire, tandis que la préservation de l'innervation pourrait maintenir la
36 proprioception du poignet.

37

38 *Keywords:* Capsulotomy; Carpal bones; Dorsal approach; Midcarpal joint; Radiocarpal joint;

39 Wrist

40

41 *Mots-clés :* Abord dorsal ; Articulation médiocarpienne ; Articulation radio-carpienne ;

42 Capsulotomie ; Os du carpe ; Poignet

43

44 **1. Introduction**

45 Several traumatic, rheumatic or degenerative pathologies require a wrist joint approach. Most
46 authors suggest using a dorsal approach rather than a palmar one for easier exposure [1].
47 Several capsulotomy techniques have been described such as longitudinal, transverse,
48 oblique, “L-shaped”, “T-shaped” or “distally-based U-shaped” designs [2]. The “V-shaped”
49 fiber-splitting capsulotomy described by Berger et al. is the most commonly used [3]. Its main
50 advantage is that it provides good exposure of the radiocarpal and midcarpal joint spaces.
51 However, in an anatomical study, Hagert et al. showed that it failed to maintain the integrity
52 of the dorsal radiocarpal ligament (DRCL) and dorsal intercarpal ligament (DICL) fibers [4].
53 Similarly, the dorsal capsular innervation provided by the posterior interosseous nerve
54 (PION) is always interrupted with the Berger procedure. Hagert et al. also highlighted the
55 importance of preserving this nerve for its proprioceptive function, which is essential during
56 postoperative rehabilitation [4]. In this cadaver study, we wanted to describe a new dorsal
57 wrist capsulotomy procedure, its technical feasibility, and its advantages with regards to
58 preserving anatomical structures and exposing the carpal joint spaces.

59

60 **2. Materials and Methods**

61 2.1. Study protocol

62 Six upper limbs (three left and three right) from fresh, unembalmed adult cadavers were
63 provided by our Medical School Anatomy Laboratory. The limbs had been disarticulated at
64 the scapulohumeral joint and were prepared using the same protocol by a specialist surgeon
65 (LA) [5]. The radial and ulnar arteries were dissected through an incision at the anterior
66 aspect of the forearm and isolated to perform arteriotomy of each artery and then inject
67 colored silicone rubber (Microfil®, Carver, Massachusetts). Each artery received 10 cc of
68 radio-opaque silicone and was ligated to limit the silicone’s effusion outside the vascular
69 pedicles studied. After 1 week’s rest in the refrigerator, we dissected the dorsal side of each
70 wrist using the same surgical technique.

71

72 2.2. Capsulotomy technique

73 This technique was developed by one of the authors (LA), a specialist surgeon [5] who
74 performed all the dissections.

75 A dorsal incision was made along the axis of the third metacarpal, centered on the
76 midline of the radiocarpal joint. The extensor retinaculum was opened between the third and
77 fourth compartments. The fifth compartment was also opened. To expose the dorsal joint
78 capsule, the extensor pollicis longus was retracted on the radial side, while the fourth and
79 fifth compartment extensors were retracted on the ulnar side. It was then possible to identify
80 the DRCL and DICL, the dorsal radiocarpal arterial arch (DRCA) and the dorsal intercarpal
81 arterial arch (DICA), the dorsal branch of the anterior interosseous artery (AIOA) and the
82 terminal branch of the PION.

83 The next step consisted of drawing an outline of the capsulotomy with a surgical
84 marker (Purple surgical International, Herts, England). The design was “U-shaped with
85 proximal base”. The ulnar border was a longitudinal axis located directly on the triquetral
86 bone insertion of the DRCL and DICL, respecting the dorsal ulnocarpal ligament. The radial
87 border was a longitudinal axis located in the extension of the medial edge of the radial styloid
88 process. Finally, the distal transverse branch was located directly distal to the DICA (Fig. 1).
89 Using a scalpel blade (Swann-Morton®, Sheffield, England), an arthrotomy was performed
90 without elevating a bony chip from the dorsal aspect of the triquetrum. The capsular flap was
91 raised to expose the carpal bones and the radiocarpal and midcarpal joint spaces. The final
92 step was suturing the capsule and retinaculum with absorbable PDS™ sutures (Ethicon®,
93 One Johnson & Johnson Plaza, New Brunswick, NJ).

94

95 2.3. Descriptive anatomy

96 For each wrist, an independent examiner (MCS) documented the anatomical configuration
97 (origin, trajectory, and insertion) of the DRCL, DICL, DRCA, DICA, dorsal branch of the AIOA
98 and the terminal branch of the PION. He also measured the width and length of each
99 capsulotomy border in millimeters (accuracy 1 mm) with a graduated ruler (Purple surgical

100 International™, Herts, England). This information was used to determine the average surface
101 area in mm² of the capsular flap and thus its exposure capacity relative to the carpal bones
102 and joint spaces. The last step was checking that all these individual anatomical structures
103 were present and intact within the capsular flap. Finally, we tested the capsular stitching
104 using PDS slow-absorbing sutures (Ethicon®).

105

106 2.4. Statistical analysis

107 Quantitative parameters were described by their means and ranges and qualitative
108 parameters by their counts and percentages.

109

110 **3. Results**

111 Six wrists were dissected in this study; each of them had the same anatomical configuration.

112 The origin, trajectory, and insertion of the DRCL and DICL were consistent. The DRCL
113 originated proximally from the dorsal rim of the distal radius, ulnar to Lister's tubercle. Next,
114 the ligament had an oblique trajectory from proximal to distal and from lateral to medial. Its
115 distal insertion was on the dorsal part of the triquetrum. The DICL originated proximally on
116 the dorsal part of the triquetrum. Then, the ligament had a horizontal trajectory from medial to
117 lateral. Its distal insertion was on the distal and dorsal part of the scaphoid and trapezium.
118 The DCSS can be repaired by fixing it at its old bone insertion using an anchor.

119 The terminal branch of the PION ran longitudinally on the ulnar side of Lister's
120 tubercle and was affixed to the floor of the fourth extensor compartment. At the level of the
121 DRCL, the nerve penetrated the dorsal articular capsule at its surface. Both the DRCA and
122 DICA were systematically found running perpendicular to the distal radius axis. The DRCA
123 ran along the radiocarpal joint line while the DICA followed a trajectory parallel to the distal
124 insertion of the DICL from medial to lateral. The dorsal branch of the AIOA had a longitudinal
125 course, with its proximal part following the terminal branch of the PION along its ulnar edge.
126 On the surface of the joint capsule, this branch was anastomosed perpendicularly to the two
127 arterial arches.

128 The mean length of the capsular flap was 35 mm (range 29–38 mm) and its mean
129 width was 27 mm (range 25–29 mm). The mean surface area of the articular exposure was
130 945 mm² (range 725–1102 mm²). It systematically provided easy access to both rows of
131 carpal bones, except the pisiform. It also provided good exposure of the radiocarpal and
132 midcarpal joint spaces (Fig. 2). Access to the scaphotrapeziotrapezoid joint space was
133 limited. In each dissected capsular flap, we found all the individual ligament, vascular, and
134 nerve structures, implying that they were intact over their entire trajectories (Fig. 3) (Video 1).
135 The capsular stitching was systematically easy to perform, including at the level of triquetral
136 bone insertion of the DRCL and DICL by the ligament remnant on the bone.

137

138 **4. Discussion**

139 Our anatomical study confirmed the technical feasibility of this new dorsal capsulotomy and
140 the resulting good carpal joint exposure. We also confirmed that the integrity of the dorsal
141 extrinsic ligament fibers is maintained as well as the vascularization and innervation of the
142 dissected capsular flap.

143 Several authors emphasize that the extrinsic ligaments are key stabilizers of the
144 scapholunate complex. Viegas et al. [6], Mitsuyasu et al. [7] and Short et al. [8] showed that
145 the DRCL and the DICL are important stabilizers, especially during the progression from
146 dynamic to static scapholunate instability. More recently, Van Overstraeten et al. [9]
147 described another stabilizer – the dorsal capsulo-scapholunate septum (DCSS) – which is a
148 thickened portion of the capsule that joins the dorsal part of the scapholunate ligament and
149 the DICL. This means that both the scapholunate interosseous ligament and extrinsic
150 ligaments must be damaged for static scapholunate instability to develop [10].

151 With our capsulotomy, we were able to systematically preserve the DRCL and DICL
152 fibers over their entire trajectories. We believe it is essential to preserve these stabilizers
153 during intracarpal surgery, especially when doing intrinsic ligament reconstruction surgery.
154 The objective is to avoid any intra-ligament scarring that could weaken its biomechanical
155 properties.

156 The vascular anatomy of the wrist joint was described by Gelbermann et al. [11]. On
157 the dorsal side, it consists of an anastomotic network including the DRCA, the DICA and the
158 dorsal branch of the AIOA. The latter emerges dorsally after crossing the interosseous
159 membrane near the proximal edge of the pronator quadratus. This dorsal branch runs with
160 the PION affixed to the floor of the fourth extensor compartment. This nerve innervates the
161 dorsal joint capsule [12]. Recently, in their histological study of the dorsal wrist capsule,
162 Bonczar et al. showed the PION innervated 60% of the central portion; the remaining area
163 was innervated by the superficial branch of the radial nerve and the medial antebrachial
164 cutaneous nerve [13].

165 The design of this capsulotomy made it possible to preserve all these vascular and
166 nerve structures in the capsular flap. Thus, in clinical practice, this could presage maintaining
167 the dorsal joint capsule's vascularization and innervation. Vascular integrity would boost the
168 capsule's healing which could in turn decrease retraction. The absence of intra-ligament
169 scars in the radiocarpal area by preserving a proximal hinge could reduce joint stiffness
170 secondary to any wrist arthrotomy.

171 Moreover, with a "U-shaped with proximal base" capsulotomy, the tension on the
172 capsular closure can be adjusted by changing the location of distal anchorage points along a
173 proximo-distal axis, such as an advancement flap, without filling the gap. This trick could be
174 useful in cases of intracarpal osteoarthritis surgery in which restoring carpal height would
175 require rebalancing the capsular closure tension to minimize stiffness in wrist's flexion-
176 extension arc.

177 According to Hagert et al., [4] preserving the terminal branch of the PION would
178 maintain wrist proprioceptive innervation. This could be useful for postoperative rehabilitation
179 after performing wrist joint surgery. The recovery of grip strength and wrist mobility would be
180 optimized. Given the anatomical configuration of this nerve branch, confirmed in our study,
181 any capsulotomy with an incision on the radiocarpal joint line causes an iatrogenic lesion.

182 One of the aims of our study was to confirm how this dorsal capsulotomy can be done
183 to expose carpal joint spaces. Omokawa et al. [14] described a longitudinal DICL preserving

184 arthrotomy. The dorsal wrist capsule is opened between the DICL and DRCL, and the dorsal
185 scapholunate joint space can be observed. The authors used this approach to treat
186 scapholunate dissociation by transferring the DICL to reconstruct the dorsal scapholunate
187 ligament. However, this procedure does not provide sufficient joint exposure to perform
188 surgery on anything else than scapholunate pathologies. Based on our findings, our surgical
189 approach provides access to the carpal bones as well as the radiocarpal and midcarpal joint
190 spaces. Thus, this procedure could be suitable for many types of intracarpal bone or
191 ligament surgeries. Nevertheless, access to the scaphotrapeziotrapezoid joint space remains
192 difficult with this purely dorsal approach. A lateral or palmar approach seems to be better
193 suited [2].

194 Our study has its limitations. Firstly, we had a limited sample size, which did not allow
195 us to study this surgical procedure relative to the different anatomical variations of the wrist
196 ligaments [15,16]. However, it was sufficient to assess the technical feasibility of this
197 technique. Another limitation is the fact that a cadaver study, albeit with positive results, may
198 not translate fully to the clinical scenario, particularly in terms of functional recovery.
199 Likewise, we were not able to assess how well the capsular flap vascularization's was
200 preserved with punctate bleeding. Finally, we did not compare our dorsal capsulotomy with
201 other procedures such as Berger et al. [3] capsulotomy. A prospective clinical study would be
202 the next step to validate our findings.

203

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242 **Figure legends**

243 Fig. 1. Diagram and photograph of a posterior view of the wrist illustrating the anatomical
244 structures and the outline of the capsulotomy (*black lines*). 1: Dorsal radiocarpal ligament
245 (DRCL) (*dashed line*); 2: dorsal intercarpal ligament (DICL) (*dashed line*); 3: terminal branch
246 of posterior interosseous nerve (PION); 4: dorsal branch of anterior interosseous artery
247 (AIOA); 5: dorsal radiocarpal artery arch (DRCA); 6: dorsal intercarpal artery arch (DICA).

248

249 Fig. 2. Photographs of a posterior view of a right (A) and a left (B) wrist illustrating the carpal
250 joint space exposure and its dimensions. The *black arrows* indicate the capsulotomy's
251 outlines. *S*: Scaphoid; *L*: lunate; *T*: triquetrum; *C*: capitate; *H*: hamate.

252

253 Fig. 3. Photograph of a posterior view of a right wrist illustrating the capsular flap. The *white*
254 *arrows* indicate the capsulotomy's outline. 1: capsular flap with the dorsal radiocarpal and
255 dorsal intercarpal ligaments; 2: terminal branch of posterior interosseous nerve; 3: dorsal
256 branch of anterior interosseous artery (AIOA)

257

258 **Video**

259 Video 1. Video showing a posterior view of the wrist illustrating the dissected capsular flap
260 with its vascularization and the carpal joint space exposure.

261





