Metacarpal Cortical Index as a Measure of Local Bone Mineral Density and Prognostic Factor in Osteoarthritis Patients Undergoing Primary Metacarpophalangeal Arthroplasty

Adam Schluttenhofer, Audrey Bankes, Zoe E Postal, Marco Rizzo

INTRODUCTION: Poor bone quality is a significant risk factor for poor outcomes in patients with osteoarthritis undergoing metacarpophalangeal arthroplasty. A dual x-ray absorptiometry (DEXA) scan is the gold standard for assessing BMD, but is not always available in the preoperative setting. The metacarpal cortical index (MCI) is a simple measure of cortical thickness known to correlate with global bone mineral density. We sought to determine the utility of the metacarpal cortical index at the second digit (2MCI) and operative digit (opMCI) as a simple and accessible measure of local BMD in the preoperative setting. We analyzed the correlation of 2MCI and opMCI to DEXA-derived BMD and T-score measures and assessed these two indices as risk factors for revision, all-cause reoperation, and postoperative complications in osteoarthritis patients undergoing primary MCP arthroplasty.

METHODS:

We utilized our institution's Total Joint Registry to identify 149 primary MCP arthroplasties performed in 99 unique patients with osteoarthritis between 1/1/2004 and 12/31/2022. Patients were included if they underwent primary MCP arthroplasty for osteoarthritis and had at least two years of follow-up. Preoperative, posteroanterior radiographs were used to calculate 2MCI and opMCI by measuring the outer (OD) and intramedullary diameter (IMD) at the narrowest point of the metacarpal mid-diaphysis, calculating MCI as (OD-IMD)/(OD) (Figure 1). Preoperative bone mineral density and T-scores were taken from DEXA scans available within 1.5 years before surgery. Pearson's correlation coefficients were used to determine the relation of 2MCI and opMCI to DEXA-derived T-score and BMD. 2MCI and opMCI were evaluated as risk factors for revision (implant removal or replacement) and all-cause reoperation (including revisions) using a Cox proportional hazards model, controlling for implant type. Logistic regression was used to assess the risk of developing any postoperative complication, controlling for implant type.

RESULTS:

There were 149 included joints in 99 patients with an average follow-up of 6.3±5.0 years. The cohort was 54.4% male with an average age of 64.4±10.6 years. There were 92 pyrocarbon, 49 silicone, and 8 surface replacement arthroplasty implants used. There were 17 total revisions (11.4%) and 8 non-revision reoperations (5.4%), most commonly involving tenolysis with or without radial collateral ligament reconstruction (Table 1). There were 44 joints with at least one complication, most commonly limited motion (n = 17, 11.4%). The mean preoperative 2MCI and opMCI of the cohort were 0.49±0.09 and 0.48±0.09, respectively (Figure 2). Preoperative 2MCI was moderately correlated with DEXA-BMD (r = 0.63, 95% CI = 0.27-0.83, p = 0.002) and DEXA-T score (r = 0.55, 95% CI 0.15-0.79, p = 0.01). Preoperative opMCI was moderately correlated with DEXA-BMD (r = 0.62, 95% CI 0.26-0.83, p = 0.002) and DEXA-T score (r = 0.54, 95% CI = 0.13-0.79, p = 0.01). Higher opMCI was protective against revision (HR 0.74 for each 0.05 unit increase, 95% CI 0.57-0.95, p = 0.02), but not statistically significant for all-cause reoperation (HR 0.81, 95% CI 0.65-1.01, p = 0.06). 2MCI did not have a statistically significant effect on revision (HR 0.76, 95% CI 0.58-1.01, p = 0.06) or all-cause reoperation (HR 0.86, 95% CI 0.68-1.09, p = 0.20). There were no revisions among joints with a 2MCI > 0.54 (n = 42, 28%) or opMCI > 0.55 (n = 33, 22%). Higher preoperative opMCI was protective against having any postoperative complication (OR 0.74 for each 0.05 unit increase, 95% CI 0.59-0.91, p = 0.005).

DISCUSSION AND CONCLUSION: Both 2MCI and opMCI correlate with DEXA-derived measures of bone density in osteoarthritis patients undergoing MCP arthroplasty, highlighting their utility as accessible preoperative measures of local BMD in the absence of a recent DEXA scan. Each 0.05 unit increase in preoperative opMCI decreases the hazard for revision by 26% and risk for having any complication by 26%, highlighting the importance of bone quality in long-term outcomes for these patients.

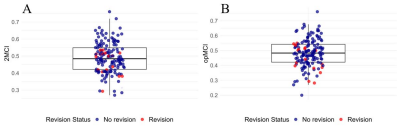
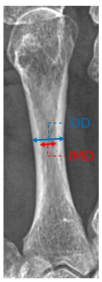


Figure 2: Distribution of second metacarpal cortical index (A) and operative metacarpal cortical index (B) in osteoarthritis patients undergoing primary metacarpophalangeal arthroplasty. Box indicates interquartile range, with middle horizontal line indicating median and whiskers indicating 1.5*IQR.



$$MCI = \frac{OD - IMD}{OD}$$

Figure 1: Method of calculating the metacarpal cortical index (MCI) from posteroanterior hand radiographs. OD, outer diameter. IMD, intramedullary diameter.

Table 1: Cohort reoperation descriptions

Description	Count (%), n = 149
Total reoperations	23 (15.4%)
Arthroplasty revision	17 (11.4%)
Non-revision reoperations	8 (5.4%)
Flexor or extensor tenolysis with radial collateral ligament repair	2 (1.3%)
Isolated flexor tenolysis	1 (0.7%)
Isolated with radial collateral ligament repair	1 (0.7%)
Trigger finger release	1 (0.7%)
Scar excision and deep suture removal	1 (0.7%)
Irrigation/debridement for infection concern	1 (0.7%)
Removal of impinging osteophyte	1 (0.7%)