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Radiographic Circularity of Capitellum and Its Relation to the Range of Motion

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Abstract

Background: The shape of the capitellum has been traditionally described in anatomy books as part of a sphere. Alteration in the capitellar morphology following pathologies such as fractures, osteochondrosis, and degenerative arthritis has been associated with less optimum functional results. **Aim:** To define the relationship between the sphericity of the capitellar morphology as measured on trauma series plain radiographs and the elbow range of motion. **Methods:** 40 patients were included in the study. All patients recruited from the upper limb clinics presented with non-elbow joint-related complaints. The elbow range of motion was measured using a standardized technique. Digital anteroposterior and lateral radiographs of patients' elbows were used to measure capitellar circularity using the ImageJ processing program and circularity calculation equation. Correlation analyses were conducted between the degree of capitellar sphericity and elbow range of motion. **Results:** The results of measurements from the anteroposterior radiographs showed a positive correlation between increased circularity and an increase in the range of flexion, pronation, and supination. The range of extension decreased with the increased circularity of the capitellum. This trend was repeated with measures of lateral radiographs but was statistically not significant. **Conclusion:** Native capitellar circularity has an impact on the elbow range of motion. This should be put into consideration when dealing with pathologies that affect capitellar morphology.

Keywords

Capitellum, Circularity, Anatomy, Range of Motion, Elbow Joint

1. Introduction

The shape of the capitellum is described in common anatomical textbooks as being part of a sphere to enable articulation with the radial head. Anteriorly the lateral column of the humerus ends distally in the capitellum with the articular surface being described as forming a one-hundred-and-eighty-degree arc [1].

The closest contact between the radius and capitellum is thought to occur in mid-pronation with a semi-flexed radius with the head of the radius fitting in the groove between capitellum and trochlear [2].

The morphology of the capitellum and its degree of circularity can change following different pathologies such as fractures, arthritis, and osteochondrosis. This change doesn't always correlate with poor outcomes. Patients with Panners disease or osteochondritis dissecans of the capitellum where the capitellum fragments and re-ossifies with residual change in contour still report excellent function [3].

The extent to which the change in morphology of capitellum affects the elbow function and the range of motion is not fully investigated. This question also becomes important in considering if one designed radio-capitellar replacement will fit all patient requirements and what degree of deformity in relation to arthritis change would necessitate replacement [4].

The final morphological outcome following different pathologies affecting capitellum is usually assessed using plain radiographs. Whilst the circularity of capitellum can be measured on plain radiographs using image processing software, there is no diagnostic tool to correlate between capitellar circularity on plain radiographs and clinical outcomes such as those used for hip pathologies.

In this study, we are trying to investigate the relationship between radiographic capitular shape (2D circularity) and range of motion. We trying to establish how significantly can circularity on plain radiographs correlate with a range of motion. This may be a step towards developing a capitellar circularity assessment tool.

2. Methods

Ethical approval was obtained from the institution's information governance team for the release of this study. 40 consecutive patients recruited from the upper limb clinic without elbow pathology have been included in the study between March and November of 2018. These included 12 with the diagnosis of contralateral ulna nerve entrapment at the elbow and 28 with contralateral medial epicondylitis. There were 13 males and 27 females aged between 22 and 76 years and averaging 49.4 years. Seventeen were in full-time and six in part-time work with eleven patients considering themselves as being employed in manual jobs. All patients did not complain of any reduction in daily activities concerning the studied limb.

The range of motion of both elbows was determined using a goniometer (Baseline® plastic 360˚ Goniometer—Fabrication Enterprises USA) in a standardized fashion.

For flexion/extension range of motion, the medial epicondyle was used as a bony landmark to aid placement of the goniometer medially and the two arms of the device were then placed at the midpoint of the palpated bony outline of the humerus proximally and the ulna medially.

Rotation was determined with a goniometer with the elbow held at ninety degrees against the patient's side and the wrist in a neutral position. A pen was then placed in the individual's palm to determine the clinical rotation of the forearm for pronation and supination. Measurement was done by two different others separately.

We adopted Bland and Altman's recommended method to assess the agreement of inter-rater measurements [5]. Hypothesizing that the mean difference between two measurements for each patient is equal to zero, the mean difference between each author for each angle range of motion measurement was set, in addition to the 95% confidence intervals for Bland-Altman's limits of agreement. There was a low difference in the mean of angle measurements between the two authors in all ranges of motion.

The circularity of the capitulum was measured from standardized digital anteroposterior radiographs taken as part of the patient's clinical management by a third observer who was unaware of the clinical measurements. Measurements were done using ImageJ [6] Manual and automatic measurements and calculations were done, the former in duplicate, to confirm the accuracy of the measures. The credibility of various equations available for the calculation of circularity was investigated and a preferred equation was identified [7] [8].

Results were analyzed using a statistical package for social sciences (SPSS, version 26.0; IBM, Chicago IL, USA) software package. The data is presented as the mean. $P \leq 0.05$ was considered statistically significant. The Pearson correlation test was utilized for the identification of any correlation between the studied variables.

3. Results

The results of measures from the anteroposterior radiographs suggested an increased range of flexion, pronation, and supination with increased circularity. The range of extension decreased with the increased circularity of the capitulum. This trend was repeated with measures of lateral radiographs but was much less evident.

Correlation coefficients were calculated for each type of motion and the two measures of circularity. The strongest correlations were with anteroposterior measures in all cases in the following decreasing order of strength, pronation (r = 0.8, $P = 0.016$), flexion (r = 0.6, $P = 0.022$), and supination (r = 0.6, $P = 0.04$). The extension was most weakly associated with the anteroposterior circularity of the capitulum (r = −0.4, $P = 0.02$) (**Figures 1(a)-(d)**).

Lateral measures of circularity were weakly associated with flexion (r = 0.3, $P = 0.014$), pronation (r = 0.3, $P = 0.031$), supination (r = 0.1, $P = 0.039$), and no real association with extension (r = −0.3, $P = 0.05$) (**Figures 2(a)-(d)**).

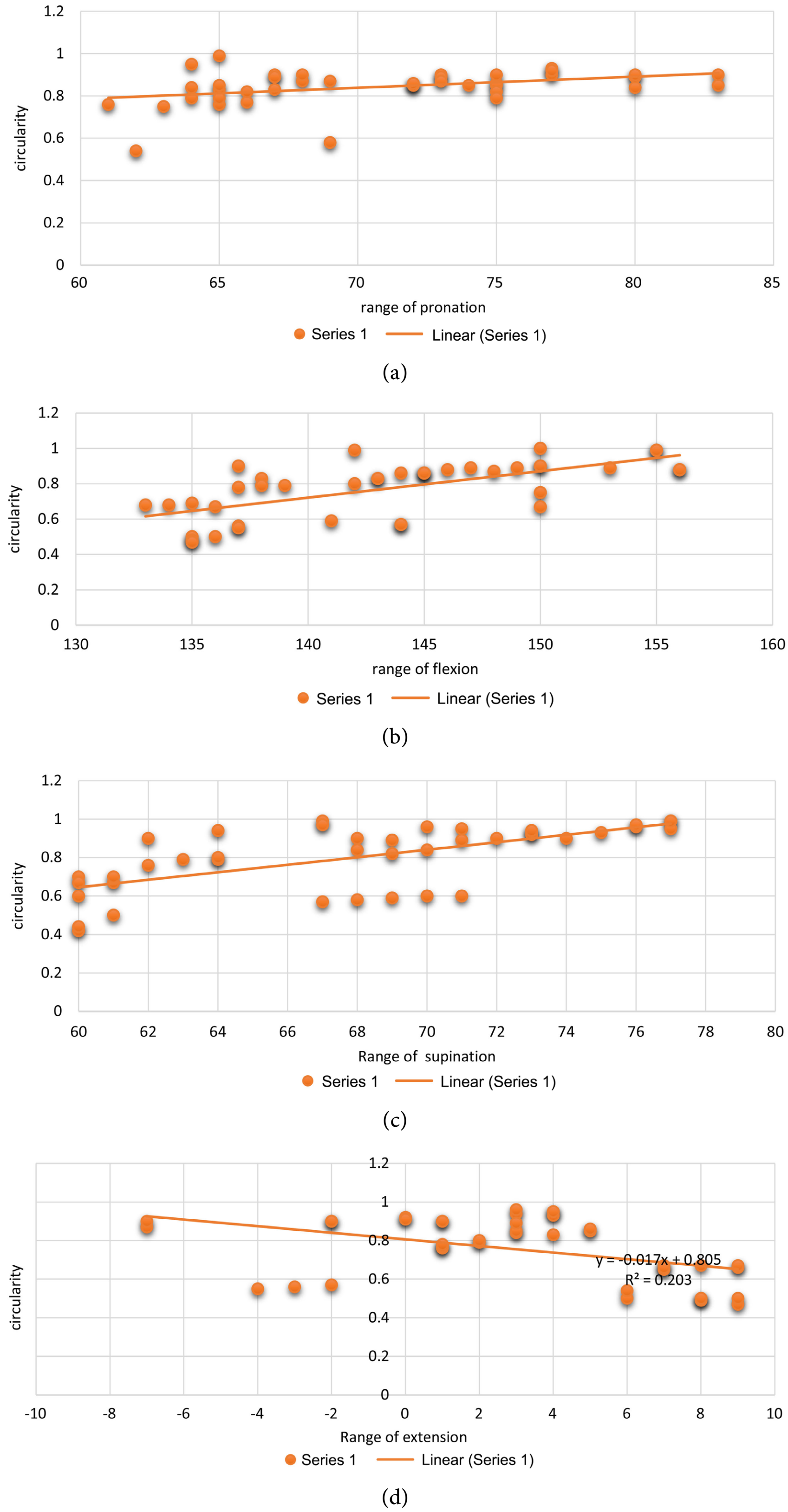

Figure 1. (a)-(d) Linear regression analysis diagrams between circularity of capitellum in anterior-posterior radiographs and range of (a) pronation, (b) flexion, (c) supination, and (d) extension.

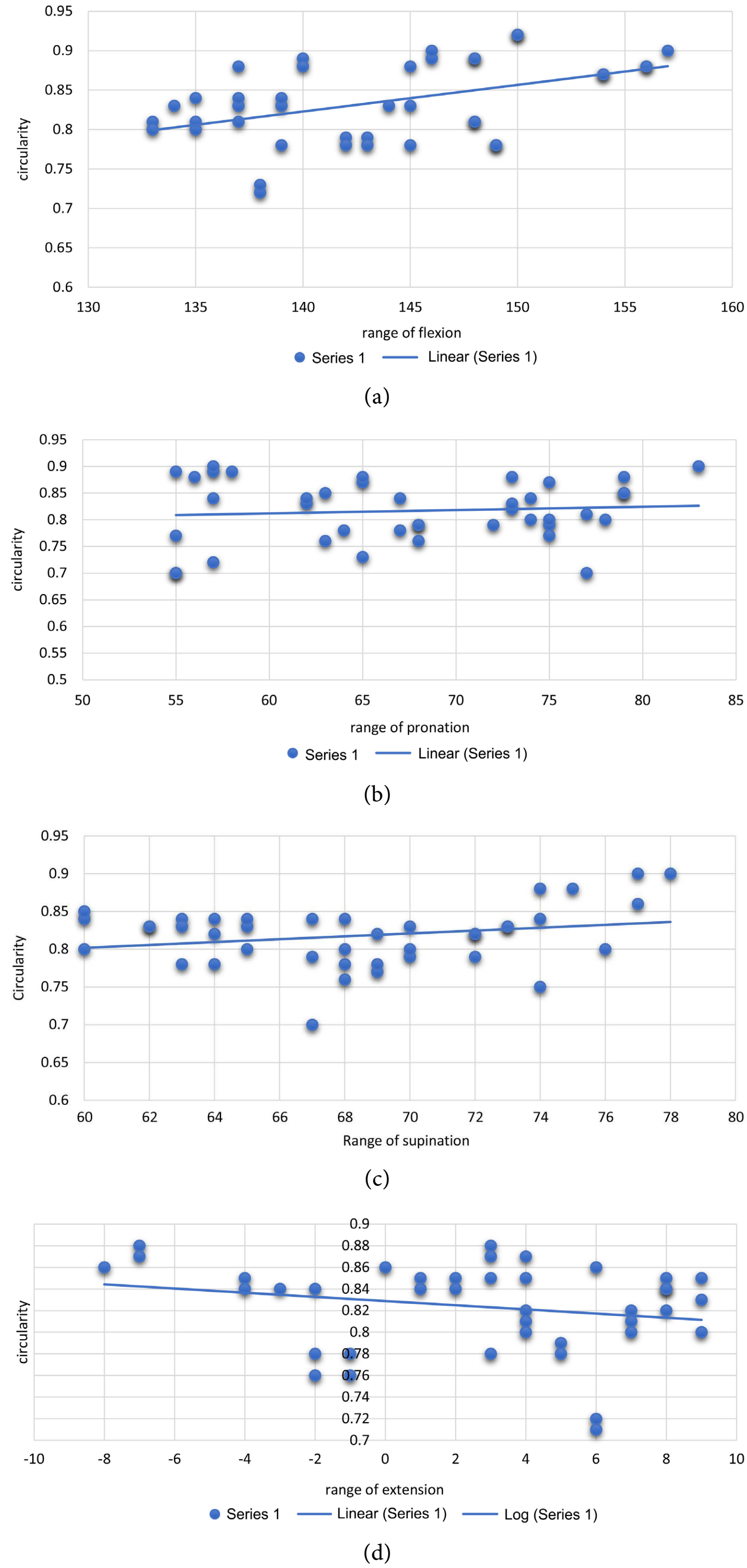

Figure 2. (a)-(d) Linear regression analysis diagrams between circularity of capitellum in lateral radiographs and range of (a) flexion, (b) pronation, (c) supination, and (d) extension.

4. Discussion

The sphericity of structures has been equated to function in diseases involving other joints in orthopaedic practice in particular the hip in Perthes disease [9]. Mose templated anteroposterior and lateral radiographs of the femoral head to determine circularity in this condition [10]. If the outline of the femoral head in both projections was identical, then the resulting prognosis was likely to be good. If the deviation is less than 2 mm, then the result is rated fair. Finally, a deviation greater than 2 mm on any one projection was rated as poor. The subsequent adoption of this rating system met with some controversy however with some authors using it as the sole criterion of success and others disagreeing that it is a long-term outcome measure [11]. It has now become accepted generally that a Mose rating that is good reflecting maintenance of sphericity tends to yield a good result but that a poor rating does not necessarily ensure a poor result. A similar disease process to Perthes disease of the hip occurring in the elbow is that of Panners disease. It also does not always lead to a poor outcome when the shape of the capitulum is distorted. However poor prognosis occurs where large unstable fragments disturb the articular surface and reconstruction is required to obtain better results. Good results are seen where remodeling can occur as the capitellar growth plates remain open and where changes in the capitulum appear localized in terms of flattening or subchondral lesions [12]. In traumatic injury to the elbow, capitellar injury in association with radial head injury appears poorly tolerated and often leads to loss of flexion range and rotation [13]. In degenerative elbow arthritis, the design of replacement options particularly of the radial head requires some further thought. Erosion of the capitulum can be seen in the long run after radial head replacement. Specific radio-capitellar replacements have recently been designed for the treatment of lateral osteoarthritis in that articulation which may prevent this problem, but it is difficult to advocate this for an isolated radial head injury [14]. A clearer understanding of why the capitulum in a certain shape may help prevent problems of loosening seen with other designs of elbow replacement requires investigation.

So, the question arises here as to which areas within the capitulum most contribute to motion or can tolerate osteochondral injury or flattening. The capitulum looks spherical to the naked eye but its bony and articular surface are not possible in subtle ways which have evolved to reduce the impact of any changes to geometry which may limit function and therefore survival. The data presented here suggests there is a relationship between the circularity of the capitulum and the range of motion of the elbow. This relationship is strongest with pronation and is noticeable with supination and flexion. The extension is limited by the abutment of the ulna in the olecranon fossa, and this may reflect that the hinge part of the motion most depends on the restoration of the ulna part of the elbow, and rotation movements are most determined by radio-capitellar articulation. It is interesting to note however that some flexion components may be limited if the capitulum was not quite spherical.

In the reconstruction of complex fractures of the capitellum, these data suggest that the reconstructive surgeon should pay particular attention to the relationship between shape and range of pronation. These data also suggest that this is best assessed from an anteroposterior perspective rather than from a lateral view.

5. Conclusion

A relationship between the range of motion and capitular shape has been established. This relationship is most evident between shape and pronation. This may help guide the intra-operative repair of complex capitular fractures, designs of joint replacements, and the development of a prognostic radiographic tool for capitellar morphology post Panner's disease.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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