

Determination of Angle of Torsion In Metacarpal Bones



Medical Science

KEYWORDS : Protracto-Torsiometer, Degree of Torsion, Metacarpal Bones, Ventro-Dorsal Axes, Distal Axes Proximal Axes.

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ABSTRACT

This research was done by Dr Shashikant Verma in Department of Anatomy, N.S.C.B. Medical College, Jabalpur M.P., to determine the angle of torsion in metacarpal bones using specially designed instrument by him. Instrument named as "PROTRACTO-TORSIOMETER". Using this instrument he established the presence of torsion determines the degree of torsion in metacarpal bones and studied the racial factors if any. After successful determination of angle of torsion he came to the conclusion that there is significant difference in degree of torsion in metacarpal bones of right and left side. The angle so obtained were much more lower than the work done previously by I.B. Singh in year 1976 and the instrument designed was also comparatively more simpler and cheaper than the instrument described by I.B. Singh in his work.

INTRODUCTION

The axiom that "Structure is conditioned by function" is well illustrated in Human Anatomy. The evolutionary changes are nothing but functional adaptations for survival. Adaptation to environment is an essentiality which is very well illustrated by the evolutionary changes. Out of all parts of human body hand evolves the most. "Wood Jones" has rightly said that "Man's place in nature is largely writ upon his hand". The hand is important functioning organ performing greatest activities. Through the hand we form a conception of the outside world. The hand is acting as an organ of sight and hearing etc. Really speaking hand is an extension of our brain in the surrounding world. It is the mirror of innermost responses to the outer world. The hand in case of man shows dominating changes which make him rule not only the animal kingdom but the universe. The most sophisticated machines of the day are the result of adaptation of the human hand. The primary distinction between animal and man in relation with hand is the development of function of prehension and grasping, to which later on added fine movements and skills. For the function of grasping and prehension palm and the fingers are to be adapted especially for holding the spherical objects, the palm has to become at times concave and at times flat. Even for holding instruments like screw driver or for holding a pen or pencil, the palm has to become shallowed out. This will lead to rotation of metacarpal bones along the central axis of the palm which is formed by third metacarpal bone. Constant use of hand for such function might lead to some permanent changes. For studying the function of hand "Kaplan" has divided the hand into component parts. Although it is somewhat artificial but it permits the better insight into the activity of the hand as a unit. In order to understand the functions of human hand, it is very helpful to compare it with the functions of any of Anthropoids, apes. For different reasons in the past, and even sometimes in the present, some observers suspected fundamental anatomical difference between human and anthropoid hands.

Actual observations on the actions of these hands and also the anatomical structure show that the differences are not very great and at times indistinguishable. This can be easily observed by the study of thumb and the function of apposition Kaplan" has divided the hand artificially into three functional units. I. Thumb .II. Index and middle finger. III. Ring and fifth finger. According to him in the major part of human activity the most important function is performed between thumb, index and middle finger. The ring and little finger form a supporting an auxiliary. With the development of the fine actions the index finger tends to become more and more independent of the middle finger, the ring and little finger. This is reflected not only outward independence, but also in separation of muscle bellies. In the

articulated hand two metacarpal arches can be seen: (a) Proximal-near the base (b) Distal near the heads of Metacarpals. The curvature of distal arch is much less pronounced than the proximal arch. The difference in curvature between the two arches is in part due to fanning out of the metacarpal bone and partly due to rotation of metacarpal bones as shown by "I.B.SINGH".

The flattening of distal arch is a factor of considerable functional importance. In the resting hand the digits lie more or less parallel to each other, in contrast to the fanning out of the metacarpals. This is made possible by the fact that the heads of metacarpal bones are not set in the straight line with the long axis of shaft, but lie at a distinct angle. In the second metacarpal bone inclination of hand with respect to the shaft is to the medial side. In the fourth and fifth digits it is towards the lateral side while the third Metacarpal shows no such inclination (Shiine 1925, cited by Landsmeer 1976). All the metacarpal heads would neutralize the affect of fanning out of metacarpal shaft; the distal metacarpal arch would still tend to have a marked forward concavity. The flattening of this concavity is a result of the presence of torsion in metacarpal bone.

It is well known that the digits of hand fan out in hyperextension and tend to be pressed together during flexion (Kaplan, 1965). But for the flattening out of the distal metacarpal arch, as a result of torsion, flexion of digit would be accompanied by a much stronger tendency to 'Crowding up' of the digits, which would grossly interfere with the efficiency of the hand in gripping. In this analysis of the various factors responsible for the shaping of the hand to produce an efficient grip, Landsmeer, (1975) includes (a) the asymmetry of metacarpal joints, (b) the asymmetry in size and position of metacarpo-phalangeal ligaments, (c) the asymmetrical disposition of the phalangeal base and (d) the inclination of head relative to the shaft of second, fourth and fifth metacarpals. In view of what has been stated above, metacarpal torsion is a pertinent edition to this test.

MATERIAL AND METHODS

One hundred metacarpal bones were studied in the present work. Out of these fifty were of the right side and fifty of left side. These were obtained from the cadavers of known sexes. All the cadavers were male. All the bones were obtained from adult male cadavers in the dissection hall during a period of two years. For measuring; the angle of torsion it is necessary that the ventro-dorsal axes of the two ends of the metacarpal bones are fixed and the angle between these two axes is the angle of torsion. The axes of the ventral and dorsal ends were fixed as suggested by I. B. Singh which is given below:-

Fixed points for determination of Ventro-Dorsal Axes

Distal Axes: (Common to all bones of the series).

(a) Ventral End: The medial and lateral margins of ventral aspect of articular surface of the head are clearly defined. The mid-point between medial and lateral margins (near the ventral end of the surface) was taken as ventral end of distal axis (Fig. 1a).

(b) Dorsal End: The dorsal aspect of the distal end of the shaft of metacarpal bones is marked by medial and lateral tubercles. The mid-point between the most prominent parts of the tubercle was taken as the dorsal end of distal axis (Fig. 1 b).

Proximal Axes

(a) First Metacarpal:

The proximal end of this bone is marked by sharp anterior and posterior margins that are convex proximally. The points of greatest convexity of these margins were taken as the ventral and dorsal ends of the proximal axis (Fig. 1c).

(b) Second Metacarpal:

The base of this bone is marked by deep groove. The line of this groove was taken as the proximal axis (Fig. 1d).

(c) Third Metacarpal:

The proximal articular surface of the base usually has well defined anterior and posterior margins.

The midpoints of these margins were taken as the ends of proximal axis (Fig.1e).

(d) Fourth Metacarpal:

The base was viewed from the ventral aspect and a point midway between the lateral and medial margins was marked (Fig.1 f). The dorsal end of the axis was marked in the same way (Fig.1 g). (The proximal articular surface of the base is subject to considerable variation and is not reliable guide for marking ventro-dorsal axis).

(e) Fifth metacarpals:

A line was drawn transversely across the proximal articular surface mid-way between the anterior and posterior margins. The midpoint of this line was taken; a line drawn through this point parallel to the sharp lateral edge of the articular surface was taken as the axis. (Fig.1h).

The angle of torsion is the angle between the ventro-dorsal axis of the proximal end and the ventro-dorsal axis of distal end. To measure this special instrument was devised by Dr Shashikant Verma which is much simpler than the Instrument designed by Prof. I. B. Singh.

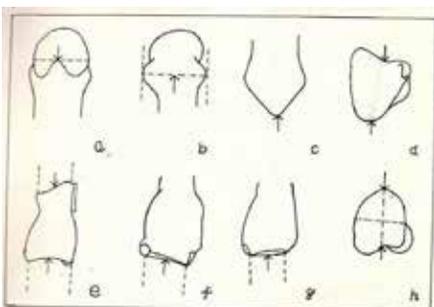


Fig.1: Drawing to show the placing of the ends of ventro-dorsal axes of metacarpal bones. In each figure the end of the axes is indicated by the tip of arrow.

DESCRIPTION OF INSTRUMENT

This instrument consists of a protractor (A) which forms a base and could measure 360 degrees. To this Horizontal plate (B) was fixed. This plate forms the platform for keeping the bone. The midline of the platform (B) corresponds with the zero degree of the Protractor (A) where a small metallic pointer (C) is fixed. To the part A on its under surface another plate (D) was fixed vertically in such a way that its midline also corresponds with the zero degree of protractor. At right angle to the plate (D) almost equal to the length of platform (B) a long metallic pointer (E) is fixed. This pointer also corresponds with the zero degree of protractor (A). The plate (D) is capable of rotation on the Central pivot. The photograph of figure is shown in Fig. 2.

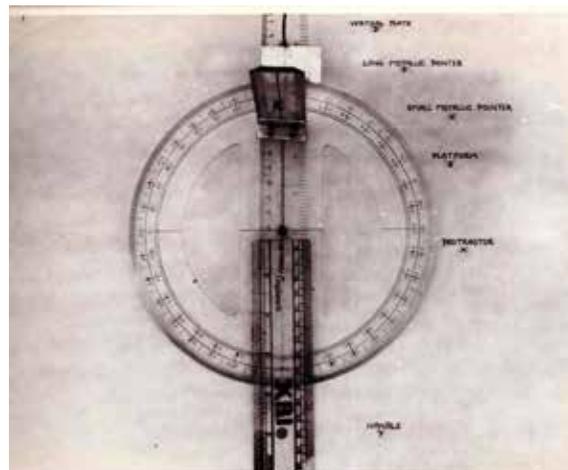


Fig.2: Photograph of the Instrument

METHOD

The measurement of the angle of torsion of metacarpal bones was carried out with the help of especially designed instrument in the following manner.

The fixed point for determination of ventro-dorsal axis of proximal and distal ends of metacarpal bones was taken.

At these points after making a hole metallic needle was introduced at the distal end, and another needle fixed to the proximal end.

The metacarpal bone was placed on the platform with the distal end towards the protractor (A) and the ventral surface facing forwards. The bone was placed in such a manner that the needle passed through the distal end touched the platform at its midline as well as the fixed needle at the zero degree mark of the protractor.

Another needle was placed at the proximal end of metacarpal bone touching the midline of platform (B) and fixed points of proximal end.

The plate (D) and the pointer (E) were rotated up to an angle so that the needle which is fixed to the proximal end of metacarpal bone began to touch the pointer.

Now the angle between the zero degree line of protractor and midline of plate (D) was directly recorded as the angle of torsion. For accuracy the reading was repeated twice and the mean was taken.

OBSERVATIONS

Fifty metacarpal bones of each side were measured by the method given above. The Table 1 give the degree of angle of torsion of each bone.

In the present observation, majority of metacarpals show a demonstrable torsion. Each metacarpal shows either medial torsion or lateral torsion, depending upon whether the head of metacarpal is appearing to be rotated medially or laterally relative to the base. The lateral rotation is denoted by letter "L" & medial rotation is denoted by letter "M".

From the Table 1 & Fig. No.3 (a) & Fig. No.3 (b) it is evident that on right side the, I, II & III metacarpals shows the lateral torsion.

There are some exceptions which are showing the opposite rotation. They are in case of:

- I Metacarpal : 8, 23, 40 & 45
- II Metacarpal : 13, 28, 32 & 46

- III Metacarpal : 7 & 28
- IV Metacarpal : 4 & 17
- V Metacarpal : 11, 25, 27 & 38

On the left side the metacarpal is showing medial torsion. The second & third metacarpals show the lareral torsion .The fourth & fifth metacarpals show the medial torsion in majority of cases.

Few exceptions which are showing opposite torsion. In case of:

- I Metacarpal : 2, 16, 22,27,37,41 & 46
- II Metacarpal : 10, 19 & 34
- III Metacarpal : 9, 13 & 48
- IV Metacarpal : NIL
- V Metacarpal : 4, 9 & 27

Table 1: Degree and direction of torsion in metacarpal bones

S/No.	RIGHT METACARPALS					LEFT METACARPALS				
	I	II	III	IV	V	I	II	III	IV	V
	1	2	3	4	5	6	7	8	9	10
	7.5 L	10.0L	6.0 L	1.5 M	3.5 M	2.5 M	7.0 L	3.5 L	2.5 M	3.5 M
	8.0 L	5.5 L	3.0 L	4.5 M	6.5 M	1.5 L	3.5 L	2.0 L	3.5 M	6.5 M
	4.5 L	5.5 L	2.5 L	5.0 M	6.5 M	4.0 M	3.0 L	2.5 L	6.5 M	7.5 M
	7.5 L	7.5 L	4.5 L	2.0 L	3.5 M	2.5 M	3.5 L	4.0 L	4.5 M	5.5 L
	5.0 L	5.5 L	3.5 L	5.0 M	6.5 M	2.0 M	2.0 L	2.5 L	7.5 M	7.5 M
	3.0L	5.0L	4.5L	5.5M	6.0M	2.0M	2.5L	2.5L	6.5M	7.0M
	5.5L	5.5L	2.5M	5.0M	5.5M	3.5M	2.5L	2.5L	5.5M	6.0M
	2.5M	9.5L	6.0L	2.5M	3.5M	2.5M	3.5L	2.5L	4.5M	5.0M
	5.5L	7.5L	3.5L	4.5M	5.5M	2.0M	3.5L	2.5M	5.0M	7.5L
	6.0L	5.0L	3.5L	4.5M	5.5M	2.0M	3.5M	12.5L	5.0M	6.5M
	2.5L	5.5L	4.0L	4.5M	4.5L	5.5M	3.5L	2.5L	6.5M	6.5M
	4.5L	5.5L	5.5L	5.0M	6.5M	4.0M	2.0L	2.5L	6.0M	6.5M
	8.5L	3.5M	3.0L	5.5M	6.5M	2.0M	3.5L	2.5M	6.5M	7.0M
	7.0L	5.0L	4.5L	4.0M	5.5M	2.5M	3.5L	2.5L	5.0M	7.5M
	4.5L	5.5L	4.5L	4.5M	6.0M	2.5M	2.5L	3.0L	5.5M	6.5M
	5.5L	4.5L	3.5L	3.0M	5.5M	2.5L	3.0L	3.5L	4.5M	6.0M
	4.0L	4.5L	2.5L	4.5L	5.0M	2.0M	3.5L	2.5L	5.0M	6.5M
	4.5L	5.0L	3.5L	2.5M	5.0M	2.5M	3.5L	2.0L	3.5M	5.5M
	4.5L	4.5L	2.5L	5.0M	6.5M	2.5M	3.0M	2.5L	5.5M	7.0M
	0.5L	7.5L	2.5L	5.5M	6.0M	4.5M	4.5L	2.0L	6.0M	6.5M
	3.5L	5.0L	3.5L	5.0M	5.5M	1.5M	3.5L	3.5L	5.5M	6.0M
	7.5L	4.5L	3.5L	6.0M	9.5M	6.0L	3.5L	2.5L	6.5M	10.5M
	5.0M	6.0L	4.5L	4.5M	5.0M	1.5M	9.5L	6.5L	6.5M	5.5M
	2.5L	3.5L	2.5L	3.0M	7.5M	3.0M	4.0L	3.5L	7.0M	7.5M
	6.5L	4.0L	4.5L	3.5M	5.5L	2.5M	4.5L	3.5L	5.5M	7.0M
	2.5L	4.5L	4.0L	3.5M	5.5M	2.5M	4.0L	3.5L	4.5M	6.0M
	0.5L	6.0L	4.5L	4.0M	5.5L	2.0L	4.5L	3.5L	5.0M	6.5L
	8.5L	3.5M	2.0M	4.5M	4.5M	0.5M	2.0L	1.5L	5.5M	6.5M
	7.0L	4.5L	2.5L	4.5M	6.0M	7.5M	4.5L	2.5L	5.0M	6.5M
	7.5L	4.5L	2.5L	4.0M	5.5M	2.5M	3.5L	2.0L	5.5M	6.0M
	3.5L	4.5L	3.0L	3.5M	7.0M	1.5M	3.0L	2.5L	5.0M	7.5M
	3.5L	4.5M	4.0L	3.5M	5.5M	2.5M	4.0L	3.5L	4.5M	6.0M
	5.0L	5.5L	2.5L	4.0M	9.5M	2.0M	4.5L	2.0L	5.5M	6.5M
	1.5L	3.5L	3.5L	4.5M	6.0M	2.5M	3.0M	3.5L	5.0M	6.5M
	7.0L	4.5L	4.0L	5.0M	5.5M	2.5M	3.5L	3.5L	6.0M	9.5M
	7.5L	4.0L	4.5L	5.5M	6.0M	2.5M	2.5L	3.0L	3.5M	6.5M
	4.5L	6.5L	3.0L	3.5M	4.5M	7.5L	3.5L	2.5L	5.5M	5.0M
	1.5L	3.0L	3.5L	4.5M	6.5L	0.5M	2.5L	2.5L	5.0M	7.5M
	9.5L	4.5L	2.5L	6.5M	7.0M	2.5M	3.0L	2.0L	7.5M	9.5M
	5.5M	4.5L	2.5L	6.0M	6.5M	2.5M	3.0L	2.0L	6.5M	9.5M
	2.5L	6.0L	5.5L	4.5M	5.0M	4.0L	3.5L	3.0L	5.5M	5.5M

	6.5L	4.5L	1.5L	5.0M	5.5M	2.5M	3.5L	2.5L	5.5M	7.0M
	2.5L	6.0L	3.5L	6.5M	7.0M	2.0M	4.5L	2.5L	6.0M	9.0M
	5.5L	5.5L	3.5L	6.0M	7.5M	2.5M	3.0L	3.0L	7.5M	9.5M
	3.5M	4.5L	4.5L	5.0M	5.5M	3.0M	3.0L	2.5L	5.5M	6.0M
	0.5L	4.5M	2.5L	3.5M	4.0M	1.5L	2.5L	3.5L	4.5M	5.5M
	5.5L	3.5L	3.0L	5.5M	7.5M	1.5M	3.0L	3.5L	4.5M	5.5M
	3.0L	6.5L	3.5L	4.5M	4.5M	2.5M	2.5L	2.0M	6.5M	5.5M
	7.5L	5.0L	4.5L	9.5M	6.5M	5.0M	4.5L	3.0L	4.5M	7.0M
	4.0L	6.5L	3.5L	4.5M	5.0M	0.5M	4.0L	2.5L	6.5M	6.0M

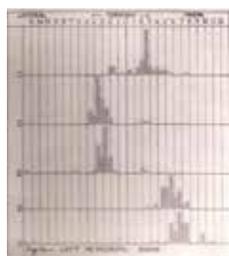
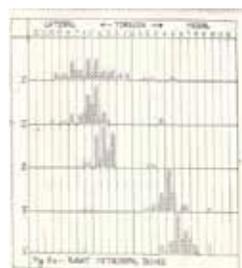


Fig. 3a

Fig. 3b

Fig 3a and 3b: Drawing showing the frequency distribution of the degree and direction of torsion in right (Fig. 3a) and left (Fig. 3b) metacarpal bones. (Each circle represents one specimen)

DEGREE OF TORSION

The mean angle of torsion is given in Table 2. This table also shows the standard deviation (SD) & Z conclusion.

While calculating the mean the case where the torsion was in opposite direction were excluded.

Table 2: Mean angle of torsion in the metacarpal bones

Metacarpal Bones	Side of Rotation	Rotation in Metacarpals of Right Side				Side of Rotation	Rotation in Metacarpals of Left side				Paired Test	
		Mean		S.D.			Mean		S.D.		I.B. Singh	Present Work
		I.B. Singh	Present Work	I.B. Singh	Present Work		I.B. Singh	Present Work	I.B. Singh	Present Work		
I	L	4.95	4.956	1.24	1.079	M	9.62	2.755	1.26	1.079	0.001	>2.56
II	L	17.50	5.50	1.57	1.526	L	6.28	3.239	1.33	1.526	0.01	>2.56
III	L	14.08	3.614	0.96	1.187	L	8.92	2.925	0.90	1.187	0.01	>2.56
IV	M	6.92	4.489	0.92	1.156	M	15.46	5.480	0.98	1.156	0.01	>2.56
V	M	11.09	4.889	1.69	1.120	M	20.86	6.760	1.56	1.120	0.001	>2.556

THE EFFECT OF SIDE OF METACARPAL BONE ON THE ANGLE OF TORSION:

From the table Nos.1 & 2 as well as fig. 3a & 3b it is evident that in case of I, II & III metacarpal bones the torsion is more on right side & in case of IV & V metacarpal bones the torsion is more on the left side.

DISCUSSION

Singh (1978) in his work on metacarpal bones has shown that there is rotation of metacarpal bones towards the central axis. The table No.2 shows the comparison of study of metacarpal bones as observed by Singh & in the present study. The present observation appears to be more in keeping with Singh's view regarding side of torsion of metacarpal bones. There is no difference in side of torsion of metacarpal bones observed in present work & the work of I.B. Singh.

THE TORSION IN THE RIGHT METACARPALS

In case of first metacarpal on the right side there is no difference in degree of torsion between present work & the work of I.B. Singh.

In second metacarpal a marked difference is observed in the degree of torsion. The degree of torsion observed by Singh is 17.50 degrees, while in the present work it is 5.50degrees. In the present work the maximum degree of torsion in case of second right metacarpal observed was 10 degrees, which was in one case (case No.1) only. In case of No.8 degree of torsion is 9.5 degrees. But in all the remaining cases it varied between 7.5 to 3 degrees.

In the third metacarpal the degree of torsion observed in present work is much less than in comparison with the observations of Singh. The degree observed by I.B.Singh is 14.08 degrees, while in the present work it is 3.614 degrees.

The fourth metacarpal shows less torsion in the present work (4.489 degrees) than that observed by I.B.Singh (6.92 degrees), though the difference is not very much.

Marked difference in degree of torsion is observed in fifth metacarpal bone again. The degree of torsion observed by I.B.Singh is much higher (11.09 degrees). In the present work it is 4.489degrees. In the present work only one case (case No.22) shows a maximum rotation of 9.5 degrees.

THE TORSION IN THE LEFT METACARPALS

In case of first metacarpal the degree of torsion observed in the present work is less (2.755 degrees) than the degree of torsion observed by I.B.Singh (9.62 degrees).

In the second metacarpal the degree of torsion observed in present work is less (3.289 degrees) than the degree of torsion observed by I.B.Singh (6.28 degrees).

In third metacarpal bone the degree of torsion observed by I.B.Singh is 8.92 degrees which is higher than degree of torsion observed in present work (2.925 degrees).

The fourth & fifth metacarpal bones show marked difference. In

case of fourth metacarpal bone the degree of torsion observed in the present work is much less (5.480 degrees) than the degree of torsion observed by I.B.Singh which is 15.46 degrees. In the fifth metacarpal again the degree of torsion observed by I.B.Singh is much higher (20.86 degrees) than the degree of torsion observed in present work (6.760 degrees). In the present work only one case (case No.22) shows maximum degree of torsion (10.5 degrees).

The parallel position of the digits in contrast to fanning out of metacarpals is attributed to the inclination of heads of metacarpals with the long axis of their shaft in the normal anatomical position.

Shiino (1925) observed inclination of head with respect to the shaft to the medial side in the second metacarpal, towards lateral side in the fourth & fifth metacarpal & no such inclination in third metacarpal. However, in the present study torsion of head in respect to shaft was found to be on lateral side in second metacarpal, towards medial side in fourth & fifth & laterally in third metacarpal, which is in line with the work of Singh (1978).

In the present work all the cases studied were male & belong to "Bundel-Khand" region only. It was assured that only local cases were studied. The bones studied were completely ossified.

Occupation of most of the cases was unskilled labour. As in the present work & the work conducted by I.B.Singh the cases were not classified according to age, sex & profession, a comparison can not be made.

Singh's study is based on the resident of "North-West India" & according to him they belong to Mediterranean stock with some proto-australoid admixture, while the present study is based on the residents of "Bundel-Khand". The variation could be due to racial factor. But no definite opinion can be given unless other factors like profession, age & sex are known.

This variation may be due to many factors, age, sex & occupation of person during life.

SUMMARY & CONCLUSION

In the present study metacarpal bones of one hundred hands (fifty right & fifty left) were studied for determining the angle of torsion

Special Instrument for measuring the angle of torsion was devised which is simpler & cheaper than the instrument described by I.B.Singh.

On study the average angle of torsion of the various metacarpal bones was as below:

S/No.	Right	Left
1	4.956	2.755
2	5.500	3.289
3	3.614	2.925
4	4.489	5.480
5	4.889	6.760

This is in most of the cases much lower than the angle observed by I.B. Singh as is evident from table no. 2. But we can say that a definite torsion is present in metacarpal bones.

There are statistically significant differences in degree of torsion in metacarpal bones of right and left sides. In case of second and third metacarpal bones, the head appears to be rotated laterally relative to the base. The torsion in second and third metacarpal bones is greater in right side (2.56). The head of fourth and fifth metacarpal bones appears to be rotated medially with respect to their bases. The torsion in case of fourth and fifth metacarpals is

greater in left side (z 2.56). The direction of torsion of the head of the first metacarpal bones is towards the lateral sides in right hand and to the medial side in the left hand. In case of first metacarpal bones the degree of torsion is more in right side.

Among the various factors responsible for the shaking of hand to produce an efficient grip, the torsion in metacarpal bones is an important factor. It is well known that digits of hand fan out in hyperextension and tend to be pressed together during flexion. The flexion of digits would be accompanied by much stronger tendency to crowding up the digits, this would interfere with the efficiency of hand in gripping and this is overcome by the torsion of metacarpal bones and the efficiency of hand is increased.

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