Misconceptions about the three point bony relationship of the elbow

Mandeep S Dhillon, Nirmal Raj Gopinathan, Vishal Kumar

ABSTRACT

Introduction: The 3 bony point relationship of the elbow is an important surface evaluation done in all cases of elbow pathology; its importance is highlighted by the fact that significant emphasis is also laid on this during the specialty board examinations. Confusion about the exact inter relationship exists even in the standard orthopaedic books, with various authors labeling it as isosceles, equilateral or a different triangle, without any citation to back this statement.

Materials and Methods: The knowledge of the three bony points relationship in elbow was verified after a survey of orthopaedic surgeons undertaken by the senior author, produced disparate answers. Most (63%) classified this as an isosceles triangle. To clarify this further, 200 elbows were prospectively evaluated to measure the distances between these points and the angles were calculated.

Conclusion: Our observations indicate that this triangle is neither isosceles, nor equilateral, but a scalene triangle of unequal sides. There may even be a minimal difference in the 2 sides of the same individual, which has the potential to complicate routine comparison of the two elbows during examination.

Results: The analysis of data revealed that all surgeons were aware of the three bony points relationship; however 21 of the 179 (mostly senior surgeons) did not give too much importance to this evaluation in daily clinical practice. Nine surgeons were not sure what type of triangle was formed, 17 thought it was an equilateral triangle, 40 thought it was some other type of triangle while 113 (63%) thought these points formed an isosceles triangle. This is a reflection of the disparity in the perception about this triangle in the orthopaedic community in general.

Key words: Elbow surface markings, elbow triangle, three bony point relationship

MeSH terms: Elbow joint, dislocation, observation

INTRODUCTION

The three prominent points of the elbow, namely the tips of the medial and lateral epicondyles and the tip of the olecranon, have a fixed relationship with one another. This allows for an easy and reproducible examination of the elbow as distortions in this relationship can be fairly easily picked up. Malunited elbow fractures, or a neglected dislocation, are commonly seen problems both in daily practice, as well as cases for the orthopaedic speciality examinations of postgraduates. However, modern advances in diagnostic orthopaedic imaging have somewhat reduced our everyday dependence on this palpatory evaluation; nevertheless most orthopaedic residents are expected to evaluate the elbows clinically during their practical examinations. Unfortunately, significant confusion exists about this interrelationship, even in the minds of senior surgeons and examiners. There is no specific evidence based documentation available about the importance, the exact surface anatomy interrelationship and how the examination is to be conducted. In addition, the issue is complicated by the fact that the bony configuration is not clearly defined in the standard reference textbooks, both of anatomy and orthopaedics, with measurement values of the normal elbow itself being stated differently. A survey of the standard orthopaedic books1-13 revealed confusing documentation of the interrelationship of these three points and no cross references or evidence from any measurements from cadavers or actual patients were cited to validate their claims. The triangle formed by these points has been variously labeled as equilateral1,2,5,6,9,11 isosceles,2,3,7,8,10 or to have unequal dimensions.4 An email survey and a personal survey of doctors by the senior author regarding the type of triangle formed at the elbow in flexion raised
Serious doubts about the understanding of this relationship by the average orthopaedic specialist. We thus decided to evaluate this relationship in normal individuals and present our findings of this examination in 200 elbows.

Materials and Methods

The initial part of this study consisted of an email survey of doctors from India and abroad, as well as a survey of orthopedic surgeons attending an advanced operative orthopaedic course. E-mails were sent out to 300 doctors, out of which 106 responded; subsequently 73 surgeons of varying levels of experience were handed out the proforma at an AO trauma course on Advances in Fracture Management in June 2013, giving us a total of 179 responses. Surgeons were classified into 3 levels of experience as under: Young surgeons-postgraduate trainee or within 5 years of securing MS/DNB; midlevel orthopaedic surgeons: Greater than 5 years of professional experience and less than 45 years of age; senior surgeons more than 45 years of age. All were asked to answer three questions posed within 10 min of reading the proforma, without consulting anything.

An evaluation of 200 normal elbows was carried out in the Department of Orthopedics, PGIMER over a 2 month period; 100 adult volunteers (200 elbows), aged between 18 and 65 years, of either sex were included in the study after obtaining an informed consent. A thorough history was taken to rule out any childhood elbow injury; the exclusion criteria were a positive history of previous upper limb trauma, restriction of elbow motion due to varied reasons and any birth deformity. Two consultants sequentially carried out the measurements to rule out interobserver error; the mutually agreed upon markings and measurements were documented.

As a first step, the bony landmarks were marked in the elbow flexed to 90°, with the examinee sitting on an examination stool with no armrest or backrest. The examiner sat behind the patient and ensured that the patient kept the shoulder in a neutral position and the elbow flexed at 90°. The lateral supracondylar ridge was traced downwards and the most prominent bony landmark beneath which the bone starts receding was marked [Figure 1]. The measurements were carried out by two orthopaedic surgeons of junior consultant level and the average was tabulated. The mean values were calculated and are as shown in the master chart. The angles were calculated using the cosine equation with the help of a mechanical engineer. A master chart containing the measurements of all individuals was prepared and evaluated.

Results

The analysis of data revealed that all surgeons were aware of the three bony points relationship; however 21 of the 179 (mostly senior surgeons) did not give too much importance to this evaluation in daily clinical practice. Nine surgeons were not sure what type of triangle was formed, 17 thought it was an equilateral triangle, 40 thought it was some other type of triangle, while 113 (63%) thought these points formed an isosceles triangle [Table 1]. This is a reflection of the disparity in the perception about this triangle in the orthopaedic community in general.

Out of the 100 individuals examined for elbow measurements, 56 were males and 44 were female subjects. The average age of the study population was 28.26 years and varied from 18 years to 62 years. The mean values of measurements are given in Table 2. The mean value of the distance between medial condyle to tip of olecranon was 4.494 cms. The mean distance between lateral epicondyle and tip of olecranon was 5.069 cm. The mean intercondylar distance was 6.31 cms. The triangle constructed with these measurements came out to be a scalene triangle and the angles formed by respective limbs of the triangle are shown in Figure 4. The mean values of the angles formed are measured [Table 3].

The significant points that we were able to conclude from our study can be listed as follows

Table 1: Results of survey of orthopaedic surgeons; numbers indicate agreement of the interviewed surgeon with the question

| Questions asked | Senior surgeons | Mid level surgeons | Junior surgeons | Total responses |
|------------------|-----------------|--------------------|-----------------|----------------|
| Are you aware of 3 bony point relationship at elbow? | 65 yes | 66 yes | 48 yes | 179 (all aware) |
| Do you give importance to this in clinical practice? | 53 (yes) | 57 (yes) | 48 (yes) | 158/179 (yes) |
| Is it equilateral triangle | 7 yes | 7 yes | 3 yes | 17 yes |
| Is it isosceles triangle | 32 yes | 46 yes | 35 yes | 113 yes |
| Other type of triangle | 24 yes | 10 yes | 6 yes | 40 yes |
| Do not know, unsure | 2 | 3 | 4 | 9 |
Table 2: Mean values of three sides of triangle

| Side         | Intercondylar distance (cm) (A) | Lateral epicondyle to olecranon (cm) (B) | Medial condyle to olecranon (cm) (C) |
|--------------|---------------------------------|------------------------------------------|-------------------------------------|
| Right side   | 6.314 (mean) (5.4-7.0)          | 5.068 (mean) (4.2-6.2)                   | 4.502 (mean) (3.2-5.9)              |
| Left side    | 6.306 (mean) (5.2-7.1)          | 5.07 (mean) (4.1-6.3)                    | 4.486 (mean) (3.2-6.0)              |
| Both sides   | 6.31 (mean)                     | 5.069 (mean)                             | 4.494 (mean)                        |

Table 3: Angles of the triangles formed

| Side         | Angle α (in degrees) | Angle β (in degrees) | Angle Ø (in degrees) |
|--------------|----------------------|----------------------|-----------------------|
| Right side   | 82.336               | 52.702               | 44.963                |
| Left side    | 82.340               | 52.828               | 44.833                |
| Both sides   | 82.338               | 52.765               | 44.898                |

1. No two sides of the triangle in any elbow measured were equal (hence these lines formed a scalene triangle, i.e., one with unequal sides)
2. Even measurements on both limbs were not exactly the same in more than half the elbows; this was not affected by dominance of hand. Its clinical implication needs to be validated. Inter-observer variability is not the cause, as two surgeons measured all the elbows and the mutually agreed points were taken. However, parallax error cannot be ruled out.

**Discussion**

In modern orthopaedics, radiological examination has reduced the significance of a good orthopaedic palpation at many anatomical sites and many surgeons are taking this point in their stride. The diagnosis is invariably confirmed by a combination of the above two methods and treatment is subsequently planned. However, the resident examining a case for presentation is often not afforded this choice; in the underdeveloped world, varying presentations of fractures or dislocations with different treatment regimens...
and sometimes neglect, is common. This leads to significant variations from the normal that could be present; it is the experience and observation of the senior author that these cases are invariably discussed in most postgraduate and specialty board examinations. In our survey also, 158 of 179 surgeons surveyed by us gave importance to this relationship. Surprisingly, significant confusion as to what is normal exists in the literature available for these students to study and for young surgeons to quote as references.

We evaluated two anatomy reference books; the standard tone, Gray’s Anatomy\(^1\) labels this triangle an equilateral triangle and states that even in extension the three points do not form a straight line. Kulkarni\(^2\) in her textbook of anatomy has labeled this triangle vaguely as “isosceles or equilateral” and has drawn a figure also. A Layman’s Guide to Health Care\(^3\) talks of this bony relationship, but lays emphasis on comparison with the opposite side in case of injury; this point has also been brought into dispute by our findings, although, it may be by and large true. A text on primary surgery\(^4\) also emphasizes the importance of evaluating these surface landmarks, but does not clarify any further.

Nine reference books for orthopaedics were surveyed; books by Apley,\(^5\) Magee\(^6\) and Pandey\(^7\) clearly labeled this as an Isosceles triangle, while texts by Dumontier,\(^8\) Ebnezar,\(^9\) McRae\(^10\) and Reider\(^11\) clearly labeled this as an equilateral triangle. Maheshwari,\(^12\) though citing it as a “near isosceles triangle” labels the medial side as the shortest distance. Das\(^13\) is the only standard book that has clearly labeled this as a “triangle of unequal sides”. Unfortunately, none of these authors has cited a reference to support any of their statements, making all of these level 5 (eminence based) documentations.

We undertook this study to clarify the prevalent confusion. To avoid the problem of interobserver variability, it was decided that two consultants would make all measurements and the mutually agreed markings and measurements were then documented. Although, patients were asked to hold their elbow joints in 90° of flexion, this is one area where some variation in position is possible and has the potential for some amount of intraobserver variability.

Our readings clearly indicated that the triangle formed is neither equilateral nor isosceles. All the three sides varied and the resultant triangle formed was scalene in configuration. It was the same when both sides were analyzed separately or when both elbows were dubbed together. The triangle formed with mean values are depicted in Figures 1 and 2, with the respective angles.

Incidentally, the measurements were unequal on both sides in the cases evaluated, which raises more food for thought.

We are not able to give a scientific explanation to this, although one possibility is observer error in measurement, as the subjects were asked to keep their elbows in 90° of flexion. A slight variation in the degrees of flexion between the two sides may result in potential differences in readings. However, a point against this explanation is the documented variation in inter-condylar distance; this would be unaltered, even if the elbows are kept in varied flexion attitudes.

One way of overcoming the possibility of variation in flexion attitude is by using splints or braces that can hold the limb in 90° of flexion, but allow unimpeded elbow measurements. Another method of improving the accuracy is by roping in imaging modalities like computerized tomography for more precise measurements. However, since this is just a preliminary observational study consequent to prevalent misconceptions, larger subsequent studies could address these issues. The variation in measurements did not correlate well with dominant handedness also.

**Conclusion**

Lines joining the three bony points in 90° flexed elbow form a scalene triangle; there may also be some difference in measurements between the two sides and this should be kept in consideration.

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