

1 **It's time to change perspective! New diagnostic tools for lateral elbow pain.**

2

3 **Abstract**

4 **Purpose:** The presence of intra-articular findings that may complement the extra-articular
5 pathology in lateral epicondylitis has been suggested and a role for minor instability of the elbow as
6 part of the causative process of this disease has been postulated. This study was designed to
7 describe two new clinical tests, aimed at detecting intra-articular pathology in patients affected by
8 recalcitrant lateral epicondylitis and investigate their diagnostic performance.

9 **Methods:** Ten patients suffering of atraumatic lateral elbow pain unresponsive to conservative
10 treatment were considered in this study. Two clinical tests were developed and administrated prior
11 to arthroscopy: Supination and Antero-Lateral pain Test (SALT); Posterior Elbow Pain by
12 Palpation-Extension the Radiocapitellar joint (PEPPER). Sensitivity, specificity, predictive values
13 and accuracy of SALT and PEPPER as diagnostic tests for seven intra-articular findings were
14 calculated.

15 **Results:** In 90% of the patients at least one test was positive. All patients with signs of lateral
16 ligamentous patholaxity or intra-articular abnormal findings had a positive response to at least one
17 of the two tests. SALT proved to have a high sensitivity but a low specificity and is accurate in
18 detecting the presence of intra-articular abnormal findings, especially synovitis. PEPPER test was
19 sensible, specific and accurate in the detection of radial head chondropathy.

20 **Conclusions:** Two new diagnostic tests (SALT and PEPPER) were specifically designed to evoke
21 pain from intra-articular structures. These tests could be a valid support in the diagnostic algorithm
22 of recalcitrant lateral elbow pain. Positive findings may be indicative of a minor instability of the
23 lateral elbow condition.

24 **Level of Evidence:** II, diagnostic study, development of diagnostic criteria on basis of consecutive
25 patients.

26 **Keywords:** Elbow arthroscopy; Lateral epicondylitis; Tennis elbow; SMILE; Minor instability;
27 Diagnostic test

28

29 **Introduction**

30 Degeneration and tendinosis of the common extensor origin, specifically the extensor carpi radialis
31 brevis (ECRB), are generally considered the main causes of lateral epicondylitis, or tennis elbow [1,
32 2]. Numerous tests have been described to investigate lateral elbow pathology, all of which
33 specifically focus on extra-articular insertion of ECRB tendon.

34 Recent evidence suggests that the extra-articular/tendon-related source could be not the sole source
35 of lateral elbow pain, but part of a multi-factorial process, involving extra-articular as well as intra-
36 articular and systemic factors [3]. Elbow arthroscopy allows to demonstrate the presence of several
37 intra-articular lesions associated to lateral elbow pain like plicae, capsular tears, synovitis, radial
38 head and capitellar erosion or chondromalacia and to investigate conditions related to laxity of the
39 radial component of the lateral collateral ligament (R-LCL) [3–8].

40 The aim of the present study is to describe two new clinical tests that specifically aimed at detecting
41 intra-articular pathology in patients affected by recalcitrant lateral epicondylitis and to present the
42 results of a pilot study on their diagnostic performance.

43

44 **Materials and Methods**

45

46 After institutional approval of the study protocol, the enrollment of consecutive patients referring to
47 the lead author for recalcitrant lateral epicondylitis was initiated. Patients between 20 and 65 years
48 of age were included if their symptoms had not responded to at least 6 months of conservative
49 treatment (including ice, non-steroidal anti-inflammatory drugs, stretching, steroid injections and
50 physical therapy) and excluded in the case of previous history of trauma or signs of major
51 instability (positive posterolateral drawer, posterolateral pivot shift and varus-valgus stress tests).
52 Patients were also excluded if any radiographic or magnetic resonance imaging (MRI) features of
53 trauma or arthritis were present.

54

55 To refine the clinical examination and to further evaluate this subgroup of patients, two clinical
56 provocative tests were developed:

57

- 58 1. Localized pain anterior to the radial head, exacerbated by sliding the examiner's finger from
59 the lateral to the anterior aspect of the radial head while simultaneously supinating the
60 elbow (Supination and Antero-Lateral pain Test - SALT - video 1).

61 2. Localized pain on the posterior aspect of the radio-capitellar joint. This is identified with
62 thumb pressure at the level of the joint while extending the elbow (Posterior Elbow Pain by
63 Palpation-Extension the Radiocapitellar joint - PEPPER - video 2).
64

65 All patients underwent elbow arthroscopy for their recalcitrant symptomatic tennis elbow. All pre-
66 operative and intra-operative evaluations were performed by a single examiner with extensive
67 experience in elbow surgery.

68 Arthroscopy was performed with the patient in a modified lateral decubitus position using an
69 axillary block and general anesthesia. Standard posterior, posterolateral and midlateral portals were
70 first established in order to explore the posterior compartment, the posteromedial gutter and the
71 posterior aspect of the radiocapitellar joint. The anterior compartment of the elbow was then entered
72 after posterior compartment evaluation. A proximal anteromedial portal was created 2 cm proximal
73 to the medial humeral epicondyle and 1 cm anterior to the intra-muscular septum. Insertion of a 30°
74 arthroscope into this portal allowed intra-articular diagnostic evaluation.

75 The presence of three intra-articular signs of lateral ligamentous patholaxity was prospectively
76 documented as follows:

- 77 1) Annular Drive Through (ADT), defined as the possibility to slide a 4.2 mm shaver between
78 the radial head and the annular ligament with no or minimal resistance.
- 79 2) Loose Collar Sign (LCS), defined as exposure of the radial neck beyond the cartilaginous
80 portion of the head when the elbow is at 90° flexion.
- 81 3) R-LCL pull-up sign (RPS), defined as the possibility to mobilize the R-LCL for more than 1
82 cm in the direction of the capitellum, using an arthroscopic grasper introduced via the
83 anterolateral portal.

84 The presence of four intra-articular specific pathologic findings was also prospectively documented
85 as follows:

- 86 1) anterior or anteromedial synovitis [4, 5, 9–11];
- 87 2) Chondropathy of the Lateral Aspect of the Capitellum (CLAC);
- 88 3) lateral tear of the capsule at the level of the radiocapitellar joint [8, 12];
- 89 4) anterosuperior chondropathy of the radial head [4, 5, 9, 10, 13, 14].

90 Contingency tables were developed for the results of each test and intra-articular lesions, to
91 compare each test with the arthroscopy as gold standard of comparison. The sensitivity, specificity,

92 positive and negative predictive value (PPV and NPV) and accuracy of SALT and PEPPER as
93 diagnostic tests for the aforementioned intra-articular lesions were calculated, as were 95%
94 confidence intervals. Sensitivity was defined as the probability of a positive result if arthroscopy
95 was truly positive. Specificity was the probability of a negative result if arthroscopy was truly
96 negative. The PPV was defined as the probability that arthroscopy was positive if the test was
97 positive, while the NPV was the probability that arthroscopy was negative if the test was negative.
98 Accuracy is defined as the probability that a test result reflects the true arthroscopic finding. Data
99 were expressed as percentages and confidence intervals. Statistical analysis was performed using
100 GraphPad Prism v 6.0 software (GraphPad Software Inc.).

101

102 **Results**

103

104 Ten patients were considered in this pilot study (Table 1). In 90% of the patients at least one test
105 was positive. All patients with signs of lateral ligamentous patholaxity or intra-articular abnormal
106 findings had a positive response to at least one of the two tests, [with elective, localized pain either
107 anterolaterally or posteriorly on the elbow joint](#). Performance measures of SALT and PEPPER as
108 diagnostic tests for the aforementioned intra-articular findings are summarized in Table 2.

109 SALT proved to have a high sensitivity for almost all signs of lateral ligamentous patholaxity and
110 intra-articular findings but a low specificity. The test is accurate in detecting the presence of at least
111 one abnormal intra-articular finding. A high accuracy is obtained also when SALT is assessed
112 specifically for anterior synovitis. PEPPER test was sensible, specific and accurate in the detection
113 of radial head chondropathy but only moderately accurate for the other findings. Diagnostic
114 performance in predicting radial head chondropathy was increased when both test were
115 simultaneously positive.

116

117 **Discussion**

118

119 This study presents two new clinical tests, SALT and PEPPER, and shows their effectiveness in
120 identifying a subgroup of patients in which associated intra-articular findings are detected at
121 arthroscopy. The authors consider this findings as possibly related to a minor instability of the
122 lateral elbow in many cases [15].

123 Numerous tests have been described to investigate lateral elbow pathology, all of which specifically
124 focus on extra-articular insertion of ECRB tendon. The Bowden, Thomson and Chair tests trigger
125 pain by muscular activation in grip or lifting gestures, while the Mills and Cozen tests provoke pain
126 by elongation of the inflamed tendinous structures [16–18].

127 All of these tests focus on extra-articular insertion of ECRB tendon, namely the lateral epicondyle
128 and the common extensor origin. Being the major complaints on the lateral side, no tests have been
129 designed to investigate the anterior and the posterior compartments of the elbow. Considering the
130 recent growing evidence on a possible intra-articular origin for lateral elbow pain [4–7, 9], it seems
131 reasonable, apart from the classical tests, to investigate also points of tenderness closer to the joint
132 space. SALT and PEPPER are specifically designed to evoke pain from intra-articular structures,
133 without directly stimulating those points considered elective source of ECRB-related pain from
134 classical papers [\(figure 1\). In the present series, SALT and PEPPER were performed on patients](#)
135 [already diagnosed with recalcitrant lateral epicondylitis, which showed positive repose to at least](#)
136 [one of the aforementioned classical tests.](#)

137 We suppose that in the SALT test the examiner's thumb, while gliding along the anterolateral
138 surface of the radial head, can selectively compress the anterior capsule and the synovial tissue
139 lying underneath it. In case of synovial hypertrophy and inflammation, the supination movement
140 pushes this synovial tissue in the sigmoid notch. Compression of the inflamed synovial tissue is
141 considered the source of pain.

142 In the PEPPER test the examiner's thumb is placed on the surface of the radial head with the elbow
143 in 90° flexion. With extension of the radiocapitellar joint, pressure on the thumb and, indirectly, on
144 the radial head, is increased. Compression of a chondropathic radial head might be the main source
145 of pain when performing this test.

146 The main limitation of this study is the small number of patients included, intrinsically related to its
147 design as pilot investigation. Nevertheless, all patients were recruited prospectively after a
148 minimum 6-month trial of non-operative management by an experienced surgeon in the field of
149 elbow surgery. Intra-operative findings were also documented as precisely and objectively as
150 possible in standardised fashion by the primary author. This was done, in order to minimize
151 possible bias which may arise especially from the classification of signs of laxity, which is known
152 as a difficult feature to assess and quantify.

153 Finally, this study focused primarily on the relation between clinical tests and arthroscopic findings.
154 It is however worth remembering that these intra-articular elements may coexist with extra-
155 articular/tendon-related pathologic elements and with systemic factors. A condition of minor
156 instability of the lateral elbow may be the result of these multiple coexisting primary causes and

157 future research will confirm the role of this pathologic model in generation of lateral elbow pain
158 and suggest treatment options [19].

159

160 **Conclusions**

161 This pilot study describes two new diagnostic tests, specifically designed to detect pathology
162 located at intra-articular elbow structures. SALT proved to have a high sensitivity but a low
163 specificity and is most accurate for synovitis, while PEPPER performed best in the detection of
164 radial head chondropathy. SALT and PEPPER could be a valid support in the diagnostic algorithm
165 of recalcitrant lateral elbow pain and positive findings may be indicative of a minor instability of
166 the lateral elbow condition.

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168 **Compliance with Ethical Standards**

169

170 **Funding:** This study was not funded

171

172 **Conflict of interest:** Author PA declares that he has no conflict of interest. Author DC declares that
173 he has no conflict of interest. Author AM declares that she has no conflict of interest. Author PR
174 declares that he has no conflict of interest.

175

176 **Ethical approval:** All procedures performed in studies involving human participants were in
177 accordance with the ethical standards of the institutional and/or national research committee and
178 with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

179

180 **Informed consent:** Informed consent was obtained from all individual participants included in the
181 study.

182

183 VIDEOS

184 **Video 1:** Supination and Antero-Lateral pain Test (SALT). The examiner positions his own thumb
185 at the level of the anterolateral aspect of the radial head. The thumb is progressively slid anteriorly
186 over the radial head combined with supination of the radius. Muscles of the anterolateral
187 compartment are pushed away to keep contact between finger and bone. [The test is positive if the](#)
188 [patient experiences anterolateral pain with forearm supination.](#)

189 **Video 2:** Posterior Elbow Pain by Palpation-Extension the Radiocapitellar joint (PEPPER). The
190 examiner positions his own thumb at the level of the posterior aspect of the radiocapitellar joint.
191 The test is positive if the patient experiences pain while extending the elbow.

192

193 [FIGURES](#)

194 [Figure 1: A\) Illustration of pain-evoking structures triggered by classical tests for lateral elbow](#)
195 [pain \(red oval\). B\) Illustration of pain-evoking areas triggered by the SALT test \(right green oval\)](#)
196 [and the PEPPER tests \(left green oval\).](#)

197

198 TABLES

199 **Table 1:** Demographic data of the enrolled patients.

	Age	Sex	Side	Dominant side?
1	28	M	R	Yes
2	34	M	R	Yes
3	29	F	R	Yes
4	45	F	R	
5	60	M	L	Yes
6	56	F	R	Yes
7	57	F	L	Yes
8	43	F	R	Yes
9	45	F	L	
10	49	M	L	Yes

M: male, F: female; R: right; L: left.

Table 2: Performance measures of SALT and PEPPER for different intra-articular findings.

		Sn	CI [95%]	Sp	CI [95%]	PPV	CI [95%]	NPV	CI [95%]	Acc	CI [95%]
SALT	ADT	100.00	[100.00 - 100.00]	33.33	[17.72 - 48.95]	50.00	[33.43 - 66.57]	100.00	[100.00 - 100.00]	60.00	[43.77 - 76.23]
	LCS	100.00	[100.00 - 100.00]	25.00	[10.65 - 39.35]	25.00	[10.65 - 39.35]	100.00	[100.00 - 100.00]	40.00	[23.77 - 56.23]
	RPS	50.00	[33.43 - 66.57]	12.50	[1.54 - 23.46]	12.50	[1.54 - 23.46]	50.00	[33.43 - 66.57]	20.00	[6.75 - 33.25]
	Laxity (any)	80.00	[66.75 - 93.25]	20.00	[6.75 - 33.25]	50.00	[33.43 - 66.57]	50.00	[33.43 - 66.57]	50.00	[33.43 - 66.57]
	Synovitis	87.50	[76.54 - 98.46]	50.00	[33.43 - 66.57]	87.50	[76.54 - 98.46]	50.00	[33.43 - 66.57]	80.00	[66.75 - 93.25]
	CLAC	66.67	[51.05 - 82.28]	14.29	[2.69 - 25.88]	25.00	[10.65 - 39.35]	50.00	[33.43 - 66.57]	30.00	[14.82 - 45.18]
	Capsular tears	100.00	[100.00 - 100.00]	25.00	[10.65 - 39.35]	25.00	[10.65 - 39.35]	100.00	[100.00 - 100.00]	40.00	[23.77 - 56.23]
	Rh chondropathy	100.00	[100.00 - 100.00]	22.22	[8.45 - 36.00]	12.50	[1.54 - 23.46]	100.00	[100.00 - 100.00]	30.00	[14.82 - 45.18]
	I-A findings (any)	87.50	[76.54 - 98.46]	50.00	[33.43 - 66.57]	87.50	[76.54 - 98.46]	50.00	[33.43 - 66.57]	80.00	[66.75 - 93.25]
PEPPER	ADT	25.00	[10.65 - 39.35]	66.67	[51.05 - 82.28]	33.33	[17.72 - 48.95]	57.14	[40.75 - 73.54]	50.00	[33.43 - 66.57]
	LCS	N.A.	N.A.	62.50	[46.46 - 78.54]	N.A.	N.A.	71.43	[56.46 - 86.40]	50.00	[33.43 - 66.57]
	RPS	50.00	[33.43 - 66.57]	75.00	[60.65 - 89.35]	33.33	[17.72 - 48.95]	85.71	[74.12 - 97.31]	70.00	[54.82 - 85.18]
	Laxity (any)	40.00	[23.77 - 56.23]	80.00	[66.75 - 93.25]	66.67	[51.05 - 82.28]	57.14	[40.75 - 73.54]	60.00	[43.77 - 76.23]
	Synovitis	37.50	[21.46 - 53.54]	100.00	[100.00 - 100.00]	100.00	[100.00 - 100.00]	28.57	[13.60 - 43.54]	50.00	[33.43 - 66.57]
	CLAC	33.33	[17.72 - 48.95]	71.43	[56.46 - 86.40]	33.33	[17.72 - 48.95]	71.43	[56.46 - 86.40]	60.00	[43.77 - 76.23]
	Capsular tears	N.A.	N.A.	62.50	[46.46 - 78.54]	N.A.	N.A.	71.43	[56.46 - 86.40]	50.00	[33.43 - 66.57]
	Rh chondropathy	100.00	[100.00 - 100.00]	77.78	[64.00 - 91.55]	33.33	[17.72 - 48.95]	100.00	[100.00 - 100.00]	80.00	[66.75 - 93.25]
	I-A findings (any)	37.50	[21.46 - 53.54]	100.00	[100.00 - 100.00]	100.00	[100.00 - 100.00]	28.57	[13.60 - 43.54]	50.00	[33.43 - 66.57]
SALT and PEPPER	ADT	25.00	[10.65 - 39.35]	83.33	[70.99 - 95.68]	50.00	[33.43 - 66.57]	62.50	[46.46 - 78.54]	60.00	[43.77 - 76.23]
	LCS	N.A.	N.A.	75.00	[60.65 - 89.35]	N.A.	N.A.	75.00	[60.65 - 89.35]	60.00	[43.77 - 76.23]
	RPS	N.A.	N.A.	75.00	[60.65 - 89.35]	N.A.	N.A.	75.00	[60.65 - 89.35]	60.00	[43.77 - 76.23]
	Laxity (any)	20.00	[6.75 - 33.25]	80.00	[66.75 - 93.25]	50.00	[33.43 - 66.57]	50.00	[33.43 - 66.57]	50.00	[33.43 - 66.57]
	Synovitis	25.00	[10.65 - 39.35]	100.00	[100.00 - 100.00]	100.00	[100.00 - 100.00]	25.00	[10.65 - 39.35]	40.00	[23.77 - 56.23]
	CLAC	N.A.	N.A.	71.43	[56.46 - 86.40]	N.A.	N.A.	62.50	[46.46 - 78.54]	50.00	[33.43 - 66.57]
	Capsular tears	N.A.	N.A.	75.00	[60.65 - 89.35]	N.A.	N.A.	75.00	[60.65 - 89.35]	60.00	[43.77 - 76.23]
	Rh chondropathy	100.00	[100.00 - 100.00]	88.89	[78.48 - 99.30]	50.00	[33.43 - 66.57]	100.00	[100.00 - 100.00]	90.00	[80.06 - 99.94]
	I-A findings (any)	25.00	[10.65 - 39.35]	100.00	[100.00 - 100.00]	100.00	[100.00 - 100.00]	25.00	[10.65 - 39.35]	40.00	[23.77 - 56.23]

SALT: Supination and Antero-Lateral pain Test; PEPPER: Posterior Elbow Pain by Palpation - Extension the Radiocapitellar joint; ADT: annular drive through; LCS: loose collar sign; RPS: radial component of the lateral collateral ligament pull-up sign; CLAC: Chondropathy of the lateral aspect of the capitellum; I-A: intra-articular; Sn: sensitivity; Sp: specificity; Acc: PPV: positive predictive value; NPV: negative predictive value; acc: accuracy; CI [95%]: 95% confidence intervals; N.A.: not available.

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