International Journal of Orthopaedics Sciences

ISSN: 2395-1958
IJOS 2017; 3(1): 01-04

www.orthopaper.com
Received: 12-11-2016
Accepted: 13-12-2016

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Normative study of paediatric hand in an Indian population and a novel method of measurement of first web space arc radius

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DOI: http://dx.doi.org/10.22271/ortho.2017.v3.i1a.01

Abstract
The aesthetic appearance of the thumb hasn't been analysed to a similar extent as thumb function which would aid during reconstructive surgeries of the thumb and first web space and analyse its outcome. The purpose of this study is to determine the relative length, girth, nail width of thumb with respect to the index finger and intermetacarpal distance. Measurement of the 1st web space arc radius has been done to tackle the problem of webbing which is not addressed by IMD and palmar abduction angles. A total of 482 hands in 241 subjects were studied to measure the relative length of the thumb with respect to the index finger, the relative nail width of thumb with respect to index finger, the relative girth of IP joint of thumb with respect to PIP joint of index finger and Intermetacarpal distance was calculated. The 1st web space arc radius was calculated by the "best arc fit" with the thumb in maximum radial abduction using a radius gauge. The data collected was analysed by age, gender, laterality of the hand and the height and weight of the child. Hands of subjects of which with a mean age of years were analysed. The relative Thumb length, girth and nail width remained independent of age. It has been observed that the reliability of the measurements between the right and left web space arc radius measurement is significant [ICC– p value<0.01]. The provided would help reconstructive surgeons analyse aesthetic outcomes of reconstructive surgeries intraoperatively and post operatively. A correlation between the 1st web space arc radius of right and left hands would help predict the expected post-operative outcome.

Keywords: Paediatric thumb, First web space, thumb reconstruction, webbing, web space contracture

1. Introduction
The study of the aesthetic appearance of the thumb and the 1st web space has been quite infrequent and inconsistent in literature with not many methods available to quantify it after a reconstructive procedure. This is in stark contrast to the wide variety of objective assessment tools available to quantify the functional outcomes, only subjective measures of outcomes have been used by surgeons concerned with reconstructive procedures [1], and we feel that the aesthetic appearance is equally important Adequacy of thumb length is important for thumb function and aesthetics, which all reconstructive procedures aim to achieve. There is one on the relative length of the thumb with respect to the index finger in a paediatric population, such as the study by Goldfarb *et al.* in 2005 [1] in a Caucasian pediatric population and another in Chinese and Caucasian adult population by Sunil [2]. No such study is available in an Indian population. Some authors have described the tip of the adducted thumb reaches the middle of the index finger proximal phalanx and others have described it to be till the proximal interphalangeal joint crease, but no data exists to support the same [3, 5].
The 1st web space contracture is disabling and it reduces the span of the hand. It is a common problem seen in trauma to the hand, burns and intrinsic paralysis. There are many methods described to measure the 1st web space such as conventional goniometer, pollexograph thumb method, pollexograph- metacarpal method, IMD method, AMA method and ASHT method, of which the IMD was found to be most reliable [6, 7]. Webbing of the 1st web space is a problem that is not addressed by measurements of IMD and palmar abduction angles, which we try to tackle by measuring the arc radius of the web space.

The purpose of this study is to provide a measure for the length, girth, nail width in and Indian population and a new technique to measure the 1st web space arc radius. Objective methods of measuring the same can be used during reconstructive procedures for more accurate results and post operatively to judge the surgical outcomes.

2. Materials and methods

A total of 482 hands of 241 subjects were studied to measure the relative length of the adducted thumb against the index finger proximal phalanx and the entire index finger, the relative girth of thumb IP joint to the index finger PIP joint and the relative thumbnail width to index finger nail width, the IMD and the 1st web space arc radius.

Volunteers were chosen from schools and orphanages. All children with thumb and 1st we space deformities (congenital, traumatic or post burns), previous surgeries of the hand, 1st CMC arthritis and systemic abnormality and hyperlaxity syndromes were excluded from the study. All volunteers consented to examination of both hands.

All measurements were done by the same examiner.

2.2 Relative Length of the Thumb

The relative length of the adducted thumb was calculated with respect to the entire index finger and the proximal phalanx of the index finger. To do this we followed the method described by Goldfarb *et al*. [1] (Fig 1)

The hand is placed on a piece of paper with a straight line on it, the longitudinal axis of the index finger was aligned to the to that line.4 points were marked on each hand, 1) The base of the index finger proximal phalanx (by palpation along the radial border) [A] 2) the index finger proximal interphalangeal joint (flexion crease identified bv flexion and extension of PIP joint) [B] 3) the tip of the finger (distal pulp) [C].

The fourth mark was added when the thumb was abducted against the extended index finger. Subjects were instructed to keep the thumb extended. A straight edge was placed against the tip of the thumb perpendicular to the line representing the long axis of the index finger and marked [D].

3. Measurements were performed

1) AB, the length of the proximal phalanx of the index finger;
2) AC, the length of the entire index finger (proximal, middle, distal phalanges); and
3) AD, the position of the adducted thumb on the index finger.

The ratio of the relative length of the thumb with respect to the proximal phalanx and the entire index finger then were calculated: (1) thumb/index proximal phalanx, AD/AB and (2) thumb/entire length of index finger, AD/AC.

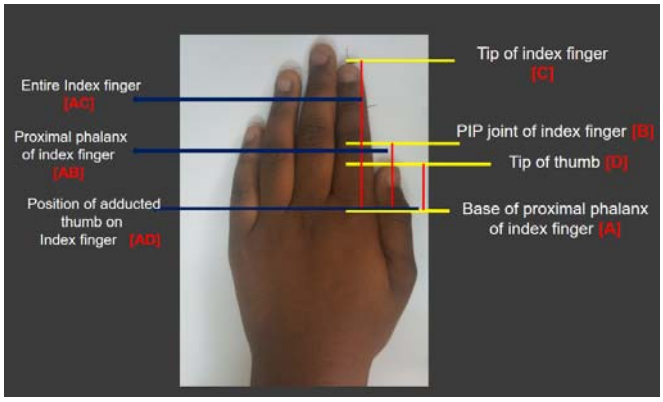

Fig 1: Various measurements recorded with the hand placed on a white paper with a straight line with the longitudinal axis of index finger aligned to that line.

3.1 Relative Girth of the Thumb

A finger circumference gauge is used to measure the thumb IP joint in neutral extension and index finger proximal interphalangeal joint in neutral extension. The ratio of thumb to index finger girth then was calculated [1] (Fig 2).

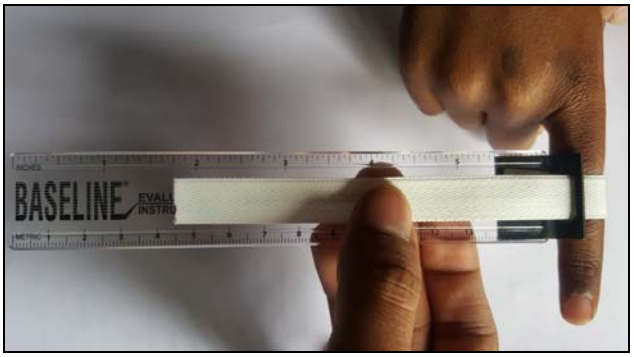

Fig 2: Circumference of PIP joint of the index finger in neutral extension measured with a finger circumference gauge

3.2 Relative Nail Width

The upper jaws of a digital Vernier calliper were used to measure the thumb and index finger nail width at their widest points. The ratio of the thumbnail width to the index nail width was calculated [1]. (Fig 3)

Fig 3: Thumb nail width measured using upper jaws of a Vernier calliper

3.3 IMD

The thumb web space IMD measurement was introduced by Murugkar *et al*. the mid-dorsal points of the first and second metacarpal heads were marked, and 2 calliper points were placed on the markings while the thumb was in maximal passive palmar abduction [3]. (Fig 4)

Fig 4: IMD measured between mid-dorsal points of 1st and 2nd metacarpal heads.

3.4 1st web space arc radius

We define the 1st web space as the arc between the distal palmar crease and thenar crease. This arc was marked a paper in maximal radial abduction and the arc radius measured using a radius gauge for "best arc fit". (Fig 5)

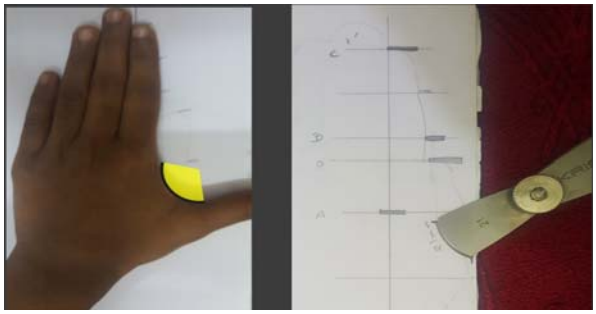

Fig 5: Figure on left showing 1st web space arc being traced from the distal palmar crease to digital crease of thumb. Fig on right showing the arc being measured with radius gauge for "best arc fit "

3.5 Ethical clearance – Yes

Statistics

Descriptive statistics of relative thumb length relative nail width, relative girth, IMD and 1st web space arc radius will be analyzed and presented in terms of mean with SD. Correlation coefficient between age and ratio will be analyzed and its significance tested by "t" test.

4. Results

The mean percentage of the thumb length relative to the proximal phalanx of the index finger in our sample size was 66.4% (SD, 11.2%; range, 35%–90%) and the mean percentage of the thumb length relative to the entire length of the index finger was 33.3% (SD, 3%; range, 25%–57%). The mean percentage of the thumb girth to index girth was 105% (SD, 4.6%; range, 90%–121%) and the mean percentage of the thumbnail width to the index fingernail width was 134% (SD, 7.7%; range, 115%– 157%).

Table 1: Comparative results Descriptive statistics of our study in comparison with study by Goldfarb *et al*.

	Mean		SD		Range	
	Our Results	**Goldfarb *et al.***	**Our Results**	**Goldfarb *et al.***	**Our Results**	**Goldfarb *et al.***
Thumb length relative to proximal phalanx of index finger	66.4 %	70 %	11.2 %	11%	35-90 %	42-95%
Thumb length relative to entire length of index finger	33.3%	32%	3 %	5%	25-57%	16-46%
Thumb girth to index finger girth	105%	105%	4.6%	5%	90-121%	90-133%
Thumbnail width to index fingernail width	134%	133%	7.7 %	12%	115-157%	86-190%

There was no significant correlation between relative thumb length, width, or girth when evaluated against age (age vs AD/AB, *r* –0.04; age vs AD/AC, *r* –0.4; age vs girth, *r* - 0.04; age vs nail width, *r* - 0.69). But there was a weak correlation found in our study between the ratio of thumb length to entire index finger length and the ratio of thumb IP joint girth to index finger PIP joint girth (i.e. AD/AC vs thumb IP joint girth/index finger PIP joint girth – r- 0.006)

The 1st web space arc radius of 482 hands were measured in 241 individuals. The mean 1st web space arc radius was found to be 19.28mm (SD – 5.5; range 7.5-40 mm). There was no statistically significant correlation between the 1st web space arc radius evaluated against age. But We found a statistically significant correlation between the 1st web space arc measurement of the right hand against the left and vice versa (I.e. 1st webspace arc of right hand / left hand, p- <0.001).

5. Discussion

We evaluated 241 children and 482 hands to provide normative data for relative thumb length, nail width, and girth in the paediatric hand. These percentages remained constant throughout from infancy into adulthood and there was no significant difference in these percentages from age 1 through 18 years.

A similar study done in a Caucasian population by Goldfarb *et al.* showed similar results with the relative measurements

being constant through growth.

Our results for relative thumb length, girth and nail width fell into a narrower range as compared to the study by Goldfarb *et al.* (Table 1), which is probably due to the use digital Vernier callipers as instead of a measuring tape.

Our study in addition to these measurements also evaluated the 1st web space with a novel method of measurement of the 1st web space arc. We found that there is a statistically significant correlation between the 1st web space arcs of the right and left hands of the same individual. This would help in reconstructive surgeries of the 1st web space to predict the desired post-operative web space arc. The radius circumference gauge used in this study can also be used perioperatively.

6. References

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