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Original Research Paper

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ANATOMICAL CONSIDERATIONS OF THE RADIUS BONE AND ITS CLINICAL IMPLICATIONS IN DESIGN OF MODULAR RADIAL HEAD PROSTHESES IN INDIAN POPULATION

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ABSTRACT

Radial head prostheses have found a definite place in the treatment of complex radial head fractures.. Inadequate sizing of radial head prostheses may lead to an inadvertent change in proximal radial length, with potentially adverse effects on elbow, forearm, and wrist mechanics. The main reason for this mismatch is because of very few study in literature described the anatomical data for design of radial head prostheses. The aim of this anthropometric study is to describe the anatomic features of the proximal end of the radius, then correlating the findings among themselves and compare with values found in literatures to make an idea for radial head arthroplasty in Indian population.

Materials and Methods: The sixty samples comprised of 30 right-sides and 30 left-side human radius were measured for anatomical parameters. Statistical analyses were done to know the average the values of anatomical parameters.

Results: A mean value of 240 mm, 10.06 mm, 22.04 mm were found for total radial length, radial head height, and radial head (anteroposterior) diameter respectively. The mean of 20.2 mm was found for radial neck length. Medullary canal diameter presented a variation from 5.4 mm to 9.8mm, with a mean of 7.2 mm'

Conclusion: it is feasible to design an anatomic radial head prosthesis that will match patients' variable anatomy and restoration of radiocapitellar and proximal radioulnar kinematics, thus decreasing the likelihood of long-term complication of radial head arthroplasty. Results of our study help in design of anatomic radial head prosthesis for radial head arthroplasty in Indians.

KEYWORDS : Radial head prosthesis, communited radial head fracture, anthropometric study.

Introduction

In comminuted radial head fracture, osteosynthesis is usually not possible and it is often associated with injuries where resection of radial head alone is contraindicated1,2. Even in the absence of associated injuries, late sequelae of radial head resection suggest that radial head arthroplasty is an essential procedure for prevention of late complications 3, 4, 5. Radial head prosthesis is intended to prevent proximal migration of the radius in response to axial loading of the forearm. It resists valgus and posterior elbow instability by providing effective radiocapitellar contact 6.So the clinical basis of performing this study is the radial head prosthetic replacement is the only option in these type of injuries.

Current available implant are inappropriate and these implant do not reliably reproduce the radius proximal region anatomy 1, 7 leading to stress in cartilage of radiocapitellar joint due to overstuffing which results in degenerative disorders.7-11 . In literature various study shows the Radial head prosthesis design has lagged in adequately matching morphologic characteristics of the proximalradius2,12,13.

Anthropometric studies of the radial head and neck have shown great variability amongst individuals12. On review of literature we did not find any study which describes the proximal radial anatomy and its implication in radial head arthroplasty amongst Indian population. The aim of this anthropometric study is to describe the anatomic features of the proximal end of radius, compare with values found in literatures to make an idea for radial head arthroplasty in Indian population.

Materials & Methods

The study was carried out at Nil Ratan Sircar Medical College & Hospital, Kolkata. The sample comprised of 60 anatomical pieces from 30 right-side and 30 left-side human radius that belonged to bone library of Departament of anatomy, Nil Ratan Sircar Medical College & Hospital, Kolkata from the skeletons of adult population .The samples were collected by simple random sampling from Feb 2011 to Feb 2012 and distributed equally in according to age and side determining reference values. The study was approved by institutional ethical committee of Nilratan Sarkar Medical College & Hospital, Kolkata.

The anatomical samples were measured with the help of Millimeter-gauged ruler and Sliding callipers. The anatomic measurements that were done are: Total Radius Length ,Radial Head Height, Radial Head Diameter and Radial Neck Length. Measurements was taken at at 4 points (12, 3, 6, 9'O Clock positions) and taking their average. Radial head height at Center of radial head was not taken into consideration.

The Total Radius Length was calculated from the tip of styloid process to the top of the radial head between two glass slides placed against each. The Radial Head Height was measured from the top to base of radial head, using a sliding callipers at 4 points (12, 3, 6, 9'O Clock positions) and taking their average. The radial head diameter was measured from the largest anteroposterior and transverse axis, using a sliding callipers. The radial neck length were measured from the highest point of the radial tuberosity to radial head using a sliding calliper (Fig 1). The anatomic parameters were recorded from each specimen. The following measurements: anteroposterior and mediolateral radial head diameters; head height; radial neck length; and medullary canal size was assessed at junction of junction of bicepetal tuberosity and shaft of radius for statistical analysis. Measurements done from definite bony landmark and crosscheck by other co-author.


Fig 1a

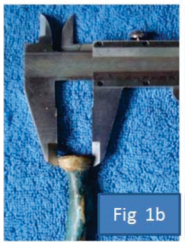
Fig 1b


Fig 1c


Fig 1d

Fig 1- Measurement of (a) Total length of radius, Radial head diameter in (b) anteroposterior and(c) lateral axis, (d) radial head height by sliding callipers

Result

On statistical analysis of data, the mean radial length, radial head height, radial head diameter-in anteroposterior and lateral axis was 240mm, 10.06mm, 22.04mm and 22.08 mm respectively. The Mean Radial neck length and medullary canal diameter was 17.2 and 5.4 mm respectively in this study (Table-1).

Table 1- Statistical analysis of Anatomical data of radius.

Anatomical parameters	Range(mm)	Mean ± standard deviation(mm)
Total radial length	216 - 268	240 ± 12
Radial head height	08 - 12.6	10.06 ± 0.1
Radial head diameter- Anteroposterior	16.4 -24.3	22.04 ± 0.2
Radial head diameter- lateral	18.2-24.6	22.08 ± 0.2
Radial neck length	17.2 – 24.0	20.2 ± 1.6
Medullary canal diameter	5.4 – 9.8	7.2 ± 1.2

Discussion

Speed (1941) first described the use of a ferrule cap to prevent heterotopic bone formation after radial head resection in displaced radial head fracture14. With time, the indication for the use of a radial head prosthesis changed from prevention of heterotopic ossification to the prevention of proximal migration of the radius and instability of the elbow. Currently, the optimal indication for the use of radial head prostheses is a non-reconstructible radial head fracture with associated injuries that would leave the elbow, or forearm unstable if the radial head were resected15. Most of radial head prostheses do not seem to be based on anatomic data. This may be partly due to the great variation of radial morphology12. More importantly, only few study reports on the dimensions of the radius. Authors have mainly studied dimensions of the radial head, with less emphasis to its relationship with the rest of the radius.

Radial length found in our study is comparable with the study performed by Van Riet et al16 and Kolstowy et al17. We found a mean radial length of 240 mm. Skalski et a 18, in their study for the development of new radial head prosthesis, performed an anatomical study using tridimensional reconstruction of the proximal radius region by computerized tomography, and found measurements that were comparable with our findings.

In our study means of 10.08 mm and 20.3 mm were found for the radial head height and whole radius neck length, respectively. These measurements found in our study are in accordance with those by Roidis et al19, who employed simple radiographs, and by Beredjiklian et al2, who employed magnetic resonance imaging. Van Riet et al16 performed his study on 27 fresh-frozen cadaveric upper extremities and found means of 10.14 mm and 13 mm for the radial head height and for the whole radius neck length, respectively. Such findings confirmed that, no matter the method for measurement, values are all

Radial head diameter (anteroposterior and lateral axis) found in this study is comparable with the anthropometric studies performed by King GJ et al13, Popovic et al20 and Swieszkowski W et al21 The native radial head is neither circular , nor it is consistently elliptical in shape. CT study of cadaveric specimens by Cone et al 22 describes that the radial head is ovoid in shape (Maximum diameter exceeds the minimum diameter by an average of 2.5 mm). Anatomical study of Koslowsky T C et al17 shows that the radial head is neither round nor conical. It has a complex shape with an increasing size from the radiocapitellar joint surface to the middle of the proximal radioulnar joint surface. In the anthropometric study of King GJ et al 13 the mean difference between the maximum and minimum radial head diameters was 1.7 +/- 0.7 mm. These findings also suggest that the native radial head is neither circular, nor it consistently has an elliptical shape. Study of Rodis et al19 based on the radiographic study of proximal radius describes the shape of radial head as elliptical, with variation in diameters when comparing anteroposterior and lateral measurements, a fact that does not match our measurements.

The medullary canal diameter of the radial neck (Mean 7.2mm) in our study is comparable with anthropometric study performed by Popovic et al 20 and Kolstowy et al23. In the study of Popovic et al the minimum and maximum intramedullary diameters of the radial neck were 8.3 +/- 1.3 mm and 9.3 +/- 1.5 mm, respectively. In the study of Kolstowy et al23 the diameter of intramedullary canal 9.7mm on x ray and corresponding optosil imprints had a mean diameter of 11.6mm at the proximal end, 10.5mm in the middle and minimum of 9.8 mm at distal end of radial neck.

In this study we found proportionality among values while performing a statistical analysis, correlating the radial length with the other measurements obtained. Pearson coefficient correlation shows good correlation between total radial length and other anatomical parameters except medullary canal diameter. In our study there was a poor correlation between the radial head diameter and the medullary canal of the radial neck, suggesting that a modular implant system should be considered for design of radial head prosthesis. This type of correlation study has not been described in literature.

Exact anatomical description of the proximal radius is imperative for the development of newer designs of radial head prostheses which in turn may lead to an improvement in function after replacement. Our study has led to the conclusion that it is feasible to design an anatomic radial head prosthesis that will match the patients' variable anatomy along with restoration of radiocapitellar and proximal radioulnar kinematics, thus decreasing the likelihood of long-term complication of radial head arthroplasty. Results of our study would help in designing anatomic radial head prosthesis for radial head arthroplasty in Indian population. The radial head height should be 10mm. The superior and medial surface of head should be contoured for articulation with capitellum and radial notch of ulna accordingly. The radial head diameter should have five options 16-24 mm with 2 mm interval. The length of radial neck should have nine options 16-24 mm with 1mm interval to restore radial length. The length of stem should be is long enough to provide stability and the diameter of the stem should be between 5-10 mm with 1mm interval.

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