J Orthop Spine Trauma. 2020 March; 6(1): 9-13. DOI: http://dx.doi.org/10.18502/jost.v6i1.4535

Educational Corner

Metacarpal Fractures: Practical Methods for Measurement of Shortening, Angulation, and Malrotation

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Received: 09 October 2019; **Revised:** 15 December 2019; **Accepted:** 17 January 2020

Keywords: Metacarpus; Fractures, Bone; Hand Deformities, Acquired

Citation: Khajeh R, Enayati B, Vosughi F, Mortazavi SMJ. **Metacarpal Fractures: Practical Methods for Measurement of Shortening, Angulation, and Malrotation.** *J Orthop Spine Trauma* 2020; 6(1): 9-13.

Background

Phalangeal, distal radius, and metacarpal fractures are the most frequent upper limb fractures, respectively (1). The incidence of metacarpal fractures in the United States of America (USA) is 13.6 among every 100000 population annually (2). Metacarpal fractures compose 30-40 percent of all hand fractures (3).

Metacarpal fractures most commonly are seen in males during 10-30 years of age, mainly after low-energy trauma like a fall from a low height or contact to hard objects such as a wall and involves predominantly the neck zone of the 5th metacarpus (2). Fifth metacarpal base fractures ("reverse Bennett" or "baby Bennett" fractures) are the most common metacarpal base fractures (4).

The treatment goals for metacarpal fractures are acceptable alignment, stable reduction, sufficient bony union, and normal range of motion (ROM).

Indications for surgical treatment are based on the degree of fracture angulation, rotational alignment, and shortening. The aim of this review article is to review the main concept of metacarpal fracture and show the practical methods to measure metacarpal shortening, angulation, and malrotation after fractures.

History and Physical Examinations

History taking should be focused on mechanism of trauma, identifying the most painful site and finally, the patient's comorbidities. Axial loading, torsion, and a direct blow may lead to transverse, oblique, and comminuted metacarpal shaft fractures, respectively (5).

Physical examination should include estimating the severity of swelling and soft tissue injuries, searching for maximal point tenderness, any bony deformity or wound, digit shortening, loss of knuckle, overlap or underlap of fingers, distal neurovascular evaluation, and determining the active and passive ROM of wrist and fingers.

Imaging

True anteroposterior (AP), oblique, and lateral views are needed to assess hand fractures, especially fracture geometry, comminution, angulation, and shortening. Degree of fracture angulation, rotational alignment, and shortening analyzed by plain radiographs or examination are paramount to decide the correct management of different metacarpal fractures.

Articular fractures involving less than 20% of the joint surface and nondisplaced or minimally displaced shaft fractures, without significant angulation, malrotation, or shortening are treated with immobilization in the intrinsic plus position (6). Bony apposition of at least 50% and maximal bone shortening of 5 mm is acceptable. 25% articular surface involvement or more and 1 mm step-off is assumed unacceptable. Also, displaced oblique or spiral metacarpal fractures with malrotation, displaced fractures of the metacarpal base with carpometacarpal (CMC) joint subluxation, digital malrotation, metacarpal shortening > 5 mm, multiple metacarpal fractures and displaced Bennett , and Rolando or reverse Bennett fractures are regarded as unstable and require reduction and bony fixation (7, 8).

Metacarpal Malrotation

Importance: Malrotation and angular deformity following first metacarpal fractures are unaesthetic but rarely cause dysfunction due to the compensatory motion of the first CMC joint. Up to 30 degrees of lateral angulation is accepted for extra-articular fractures (9). Small "5" degrees of rotation in 2nd-5th metacarpals lead to a 1.5-cm finger overlap that causes cosmetic and functional problems (5).

Assessment: Malrotation is not captured by radiographs. Thus, the patient is asked to flex and extend the fingers while the alignment of the nail plates is observed. Malrotation may be subtle, so comparing the fingers on the both side is helpful. If the patient cannot perform active finger flexion, passive wrist extension and flexion (the tenodesis effect) will be done to observe the digital cascade (5, 10). Malrotation leads to dysfunction because the deformity is magnified distally, and usually results from an unstable spiral or oblique fracture (10). Axial deformity is obvious, but malrotation needs exact examination of finger movement from extension to full flexion. 10 degrees of malrotation at the metacarpal bone result in 2-cm overlap or underlap at fingertip (Figures 1 and 2) (11).

Management: Correction of malrotation can be gained with an osteotomy at the previous fracture site or at the metaphysis. Osteotomy near the metacarpal base is good to treat malrotation (12) but the transverse metacarpal ligament is the main limiting factor (18 degrees in the 2nd, 3rd, and4th and 30 degrees in the 5th metacarpal bones are the upper limits) (13).


Figure 1. Overlap of the 4th digit on the 3rd finger suggests a possible 4th metacarpal malrotation

Metacarpal Shortening

Importance: Metacarpal shortening is unaesthetic due to loss of the knuckle made by the metacarpal head and is dysfunctional. Each 2 mm of metacarpal shortening leads to 7 degrees of extension lag. The patient may hyperextend the metacarpophalangeal (MCP) joint (up to 20 degrees) to compensate for the extension lag. Therefore, metacarpal shortening of more than 6 mm cannot be compensated by this mechanism and needs to be managed with open reduction and internal fixation (ORIF) (8).


Figure 2. Second digit positioning under the 3rd finger is a clinical clue for a possible 2nd metacarpal malrotation

Assessment

Method 1-Clinical Signs: The metacarpal shortening can be suspected in the presence of any prominence in the dorsum of the hand or distal portion of palm. Also, loss of digital knuckle is another clue suggesting this diagnosis.

Method 2-Archibald's Sign (Metacarpal Sign): Archibald's sign is shortening of metacarpal bones. When a line is drawn tangential to the distal aspects of the 4th and 5th metacarpal heads, the extension of this line normally passes distally to the 3rd metacarpal head and does not intersect the 3rd metacarpus (negative metacarpal sign). Borderline metacarpal sign is present when such a line intersects the 3rd metacarpal head. Positive metacarpal sign relates to situations during which the line intersects the distal end of the 3rd metacarpal (Figure 3) (14).


Figure 3. Positive metacarpal sign

Positive metacarpal sign is seen in fractures of the 3rd, 4th, and 5th metacarpals with shortening that amount of shortening is described in method 5. Metacarpal sign is also seen in Turner syndrome (TS), Albright's hereditary osteodystrophy (AHO), pseudo-hypoparathyroidism (PHP), basal cell nevus syndrome (BCNS), sickle cell anemia (SCA), hereditary multiple exostosis (HME), idiopathic primary hypoparathyroidism, and homocystinuria (15-18). An isolated short fifth metacarpal may be also idiopathic (19) or associated with familial variant of type 1 diabetes mellitus (DM) (14, 20, 21). Bone shortening is increased from distal phalanges to metacarpals in TS, differentiating TS from normal individuals (22).

Method 3-Relationship between Volar Angulation and Metacarpal Shortening: Mean capital-axis angles (CAA) are 14° and 12° in the 4th and 5th metacarpals, respectively. Mean apex dorsal shaft-bending angle (SBA) are 12° and 10° in the 4th and 5th metacarpals, respectively. On the posteroanterior (PA) view, the shafts are straight. CAA is less acute and the metacarpal volar angulation is less prominent on the lateral view. Much of the metacarpal apex dorsal bend is within the shaft. 5th metacarpal is 6 mm shorter than the 4th metacarpal. Significant difference between the diameters of the 4th and 5th metacarpals is not present in their proximal and distal thirds (23). The AP view shows a better view of the 5th metacarpal than PA view; thus, AP view is the preferred view (due to the volar curve of the metacarpals). There is a linear association between volar angulation and shortening in the metacarpal fractures (each 2.4° of volar angulation indicates 1 mm of metacarpal shortening) (24).

Method 4-Shortening Absolute Value (SH-Abs) (Side Difference): The length of the metacarpal is measured on the AP view as the distance between the most proximal and distal point of the midline longitudinal axis on the metacarpus. This length is subtracted from the length of the corresponding metacarpus on the contralateral side to estimate the level of shortening. The SH-Abs is the most valid method for measuring the metacarpal shortening (25).

Method 5-Shortening Stipulated (SH-Stip): In the AP view, a line is drawn through the most distal point of the 3rd and 4th metacarpal heads. The distance from this line to the most distal point of the fractured 5th metacarpal is the amount of shortening (Figure 4). SH-Stip is a reliable option and is simpler than the SH-Abs method for shortening measurement in the 5th metacarpal fractures when 1 mm is subtracted from the measured shortening (25) and also in 3rd and 4th metacarpal fractures.

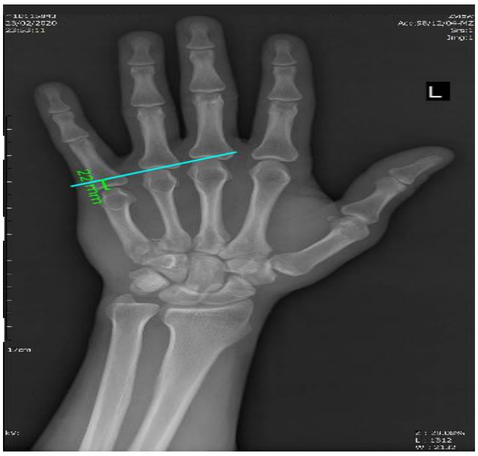

Figure 4. Shortening stipulated (SH-Stip) method for measuring 5th metacarpal shortening

Method 6-Proportional Method (Proportion of Hand Segments between the Corresponding Fingers of the Right and Left Hands): The interarticular distance is measured as the distance between the midpoint of the base and head of all the metacarpals and phalanges (proximal, middle, and distal) by electronic calipers (26). The phalangeal width, the cortical width, the hand breadth, the thickness, and the circumference are usually different markedly between the right and the left hands. Thus, the lengths of the phalanges and metacarpals and the ratio of phalangeal and metacarpal bones are different slightly between the corresponding fingers of the left and the right hands. The difference is mostly much less than 0.5%. The normal ratio of the phalanges and metacarpals is very helpful in reconstruction of hand, especially correction of bony defects of metacarpals and phalanges in the cases of tumor or trauma. Length of first, second, third, fourth, and fifth metacarpal bones is 46.22 ± 3.94 mm, 68.12 ± 6.27 mm, 64.60 ± 5.38 mm, 58.00 ± 5.06 mm, and 53.69 ± 4.36 mm, respectively. The incremental dimensions of first, second, third, fourth, and fifth metacarpal bones relative to corresponding distal phalanx are shown as ratios: 2.1, 4.3, 3.7, 3.4, and 3.4, respectively (27).

Metacarpal Angulation

Importance: Angular malunion occurs more frequently in transverse metacarpal fractures and is mostly apex-dorsal in the sagittal plane. The maximal acceptable sagittal angulation in the 2nd to 5th metacarpus is 10, 10, 20, and 30 degrees, respectively. As the 4th and 5th CMC joints are more mobile, more angular deformity can be tolerated in 4th and 5th metacarpus. Marked angular malunion is an indication for an opening or closing wedge osteotomy. A closing wedge osteotomy is technically simpler and does not lead to marked shortening (28).

35-60 degrees of angular malunion of fifth metacarpal neck fractures have unaesthetic appearance that results in unhappiness of all patients and mostly complaining of grip discomfort because of the palmar prominence of the metacarpal head. The standard PA and 45 degrees oblique views of these fractures do not show an accurate volar angulation. A true lateral view of the fifth metacarpal is needed with a cupped-palm view without overlap of the other metacarpals (Figure 5). In this view, the palms of the hands are placed together. Then the ulnar borders of the palms and the little fingers are kept in close contact while the palms are cupped with all finger tips remaining in contact. This results in flexion of 4th and 5th CMC joints bringing them forwards, clear of the other metacarpals while still maintaining the true lateral view. combination of volar and radial angulation at the malunion site is common that should be considered during correction and osteotomy (29).

Figure 5. The cupped-palm view for measuring angular deformity of the 5th metacarpal fracture

Assessment: The lateral view, preferably standardized with a position device, should be taken to improve the validity of the assessment of volar angulation at the fracture site. To avoid the metacarpal overlap in the lateral view, medullary canal-oblique (MC-30) method can be used. If MC-30 method is used, the volar angulation in the fracture is 10° over-estimated. MC-lateral (MC-90) method is the preferred method to measure volar angulation, because it has significant inter-observer and intra-observer reliability and validity (accuracy), with a maximum of 5° difference in mean volar angulation measured by observers. Mean volar angulation of 15° is considered in the metacarpal neck when MC-90 method is used. In medullary method (MC-90, Figure 6), the distal line is drawn from the center of MC in the neck fracture to the most distal and central point of the metacarpal head, and the proximal line is drawn from the center of the MC in the shaft, irrespective of where the line exits from the metacarpal base.

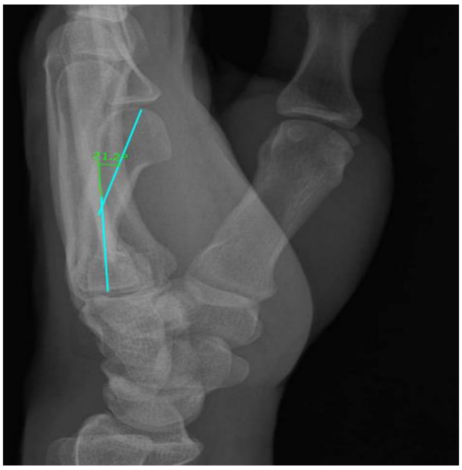

Figure 6. Medullary canal-90 degrees lateral view (MC-90) method for measuring the angular metacarpal deformity

In dorsal cortex (DC) method [DC-lateral (DC-90), Figure 7], the lines are drawn at the most dorsal aspects of the metacarpal cortices, independently of the small tuberosities where the collateral ligaments are attached. The most valid method is MC-90 (24, 25, 26).

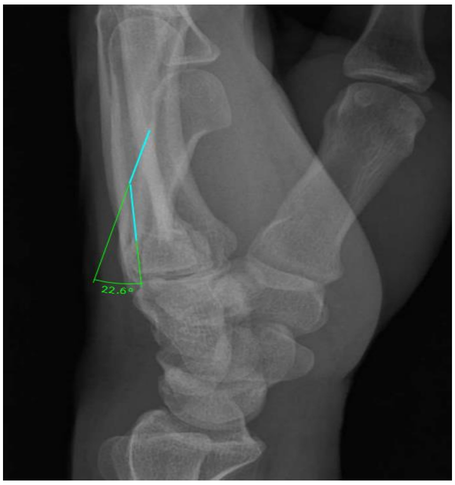

Figure 7. Dorsal cortex-90 degrees lateral view (DC-90) method for measuring the angulation of metacarpal fractures

Conclusion

Metacarpal bones are one of the most frequent sites for upper limb fractures. Careful history and physical examination helps diagnose and manage this entity. Knowing the correct way for estimating metacarpal shortening, malrotation, and angulation is necessary to decide the best management for metacarpal fractures.

Conflict of Interest

The authors declare no conflict of interest in this study.

Acknowledgments

None.

References

1. Karl JW, Olson PR, Rosenwasser MP. The epidemiology of upper extremity fractures in the United States, 2009. *J Orthop Trauma*. 2015;29(8):e242-e244. doi: 10.1097/BOT.0000000000000312. [PubMed: 25714441].
2. Nakashian MN, Pointer L, Owens BD, Wolf JM. Incidence of metacarpal fractures in the US population. *Hand (N Y)*. 2012;7(4):426-30. doi: 10.1007/s11552-012-9442-0. [PubMed: 24294164]. [PubMed Central: PMC3508027].
3. Ashkenaze DM, Ruby LK. Metacarpal fractures and dislocations. *Orthop Clin North Am*. 1992;23(1):19-33. [PubMed: 1729666].
4. Lilling M, Weinberg H. The mechanism of dorsal fracture dislocation of the fifth carpometacarpal joint. *J Hand Surg Am*. 1979;4(4):340-2. doi: 10.1016/s0363-5023(79)80070-2. [PubMed: 469209].
5. Diaz-Garcia R, Waljee JF. Current management of metacarpal fractures. *Hand Clin*. 2013;29(4):507-18. doi: 10.1016/j.hcl.2013.09.004. [PubMed: 24209950].
6. McNemar TB, Howell JW, Chang E. Management of metacarpal fractures. *J Hand Ther*. 2003;16(2):143-51. doi: 10.1016/s0894-1130(03)80009-1. [PubMed: 12755165].
7. Meunier MJ, Hentzen E, Ryan M, Shin AY, Lieber RL. Predicted effects of metacarpal shortening on interosseous muscle function. *J Hand Surg Am*. 2004;29(4):689-93. doi: 10.1016/j.jhsa.2004.03.002. [PubMed: 15249095].
8. Strauch RJ, Rosenwasser MP, Lunt JG. Metacarpal shaft fractures: The effect of shortening on the extensor tendon mechanism. *J Hand Surg Am*. 1998;23(3):519-23. doi: 10.1016/S0363-5023(05)80471-X. [PubMed: 9620194].
9. Buchler U, McCollam SM, Oppikofer C. Comminuted fractures of the basilar joint of the thumb: combined treatment by external fixation, limited internal fixation, and bone grafting. *J Hand Surg Am*. 1991;16(3):556-60. doi: 10.1016/0363-5023(91)90032-7. [PubMed: 1861044].
10. Jupiter J, Axelrod T, Belsky MC. Fractures and dislocations of the hand, metacarpal fractures. In: Browner BD, Editor. Skeletal trauma: Basic science, management, and reconstruction. Philadelphia, PA: Saunders; 2003.
11. Adkinson JM. Fractures of the Hand and Carpus: FESSH 2018 Instructional Course Book. *Plastic and Reconstructive Surgery*. 2019;144(6):1512.
12. Weckesser EC. Rotational osteotomy of the metacarpal for overlapping fingers. *J Bone Joint Surg Am*. 1965;47:751-6. [PubMed: 14301787].
13. Gross MS, Gelberman RH. Metacarpal rotational osteotomy. *J Hand Surg Am*. 1985;10(1):105-8. doi: 10.1016/s0363-5023(85)80259-8. [PubMed: 3968389].
14. Archibald RM, Finby N, De Vito F. Endocrine significance of short metacarpals. *J Clin Endocrinol Metab*. 1959;19:1312-22. doi: 10.1210/jcem-19-10-1312. [PubMed: 13794090].
15. Isozaki O, Sato K, Tsushima T, Shizume K, Takamatsu J. A patient of short stature with idiopathic hypoparathyroidism round face and metacarpal signs. *Endocrinol Jpn*. 1984;31(3):363-7. doi: 10.1507/endocrj1954.31.363. [PubMed: 6094168].
16. Tzaveas A, Paraskevas G, Gekas C, Vrettakos A, Antoniou K, Spyridakis I. Anatomical variation of co-existence of 4th and 5th short metacarpal bones, sesamoid ossicles and exostoses of ulna and radius in the same hand: A case report. *Cases J*. 2008;1(1):281. doi: 10.1186/1757-1626-1-281. [PubMed: 18959780]. [PubMed Central: PMC2586011].
17. Valizadeh N, Mehdizadeh A, Nazarbaghi S. Short fourth and fifth metacarpals in a case of idiopathic primary hypoparathyroidism. *Indian J Endocrinol Metab*. 2013;17(5):924-6. doi: 10.4103/2230-8210.117221. [PubMed: 24083181]. [PubMed Central: PMC3784883].
18. Bloom RA. The metacarpal sign. *Br J Radiol*. 1970;43(506):133-5. doi: 10.1259/0007-1285-43-506-133. [PubMed: 5424279].
19. Verma S, Phadke K, Mohindra M, Gogna P, Jain J. Wide Spectrum of Metacarpal Sign: Three Cases of Metacarpal Sign and Its Variants. *International Journal of Recent Surgical and Medical Sciences*. 2017;3(1):53-5. doi: 10.5005/jp-journals-10053-0038.
20. Deshmukh V. Images in endocrinology: Archibald's metacarpal sign. *Indian J Endocrinol Metab*. 2012;16(3):487-8. doi: 10.4103/2230-8210.95760. [PubMed: 22629539]. [PubMed Central: PMC3354880].
21. Patel VK, Davies HA. Insulin resistance Type A and short 5th metacarpals. *Diabet Med*. 2003;20(6):500-4. doi: 10.1046/j.1464-5491.2003.00982.x. [PubMed: 12786688].
22. Laurencikas E, Savendahl L, Jorulf H. Metacarpophalangeal pattern profile analysis: Useful diagnostic tool for differentiating between dyschondrosteosis, Turner syndrome, and hypochondroplasia. *Acta Radiol*. 2006;47(5):518-24. doi: 10.1080/02841850600635939. [PubMed: 16796318].
23. Rivlin M, Kim N, Lutsky KF, Beredjiklian PK. Measurement of the radiographic anatomy of the small and ring metacarpals using computerized tomographic scans. *Hand (N Y)*. 2015;10(4):756-61. doi: 10.1007/s11552-015-9766-7. [PubMed: 26568736]. [PubMed Central: PMC4641089].

24. Sletten IN, Nordsletten L, Hjorthaug GA, Hellund JC, Holme I, Kvernmo HD. Assessment of volar angulation and shortening in 5th metacarpal neck fractures: an inter-and intra-observer validity and reliability study. *J Hand Surg Eur Vol*. 2013;38(6):658-66. doi: 10.1177/1753193412461582. [PubMed: 23060463].
25. Lamraski G, Monsaert A, De Maeseneer M, Haentjens P. Reliability and validity of plain radiographs to assess angulation of small finger metacarpal neck fractures: Human cadaveric study. *J Orthop Res*. 2006;24(1):37-45. doi: 10.1002/jor.20025. [PubMed: 16419967].
26. Alicioglu B., Yilmaz A, Karakas HM, Cigali BS, Cikmaz S, Ulucam E. Sex determination by the interarticular distance of metacarpals and phalanges: A digital radiologic study in contemporary Turkish people. *Journal of Experimental and Clinical Anatomy*. 2009;3(1):14-20. doi: 10.2399/ANA.08.027.
27. Buryanov A, Kotiuk V. Proportions of hand segments. *Int J Morphol*. 2010;28(3):755-8.
28. Green DP. Complications of phalangeal and metacarpal fractures. *Hand Clin*. 1986;2(2):307-28. [PubMed: 3700489].
29. Thurston AJ. Pivot osteotomy for the correction of malunion of metacarpal neck fractures. *J Hand Surg Br*. 1992;17(5):580-2. doi: 10.1016/s0266-7681(05)80247-5. [PubMed: 1479255].