

1 **The prevalence of calcifications at the origin of the extensor carpi radialis brevis increases**
2 **with age**

3 **Running Title: THE PREVALENCE OF ECRB CALCIFICATIONS**

4 **ABSTRACT**

5 **Background:** Enthesopathy of the extensor carpi radialis brevis origin [eECRB] is a common
6 idiopathic, non-inflammatory disease of middle age that is characterized by excess
7 glycosaminoglycan production and frequently associated with radiographic calcification of its
8 origin. The purpose of our study was to assess the relationship of calcification of the ECRB and
9 advancing age.

10 **Methods:** We included 28,563 patients who received an elbow radiograph and assessed the
11 relationship of calcifications of the ECRB identified on radiograph reports with patient age, sex,
12 race, affected side, and ordering indication using multivariable logistic regression.

13 **Results:** Calcifications of the ECRB were independently associated with age (OR:1.04;p<0.001);
14 radiographs ordered for atraumatic pain (OR2.6;p<0.001) or lateral epicondylitis
15 (OR5.5;p<0.001); and Hispanic ethnicity (OR1.5;p<0.001) and less likely to be found at the left
16 side (OR0.68;p<0.001). Similarly, incidental calcifications of the ECRB, those on radiographs
17 not ordered for atraumatic pain or lateral epicondylitis, were independently associated with age
18 (OR1.03;p<0.001) and Hispanic ethnicity (OR1.5;p<0.024) and less likely to be found on the left
19 side (OR0.71;p<0.001).

20 **Conclusions:** We observed that about nine percent of people have ECRB calcification by the
21 time they are in their sixth decade of life and calcifications persist in the absence of symptoms
22 which supports the idea that eECRB is a common, self-limited diagnosis of middle age.

23 **Level of Evidence:** Level II; Retrospective prognostic study

- 24 **Keywords:** extensor carpi radialis brevis; lateral epicondyle; calcification; enthesopathy; tennis
- 25 elbow; lateral epicondylitis; radiograph; prevalence

26 **INTRODUCTION**

27 Tennis elbow and lateral epicondylitis are two common terms that refer to enthesopathy
28 of the extensor carpi radialis brevis origin (eECRB). eECRB is an idiopathic, non-inflammatory
29 disease that presents with pain over the lateral elbow. The condition occurs primarily in patients
30 35 to 54 years of age and is self-limited (1-4). On histology eECRB is characterized by excess
31 glycosaminoglycan production (mucoïd degeneration) (5-7). Calcification of the extensor carpi
32 radialis brevis [ECRB] origin at the lateral epicondyle is common with eECRB and these
33 calcifications might be permanent (5, 8-11).

34 Given that eECRB is common and often associated with calcifications, radiographic
35 calcification of the extensor carpi radialis brevis (ECRB) might be expected to accumulate with
36 age. In this sense the prevalence of calcification of the ECRB origin with age may serve as a
37 surrogate for the cumulative lifetime prevalence of eECRB.

38 Our study tested the primary null hypothesis: the prevalence of ECRB calcifications is
39 not associated with age accounting for other factors. Secondly, we tested the null hypothesis:
40 the prevalence of incidental calcifications of the ECRB is not related to age accounting for other
41 factors.

42 **METHODS**

43

44 *Study design and population*

45 After obtaining IRB approval, we searched the patient data registry of two tertiary care
46 hospitals for all patients who had an elbow radiograph with at least two views (CPT codes 73070
47 and 73080) between January 1, 2005 and January 1, 2015. We included every patient greater
48 than 18 years old who received an elbow radiograph at one of the two institutions. All patients
49 with cancelled radiographs, radiographs completed at an outside institution, incomplete
50 radiograph reports or radiographs ordered for a clinical mass or malignancy were excluded. All
51 28,563 eligible patients were included in this study. We only included the first elbow radiograph
52 report for each patient to comply with the statistical assumption of independence.

53

54 *Outcomes*

55 Our primary outcome measure was calcific enthesopathy around the lateral epicondyle.
56 We searched the first elbow radiograph report of every eligible patient for mention of
57 calcifications, enthesopathy, the lateral epicondyle or the common extensor tendon, including
58 synonyms and common misspellings: 4,983 (17%) reports were flagged and 1,236 (4.3%) of
59 these patients had probable calcifications or changes at the lateral epicondyle not likely caused
60 by trauma, inflammatory diseases, and/or arthritis. We then manually reviewed the complete
61 report text of all 1,236 patients with probable changes in the extensor tendon and found that 958
62 patients had an impression of calcification of the extensor tendon, 220 had findings consistent
63 with calcifications of the extensor tendon, and 58 did not have calcifications within the extensor
64 tendon. To assess the accuracy of our text search we randomly sampled 100 patients identified as

65 not having calcifications of the extensor tendon at the lateral epicondyle and manually reviewed
66 the report text for each patient. None of the 100 patient reports we reviewed had mention of
67 extensor tendon calcification within their reports. To assess the accuracy of the radiology reports,
68 two research fellows reviewed the elbow radiographs of 100 randomly selected patients with
69 reported calcifications of the ECRB and 100 patients without reported calcifications. Of the 100
70 patients with calcifications in their report, 81 patients had calcifications about the lateral
71 epicondyle on their radiograph. Of the 100 without calcifications noted in the report text, 8
72 patients had calcifications on their radiographs.

73 Our secondary outcome measure was incidental (i.e. non-symptomatic) common extensor
74 tendon calcifications, which included all radiographs not ordered to assess lateral epicondylitis or
75 atraumatic elbow pain.

76 Our explanatory variables were age as a continuous variable, and sex, race, affected side,
77 and the primary ordering indication for the radiograph as categorical variables. We identified
78 patient age, sex, and race from the medical record and extracted the indication from the
79 radiology report text.

80 The primary ordering indication for an elbow radiograph was determined by searching
81 the “indications” section of each elbow radiograph report. When the primary ordering indication
82 was unclear (n = 36), the indication was manually reviewed. We identified patients who had an
83 indication of lateral epicondylitis or atraumatic elbow pain to determine which calcifications
84 were incidental or asymptomatic. We included patients with primary ordering indications of
85 arthritis, tendinopathies, other painful conditions or isolated stiffness and/or swelling in a group
86 called atraumatic pain. There were 16,564 (58%) radiographs ordered to assess trauma or follow-
87 up of a surgery for trauma; 10,154 (36%) radiographs were ordered to assess atraumatic elbow

88 pain; 949 (3.3%) radiographs did not have an ordering indication in the report, 522 (1.8%) were
89 ordered for lateral epicondylitis or a synonym; and 374 (1.3%) radiographs were ordered for a
90 diagnosis that did not fit into another category, e.g. – foreign body, evaluation of dialysis fistula,
91 neuropathy. (Appendix A, Table I)

92

93 *Statistical analysis*

94 We report frequencies with percentages for categorical variables and mean with standard
95 deviation (SD) for continuous variables.

96 We used multivariable logistic regression analysis to assess the association between each
97 explanatory variable and the response variables while adjusting for potential confounding. We
98 report the odds ratio (OR), standard error (SE), and p-value for the regression analyses; a two-
99 tailed p-value below 0.05 is considered significant.

100

101 *Baseline characteristics*

102 The eligible patients averaged 50 (SD=18) years of age; 52% were men; and 75% were
103 white. Radiology reports addressed the right elbow in 13,568 (48%) patients, the left elbow in
104 12,716 (45%) patients, and in 2,279 (8%) patients the report did not identify a side or described
105 bilateral elbows. The most common ordering indication was trauma (Table I). Symptomatic and
106 incidental calcifications peaked in prevalence when patients were 60 to 80 years of age. In our
107 study population, 1,178 of 28,563 patients (4.1%, 95% confidence interval [95% CI], 3.9 – 4.4)
108 had elbow radiograph reports describing elbow calcifications within the extensor tendon. When
109 we excluded all patients with radiographs ordered for lateral epicondylitis or atraumatic pain

110 (37% [10,676 out of 28,563]) we found that 486 of 17,887 patients had incidental extensor
111 tendon calcifications identified on radiograph (2.7%, 95% CI, 2.5 – 3.0; Table II).

112 **RESULTS**

113 Age (OR 1.04; $p < 0.001$; 4% increase in likelihood per year over age 18); radiographs
114 ordered for atraumatic pain (OR 2.6; $p < 0.001$) or lateral epicondylitis (OR 5.5; $p < 0.001$); and
115 Hispanic ethnicity (OR 1.5; $p < 0.001$) were independently associated with calcifications of the
116 ECRB. The left elbow (OR 0.68; $p < 0.001$) was less likely to have calcifications of the ECRB.
117 (Table III and Figure 1)

118 Age (OR 1.03; $p < 0.001$; 3% increase in likelihood per year over age 18) and Hispanic
119 ethnicity (OR 1.5; $p < 0.024$) were independently associated with incidental calcifications of the
120 ECRB. Incidental calcifications were less likely to be found in the left ECRB (OR 0.71; $p <$
121 0.001; Table III and Figure 1).

122 **DISCUSSION**

123 Calcifications about the lateral epicondyle are associated with eECRB and thought to be
124 permanent (5, 8-11). The prevalence of calcification on elbow radiograph may reflect the
125 cumulative lifetime incidence of clinical eECRB. We found that each year of age increases the
126 odds of having ECRB calcifications. We also found that calcifications are more common on the
127 right lateral epicondyle and in people of Hispanic ethnicity.

128 Our study has certain limitations. First, our retrospective cohort study design can only
129 identify a relationship between age and calcification; it cannot address the specific cause of
130 calcification. Second, we relied on reports written by the radiologists at the two institutions we
131 reviewed. In the reports we reviewed, the calcifications of the ECRB were not systematically
132 described with the same language as all radiologists from our two institutions were included. To
133 ensure we captured all reports mentioning calcification of the ECRB, we included search terms
134 for calcification or the ECRB and all synonyms and any common misspellings.

135 Third, we relied on searching report texts to identify the affected side and radiograph
136 ordering indication. Based on manual review of the identified reports we are confident our search
137 terms accurately identified indication and the affected side listed in the reports. However, we
138 believe our estimate of incidental calcifications is conservative because we excluded all patients
139 with atraumatic pain or epicondylitis as an indication. The one-word ordering indication “pain”
140 was very common and we had no way of knowing what part of the elbow the ordering provider
141 referred to so we assumed all radiographs ordered for “pain” could represent eECRB. This may
142 have led to exclusion of patients with symptomatic medial epicondylitis or ulnar neuropathy with
143 incidental calcific enthesopathy. Fourth, we relied on radiologists reporting calcifications in each
144 radiograph and there may be inter-radiologist variability of which we are unaware. The text

145 descriptions were reasonably accurate on manual review of the radiographs, but there is some
146 degree of error introduced by variation of radiographic interpretation. Some radiologists may
147 omit commenting on calcifications which would decrease the prevalence. In addition, when
148 double-checking radiographs, we used a different software system to view the DICOM images
149 than the radiologists. It is possible that the radiologists were able to see calcifications that we
150 could not see because they had a superior DICOM viewing platform. We do not anticipate that
151 any over or under call would be significantly different than other institutions and or bias the
152 prevalence based on age, side, race or ordering indication. Fifth, there may be differences in the
153 quality of the radiographs read by radiologist in this study as our cohort includes patients who
154 received radiographs over a ten-year period. Sixth, the majority of our cohort was white and
155 lived in the [REDACTED] and therefore these results might not be generalizable to
156 all populations or geographical regions. However, these limitations are counterbalanced by the
157 number of patients in our research database. The large number of patients, radiologists, and
158 institutions mitigates variation of radiographic interpretation and reporting. In addition, the large
159 number of patients allows for a more robust statistical analysis than studies with smaller patient
160 cohorts.

161 We found all calcifications of the ECRB were predicted by advancing age, the right
162 elbow and Hispanic ethnicity. Previous studies were set up to suggest that calcifications of the
163 ECRB are related to symptomatic eECRB. For instance, Edelson et al documented calcification
164 on CT scans in 3 of 20 patients with no elbow symptoms and 6 of 10 patients with long-standing
165 elbow symptoms ($p = 0.003$), but there was no difference in patients with symptoms for less than
166 one year ($p = 0.73$) (9). Similarly, Levin et al compared ultrasound images of 25 elbows with
167 symptoms of eECRB to 32 asymptomatic elbows and found calcifications of the common

168 extensor tendons (OR 6.2; $p < 0.05$) and adjacent bone irregularity (OR 4.8; $p < 0.05$) were
169 associated with symptoms. However, patients with symptomatic elbows were significantly older
170 than asymptomatic elbows (10). It is difficult to compare our radiographic prevalences to
171 prevalences based on symptoms such as Hamilton et. al., (twice as common on the right side;
172 similar numbers of men and women) (1) and Owens et al (fewer black patients) (12). In our
173 opinion, the racial findings are likely spurious because most of the patients were white.

174 Secondarily we found that incidental calcifications of the ECRB were predicted by
175 advancing age, the right elbow and Hispanic ethnicity. The association of age with calcification
176 supports the theory that the pathophysiological changes persist and accumulate in aging
177 populations even as the symptoms resolve (Table II and Figure 1). This is supported by other
178 studies of the extensor tendon. Zeisig et al who found persistent changes in 13 of 20 sonograms
179 of the extensor origin after resolution of symptoms (11). Jaén-Díaz examined the common
180 extensor tendon using ultrasound in 240 patients and noted that 48% with changes remembered
181 symptoms consistent with eECRB compared to 2% in patients with normal elbows ($p < 0.001$)
182 (13). ██████████ studied MRI signal changes of the ECRB and found that age was
183 independently associated with ECRB enthesopathy (OR 1.04; $p < 0.001$) and that the prevalence
184 of signal changes increases to 16% in patients over age 71 (14). MRI changes are likely more
185 often detected than calcifications and this is probably a more accurate reflection of the
186 prevalence of eECRB.

187 **CONCLUSION**

188 The observation that about nine percent of the population have calcifications of the ECRB origin
189 by the time they are in their sixth decade of life supports the idea eECRB is a common, self-
190 limited disease of middle age (1, 2, 9, 11, 13). Combined with similar MRI data and the weight
191 of current best evidence, patients can be counseled that evidence to date support the concept that
192 eECRB is common and self-limiting.

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232

233 **FIGURE LEGENDS**

234 **Figure 1:** Prevalence of calcification of the extensor carpi radialis brevis and incidental
235 calcifications of the extensor carpi radialis brevis versus age.

236 **Table I:** Baseline characteristics of study population.

237 **Table II:** Prevalence of calcifications of the ECRB with age.

238 **Table III:** Predictors of common extensor tendon calcifications.

239 **Appendix A:** Indication search strings.