

# It's time to change perspective! New diagnostic tools for lateral elbow pain

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## Abstract

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

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

**Results** In 90% of the patients, at least one test was positive. All patients with signs of lateral ligamentous patholaxity or intra-articular abnormal findings had a positive

response to at least one of the two tests. SALT proved to have a high sensitivity but a low specificity and is accurate in detecting the presence of intra-articular abnormal findings, especially synovitis. PEPPER test was sensible, specific and accurate in the detection of radial head chondropathy.

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

**Level of evidence** Diagnostic study, development of diagnostic criteria on basis of consecutive patients, level II.

**Keywords** Elbow arthroscopy · Lateral epicondylitis · Tennis elbow · SMILE · Minor instability · Diagnostic test

## Introduction

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

Recent evidence suggests that the extra-articular/tendon-related source could be not the sole source of lateral elbow pain, but part of a multifactorial process, involving extra-articular as well as intra-articular and systemic factors [3]. Elbow arthroscopy allows to demonstrate the presence of several intra-articular lesions associated with lateral elbow pain like plicae, capsular tears, synovitis, radial head and capitellar erosion or chondromalacia and to investigate

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conditions related to laxity of the radial component of the lateral collateral ligament (R-LCL) [3–8].

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

## Materials and methods

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

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

1. Localized pain anterior to the radial head, exacerbated by sliding the examiner's finger from the lateral to the anterior aspect of the radial head while simultaneously supinating the elbow (Supination and Antero-Lateral pain Test—SALT—video 1).
2. Localized pain on the posterior aspect of the radiocapitellar joint. This is identified with thumb pressure at the level of the joint while extending the elbow (Posterior Elbow Pain by Palpation–Extension of the Radiocapitellar joint—PEPPER—video 2).

All patients underwent elbow arthroscopy for their recalcitrant symptomatic lateral elbow pain. All preoperative and intra-operative evaluations were performed by a single examiner with extensive experience in elbow surgery.

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

of a 30° arthroscope into this portal allowed intra-articular diagnostic evaluation.

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

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

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

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

Contingency tables were developed for the results of each test and intra-articular lesions, to compare each test with the arthroscopy as gold standard of comparison. The sensitivity, specificity, positive and negative predictive value (PPV and NPV) and accuracy of SALT and PEPPER as diagnostic tests for the aforementioned intra-articular lesions were calculated, as were 95% confidence intervals. Sensitivity was defined as the probability of a positive result if arthroscopy was truly positive. Specificity was the probability of a negative result if arthroscopy was truly negative. The PPV was defined as the probability that arthroscopy was positive if the test was positive, while the NPV was the probability that arthroscopy was negative if the test was negative. Accuracy is defined as the probability that a test result reflects the true arthroscopic finding. Data were expressed as percentages and confidence intervals. Statistical analysis was performed using GraphPad Prism v 6.0 software (GraphPad Software Inc.).

## Results

Ten patients were considered in this pilot study (Table 1). In 90% of the patients, at least one test was positive. All patients with signs of lateral ligamentous patholaxity or

**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

intra-articular abnormal findings had a positive response to at least one of the two tests, with elective, localized pain either anterolaterally or posteriorly on the elbow joint. Performance measures of SALT and PEPPER as diagnostic tests for the aforementioned intra-articular findings are summarized in Table 2.

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

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

	<b>Sn</b>	<b>CI [95%]</b>	<b>Sp</b>	<b>CI [95%]</b>	<b>PPV</b>	<b>CI [95%]</b>	<b>NPV</b>	<b>CI [95%]</b>	<b>Acc</b>	<b>CI [95%]</b>	
<b>SALT</b>	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]
	<b>Laxity (any)</b>	<b>80.00</b>	<b>[66.75 - 93.25]</b>	<b>20.00</b>	<b>[6.75 - 33.25]</b>	<b>50.00</b>	<b>[33.43 - 66.57]</b>	<b>50.00</b>	<b>[33.43 - 66.57]</b>	<b>50.00</b>	<b>[33.43 - 66.57]</b>
	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]
	<b>I-A findings (any)</b>	<b>87.50</b>	<b>[76.54 - 98.46]</b>	<b>50.00</b>	<b>[33.43 - 66.57]</b>	<b>87.50</b>	<b>[76.54 - 98.46]</b>	<b>50.00</b>	<b>[33.43 - 66.57]</b>	<b>80.00</b>	<b>[66.75 - 93.25]</b>
<b>PEPPER</b>	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]
	<b>Laxity (any)</b>	<b>40.00</b>	<b>[23.77 - 56.23]</b>	<b>80.00</b>	<b>[66.75 - 93.25]</b>	<b>66.67</b>	<b>[51.05 - 82.28]</b>	<b>57.14</b>	<b>[40.75 - 73.54]</b>	<b>60.00</b>	<b>[43.77 - 76.23]</b>
	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]
	<b>I-A findings (any)</b>	<b>37.50</b>	<b>[21.46 - 53.54]</b>	<b>100.00</b>	<b>[100.00 - 100.00]</b>	<b>100.00</b>	<b>[100.00 - 100.00]</b>	<b>28.57</b>	<b>[13.60 - 43.54]</b>	<b>50.00</b>	<b>[33.43 - 66.57]</b>
<b>SALT and PEPPER</b>	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]
	<b>Laxity (any)</b>	<b>20.00</b>	<b>[6.75 - 33.25]</b>	<b>80.00</b>	<b>[66.75 - 93.25]</b>	<b>50.00</b>	<b>[33.43 - 66.57]</b>	<b>50.00</b>	<b>[33.43 - 66.57]</b>	<b>50.00</b>	<b>[33.43 - 66.57]</b>
	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]
	<b>I-A findings (any)</b>	<b>25.00</b>	<b>[10.65 - 39.35]</b>	<b>100.00</b>	<b>[100.00 - 100.00]</b>	<b>100.00</b>	<b>[100.00 - 100.00]</b>	<b>25.00</b>	<b>[10.65 - 39.35]</b>	<b>40.00</b>	<b>[23.77 - 56.23]</b>

SALT Supination and Antero-Lateral pain Test; PEPPER Posterior Elbow Pain by Palpation-Extension of 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; PPV positive predictive value; NPV negative predictive value; acc accuracy; CI [95%] 95% confidence intervals; N.A. not available

Bold values indicate the diagnostic performance in detecting the presence of at least one sign of lateral ligamentous patholaxity or of at least one abnormal intra-articular finding

radial head chondropathy was increased when both tests were simultaneously positive.

## Discussion

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

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

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

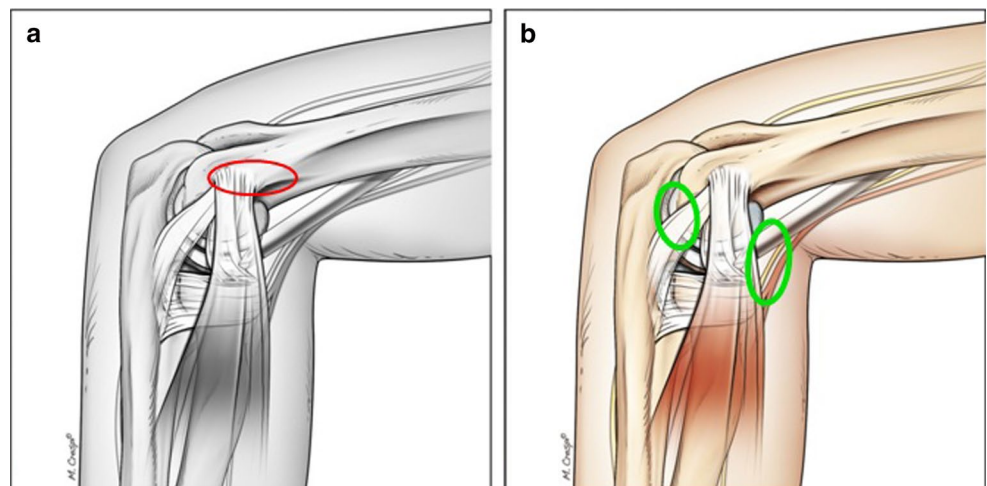
We suppose that in the SALT test the examiner's thumb, while gliding along the anterolateral surface of the radial head, can selectively compress the anterior capsule and the synovial tissue lying underneath it. In case of synovial hypertrophy and inflammation, the supination movement pushes this synovial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

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

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

Finally, this study focused primarily on the relation between clinical tests and arthroscopic findings. It is, however, worth remembering that these intra-articular elements may coexist with extra-articular/tendon-related pathologic elements and with systemic factors. A condition of minor instability of the lateral elbow may be the result of these multiple coexisting primary causes, and future research will confirm the role of this pathologic model in generation of lateral elbow pain and suggest treatment options [19].

**Fig. 1** **a** Illustration of pain-evoking structures triggered by classical tests for lateral elbow pain (red oval). **b** Illustration of pain-evoking areas triggered by the SALT test (right green oval) and the PEPPER tests (left green oval)



## Conclusions

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

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

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

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

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