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Original Article

Morphometry of the superior articular surface of head of radius

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ABSTRACT

The human elbow joint has three different articulations surrounded by a common joint capsule. These joints are the humeroulnar joint, humeroradial joint, and the proximal radioulnar joint. The humeroradial joint is a shallow ball-and-socket, hinge type of synovial joint. This aims to provide morphometric data concerning the superior articular surface of the head of radius. In a sample of 30 dry specimen of the radius, high-precision measurements were recorded to derive a statistical inference concerning: the maximal depth of the superior articular surface, its average diameter, and the articular surface area and its concavity volume. The depth and the diameter were measured using an electronic Vernier. Measuring the surface area and volume at such a small-scale was a challenge. Hence, three methods were deployed: a mathematical method, a cast material technique, and a low-surface tension fluid application.

The 95% confidence intervals were 1.847–2.119 mm (depth), 18.963–20.445 mm (diameter), 2.961–3.451 cm^2 (surface area), and 0.277–0.359 cm^3 (volume). There was a strong positive correlation for: depth vs. volume, depth vs. area, area vs. volume, diameter vs. depth, diameter vs. area, and diameter vs. volume. However, the correlation was absent (not significant) for age vs. diameter (p-value 0.361), age vs. depth (p-value 0.937), age vs. area (p-value 0.342), age vs. volume (p-value 0.512), limb orientation vs. area (p-value 0.149), limb vs. volume (p-value 0.146). This is the first study of its kind, to analyze the morphometry of the superior articular surface of the radial head, both experimentally and statistically. Derived data are of high impact in standardization and practical application in anthropology, biotechnology and biomedical applications, orthopedics, and rheumatology.

1. Introduction

The elbow joint is a synovial hinge joint between the distal end of the humerus and the proximal end of the radius and ulna; this anatomic configuration allows two axes of movement to take place: flexion–extension and pivotal rotation.[1] The humeroradial joint component of the elbow, also known as the radiocapitellar joint is a shallow ball-and-socket synovial joint. The superior articular surface (SAS) on the radial head, is a shallow cup-like disc, which is prone to dislocation of radius in relation to ulna at the proximal radio-ulnar joint. However, the presence the annular ligament secures the head of the radius in relation to the ulna, thus preventing its dislocation during elbow movements.[2,3] The relationship of articular geometry and supporting ligamentous structures provides stability to the elbow joint in flexion–extension, varus and valgus stresses, and pivotal rotation.[4] Surprisingly, radiocapitellar joint stability depends, in part, on concavity-compression mechanics.[5,6]

Numerous pathologies may affect the proximal end of the radius and its head. These pathologies include subluxation–dislocations, fractures, degenerative diseases, and other less frequent conditions that may result in alteration of joint mechanics including osteochondromas and heterotopic ossification.[7–9] These conditions do require corrective procedures including radial head resection, prosthesis implantation, and joint arthroplasty. All these corrective procedures require a high-precision restoration of joint mechanics and joint morphometry, which can be achieved well by simulation of its original in vitro dimensions and geometry,

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including those of the SAS of the radial head, i.e., diameter and depth of the articular surface, its surface area and volume, and its three-dimensional inclination (mediolateral and anteroposterior).

An important biomedical application in parallel with the scope of this research, is the radial head fractures. They comprise 5.4% of all adult fractures and 33% of elbow fractures. The treatment of radial head fractures remains controversial, and general treatment guidelines for elbow fractures are based on their severity. Accordingly, treatment for Mason's type II and III fractures include splinting and early motion, radial head excision, open reduction internal fixation (ORIF), or radial head replacement.[10,11]

In relation to Mason's fractures of the radial head, most investigators suggest ORIF for the treatment of Mason's types II and III.[10,12–18] Furthermore, De Lee and co-workers,[19] recommend excision if there is more than 3 mm of depression, 30° of angulation, or 30% involvement of the radial head. Radin and Riseborough,[20] on the other hand, achieved satisfactory results for type II and type III fractures in 83% of the cases. Mikic and Vukadinovic, had 77% good results.[21] However, Weseley and colleagues,[22] achieved 82% good results with non-operative treatment.

Although good results do not deteriorate over time, unsatisfactory results do occur in up to 50% of patients, including an intermittent elbow pain, post-traumatic elbow arthritis, restricted elbow motion, weakness, and elbow instability.[21,23–25]

We opine with high confidence, that if the prosthesis engineering could be based on the measurements reported in this study, the complications and morbidity should be substantially minimized. The primary objective of this study, is to carry out methodologically-innovative techniques for measuring the SAS morphometry. The researchers of this study, aim to provide statistically analyzed data which could be valuable for application the management of chronic elbow instability, radial head fracture, biotechnology designs and surgeries.

2. Materials and methods

All procedures in this study were conducted in accordance with the ethical standards of various committees on human experimentation in Iraq and the region of the Middle East, and in accordance with the Helsinki declaration of 1964, as revised in 1983. Identities and affiliations were concealed. The study was conducted in accordance with the ethical approval of the faculty of Medicine at the University of Baghdad. Materials used included: 30 dry specimens of human radial bone, an electronic Vernier, and a fast-setting type of an elastic dust-free alginate impression material known commercially as Hydrogum.[26] Other materials included a 100-units calibrated insulin plastic syringe, a five cubic centimeters syringe, and Acetone solution. The bony specimens belong to 30 adults, they were deceased members of the Iraqi population of Middle-Eastern and Arabic ethnicity. Unfortunately, the gender was not documented in the records. Bony specimens belonged to right and left upper limbs, 26 right and 4 left. The mean value for age was 34.3 years.

A standard electronic Vernier (UPC number 814870023454), was used to measure four dimensional parameters in relation to the SAS of the head of the radius. These included: the depth (maximum depth of the SAS in relation to the outer brim of the

Table 1
Data summarization and statistical analyses.

		Depth	Diameter	Surface area	Volume
Sample size		30	30	30	30
Mean		1.983	19.704	3.206	0.318
Median		2.045	19.46	3.12	0.31
Mode		2.04, 2.05	None	2.28, 2.97, 3.49	0.16, 0.2, 0.26, 0.28, 0.31, 0.35, 0.38, 0.39, 0.45
Lowest value		1.23	16.33	2.16	0.14
Highest value		2.58	24.17	4.75	0.53
Range		1.35	7.84	2.59	0.39
Interquartile range		0.58	3.17	1.008	0.16
First quartile		1.695	18.048	2.66	0.23
Third quartile		2.275	21.218	3.668	0.39
Variance		0.1326	3.934	0.429	0.012
Standard deviation		0.3641	1.984	0.655	0.109
Confidence interval (CI)	90%	1.87005–2.09595	19.08853–20.31947	3.00281–3.40919	0.28419–0.35181
	95%	1.84704–2.11896	18.96316–20.44484	2.96142–3.45058	0.27730–0.35870
	99%	1.79977–2.16623	18.70556–20.70244	3.00281–3.40919	0.26315–0.37285

	Correlates	Figure no.	Pearson's r value	Slope	p-Value*	Significance
Pearson's correlation test	Depth vs. volume	3	0.907	0.272	<0.00001	Yes
	Depth vs. area	4	0.764	1.374	<0.00001	Yes
	Area vs. volume	5	0.959	0.160	<0.00001	Yes
	Diameter vs. depth	6	0.754	0.138	<0.00001	Yes
	Diameter vs. area	7	0.999	0.329	<0.00001	Yes
	Diameter vs. volume	8	0.950	0.052	<0.00001	Yes
	Age vs. diameter	9	0.173	0.038	0.361	No
	Age vs. depth	10	0.015	0.00061	0.937	No
	Age vs. area	11	0.180	0.013	0.342	No
	Age vs. volume	12	0.125	0.0015	0.512	No
	Limb vs. area	13	−0.270	−0.512	0.149	No
	Limb vs. volume	14	−0.272	−0.086	0.146	No

	Variables	Age	Limb orient.	Depth	Diameter	Area	Volume
Summarization of present (Yes) and absent (No) correlations	Age	N/A	#	#	#	#	#
	Limb Orient.	No	N/A	No	No	No	No
	Depth	No	#	N/A	Yes	#	#
	Diameter	No	#	#	N/A	#	#
	Area	No	#	Yes	Yes	N/A	#
	Volume	No	#	Yes	Yes	Yes	N/A

* Statistical data were considered significance was considered at p-value less than 0.05.
# Duplicate results of correlation was written only once in the table.

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