

Measuring lengths of ulna and fibula in living individuals

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This manual contains instructions for measuring the lengths of the long bones *ulna* and *fibula* in living humans. The ulna is located parallel to the radius on the medial side of the forearm, whereas the fibula is located parallel to the tibia on the lateral side of the lower leg.

Reference points are needed for measuring bone lengths. These points have to be located at the respective ends of the long bones. Also, the reference points should meet the following criteria: (1) When measuring in living individuals, reference points should be palpated and measured painlessly. (2) Reference points should be unmistakable. (3) The reference points should be found fast and easily and (4) they should exist in every human who does not suffer from congenital or traumatic deformity of the limbs.

In the following, I will introduce reference points, which meet all of the above criteria.

Reference points of the ulna

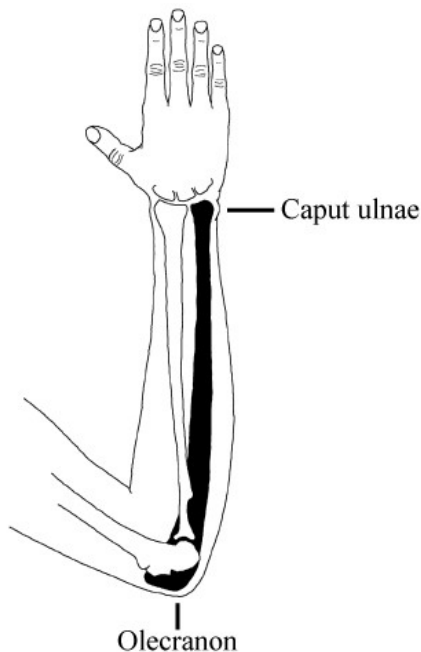


Figure 1. Reference points of the ulna.

Caput ulnae.

The head of the ulna, *caput ulnae*, is the most medial point of the ulna on the side of the little finger (Martin & Knußmann, 1998). It can be seen best when pronating the hand (see Figure 1) and palpated best when making circling movements with the index finger (Martin & Knußmann, 1998). According to Martin and Knußmann (1998), *caput ulnae* is the same reference point as *ulnar styloid process*, which is often used when measuring ulnar length. Ulnar styloid process had been a reference point for measuring ulnar length in studies from Agnihotri, Kachhwaha, Jowaheer, and Singh (2009), Ayeung et al. (2009), Gauld, Kappers, Carlin, and Robertson (2003) and Madden, Tsikoura, and Stott (2012).

Olecranon.

The *olecranon* is the most prominent point of the elbow when the forearm is angled (see Figure 1). Several studies used this point as a reference point for measuring ulnar length (Agnihotri et al., 2009; Ayeung et al., 2009; Gauld et al., 2003, 2004; Madden et al., 2012; Naik, Sujir, Tripathy, Goyal, & Rao, 2013; Pan, 1924; Valk, 1971).

Reference points of the fibula

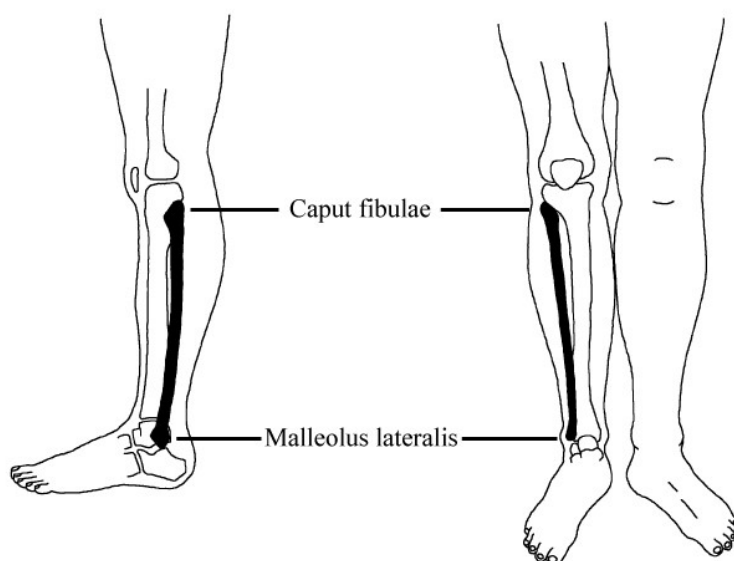


Figure 2. Reference points of the fibula.

Caput fibulae.

The head of the fibula, *caput fibulae*, is the most prominent point of the fibula on the lateral lower leg just beneath the knee (see Figure 2). It can be palpated easily at a knee angle of 90 degrees. Therefore, the investigator palpates the lateral hamstring tendon and follows it towards the knee. It is attached to the caput fibulae, which can be found simply by palpating it this way.

This reference point is often used in research literature (Ahmad, Mohd., Farooque, & Shivkumar, 2014; Auyeung et al., 2009).

Malleolus lateralis.

The *malleolus lateralis* is the outer ankle (see Figure 2). Its most distal point (cf. *Sphyrion fibulare*, Martin & Knußmann, 1998) can be palpated easily with the index finger. There are several studies using this point as a reference point for measuring fibular length (Ahmad et al., 2014; Auyeung et al., 2009; Pan, 1924).

Measuring instruments

A lot of studies used non-flexible measuring tapes for measuring long bone lengths (Ahmad et al., 2014; Naik et al., 2013; Pan, 1924). However, this measurement method is influenced by muscular mass or obesity, which lengthens the measuring distance by bulging the measuring tape. Therefore, I recommend using a sliding caliper (cf. Agnihotri et al., 2009; Gauld et al., 2003, 2004). The reference points presented above can be palpated even if the participant is obese or has a larger muscle size. The use of a sliding caliper is of advantage because it is not biased by the participant's physique.

Valk (1971) and Cassorla et al. (1984) used a self-made apparatus, called Condylgraph. With this apparatus they used another reference point instead of caput ulnae. Their reference point was the gap between the caput ulnae and the triquetral bone.

Measuring ulnar length via ALMA.

To measure the length of the ulna, one can use the *arm-length-measuring-apparatus* (ALMA; Figure 3). Participants put their elbow on the provided wooden plate (Figure 4), which is exactly as high as the lower beak-shaped spout of the sliding caliper. Hence, the measuring starts on the wooden plate with the olecranon as the reference point representing 0.00 cm. The length of the ulna is now adjusted with the upper beak-shaped spout of the sliding caliper showing on the caput ulnae. Therefore, the participant's forearm is positioned vertically on the back wall of the ALMA. The height of the caput ulnae is marked with a dot on a paper, which is fixed on the back wall of the ALMA (Figure 5). It is important, that the investigator's eyes are as high as the caput ulnae to avoid a perspective bias. Afterwards, participants take their arm away from the ALMA and the upper beak-shaped spout is adjusted on the height of the marked point. Thereafter the investigator uses a ruler to lengthen the beak-shaped spout for making a more precise measurement (see Figure 6).

To pronate the hand, the ALMA is turned 45 degrees off. It is turned to the right (counterclockwise) when measuring the right arm and to the left (clockwise) when measuring the left arm.

To approximate an angle of 90 degrees on the elbow, it is best to measure ulnar length when the participant is sitting on a chair with the ALMA standing on a table.

A reliability of $r = .91$ to $r = .99$ ($ns > 31$; $ps < .001$, Bleck, 2016) was obtained when measuring ulnar lengths (left and right side) in 126 participants by three independent raters (each measurement was conducted by two independent raters).



Figure 3. Arm-length-measuring-apparatus (ALMA).



Figure 4. ALMA with participants' forearm.



Figure 5. Marking the reference point caput ulnae on the back wall of the ALMA.

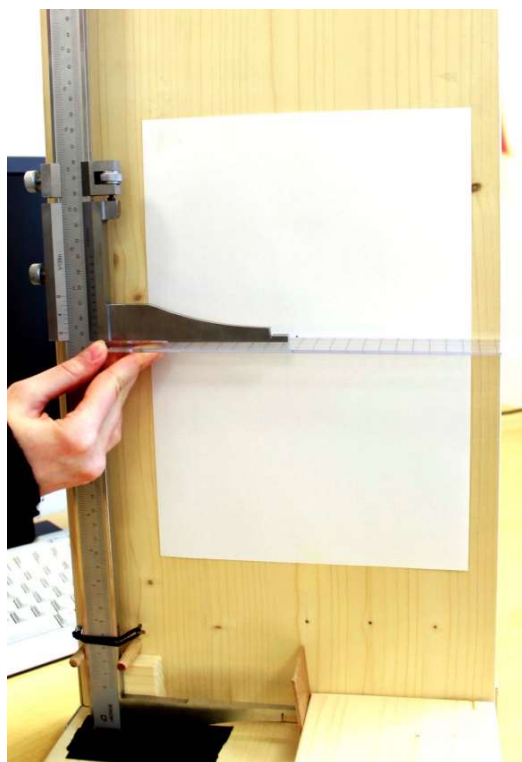


Figure 6. Reading off the ulnar length on the ALMA. A ruler is used to extend the beak-shaped spout.

Measuring fibular length by sliding caliper.

Fibular length is measured best by using a sliding caliper on sitting participants. The knee should be angled at 90 degrees and the lower legs should stand vertical on the ground. One of the beak-shaped spouts is held against the malleolus lateralis while the other beak-shaped spout is shifted on the height of the caput fibulae. Once both beak-shaped spouts meet their reference points, the sliding caliper can be read off. To simplify the sliding calipers adjustment, caput ulnae can be palpated first and the participants can be asked to put their index finger exactly on the palpated place of the caput ulnae.

In a study with 126 participants, where during each measurement two of three independent raters measured the length of the left and right fibula in the way described above, a reliability between $r = .82$ and $r = .95$ was obtained ($ns > 31$; $ps < .001$, Bleck, 2016).

Information on improving the measuring accuracy

I recommend taking off clothing and jewelry to improve measuring accuracy. For measuring the ulnar length in the above mentioned study we asked participants who wore thick sweaters or jackets to put them off or to roll up their sleeves above the elbow (Bleck, 2016). We also asked them to take off jewelry which was attached to the arms. For measuring the length of the fibula we asked participants to take off their shoes and thick socks, so we could palpate the malleolus lateralis in a better way. Because the caput ulna can be palpated even through jeans, we did not ask participants to take off their trousers.

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References

- Agnihotri, A. K., Kachhwaha, S., Jowaheer, V., & Singh, A. P. (2009). Estimating stature from percutaneous length of tibia and ulna in Indo-Mauritian population. *Forensic science international*, *187*, 109.e1-109.e3. doi: 10.1016/j.forsciint.2009.02.010
- Ahmad, N., Mohd., F., Farooque, I., & Shivkumar, B. C. (2014). Estimation of Height from the Long Bones of Lower Limb and Foot Dimensiones in South Indian Population. *Journal of Evidence Based Medicine*, *1*(8), 884–892. doi: 10.18410/jebmh/2014/135
- Auyeung, T. W., Lee, J. S. W., Kwok, T., Leung, J., Leung, P. C., & Woo, J. (2009). Estimation of stature by measuring fibula and ulna bone length in 2443 older adults. *Journal of nutrition, health & aging*, *13*(10), 931–936. doi: 10.1007/s12603-009-0254-z
- Bleck, K. (2016). *Beziehungen zwischen dem impliziten Machtmotiv, Aktivitätsinhibition und der Länge der Ulna und Fibula* (Unpublished Bachelor's Thesis). Friedrich-Alexander-Universität, Erlangen.
- Cassorla, F. G., Skerda, M. C., Valk, I. M., Hung, W., Cutler, G. B., & Loriaux, D. L. (1984). The effects of sex steroids on ulnar growth during adolescence. *The Journal of clinical endocrinology and metabolism*, *58*(4), 717–720. doi: 10.1210/jcem-58-4-717
- Gauld, L. M., Kappers, J., Carlin, J. B., & Robertson, C. F. (2003). Prediction of childhood pulmonary function using ulna length. *American journal of respiratory and critical care medicine*, *168*(7), 804–809. doi: 10.1164/rccm.200303-451OC
- Gauld, L. M., Kappers, J., Carlin, J. B., & Robertson, C. F. (2004). Height prediction from ulna length. *Developmental Medicine & Child Neurology*, *46*(07), 475–480. doi: 10.1017/S0012162204000787
- Madden, A. M., Tsikoura, T., & Stott, D. J. (2012). The estimation of body height from ulna length in healthy adults from different ethnic groups. *Journal of human nutrition and*

dietetics : the official journal of the British Dietetic Association, 25(2), 121–128. doi:

10.1111/j.1365-277X.2011.01217.x

Martin, R., & Knußmann, R. (1998). *Anthropologie: Handbuch der Vergleichenden Biologie des Menschen*. Stuttgart: Fischer. pp 232.

Naik, M. A., Sujir, P., Tripathy, S. K., Goyal, T., & Rao, S. K. (2013). Correlation between the forearm plus little finger length and the femoral length. *Journal of orthopaedic surgery*, 21(2), 163–166. doi: 10.1177/230949901302100209

Pan, N. (1924). Length of Long Bones and their Proportion to Body Height in Hindus. *Journal of anatomy*, 58(4), 374–378.

Valk, I. M. (1971). Accurate measurement of the length of the ulna and its application in growth measurement. *Growth*, 35(4), 297–310.