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"Review of contemporary non-surgical management techniques for metacarpal fractures: Anatomy and rehabilitation strategies"

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ABSTRACT

This comprehensive study explores the various aspects of metacarpal fractures, a prevalent condition in hand injuries. We delve into the anatomy of the metacarpals, elucidating how their structural characteristics influence fracture mechanics and treatment options. Special attention is given to the diverse types of fractures, particularly the differing tolerances for angular, shortening, and rotational deformities. The manuscript extensively reviews conservative treatment approaches, emphasizing the efficacy of non-surgical methods like modified braces and active mobilization techniques. Additionally, we provide a nuanced understanding of specific fracture types, such as neck fractures, highlighting their unique healing dynamics. This research offers valuable insights for orthopedic and plastic surgery practitioners, advancing the understanding and management of metacarpal fractures.

1. Introduction

Metacarpal fractures are relatively common, accounting for 18–44% of all hand fractures. Fractures in the fifth ray are the most frequent, constituting 20% of metacarpal fractures. Predominantly affecting males, who represent 85% of patients, these fractures have an average occurrence age of 31.5 years. Metacarpal fractures can occur at the base, shaft, neck, or head, and present in various forms: transverse, long oblique, short oblique, spiral, and comminuted [2,4,6,9,13,20]. The fracture geometry can lead to different deformities, including angular, shortened, or rotational. These deformities are primarily influenced by the deep flexor tendons and intrinsic muscles, particularly the interossei.

2. Anatomy of the metacarpals

The metacarpals of the long fingers form two transverse arches: a proximal and a distal one. The proximal arch is formed by the carpometacarpal (CMC) joints, stabilized by robust ligaments. These joints, especially the CMC of the second and third metacarpals, have limited mobility. The distal arch comprises the metacarpal heads articulating with the bases of the first phalanges, forming the more mobile metacarpophalangeal (MCP) joints, adaptable for grasping [1,19]. The MCPs are interconnected by the deep, flexible transverse intermetacarpal ligament, crucial in some metacarpal fracture treatments. The metacarpal bone structure, narrowing from the base to the shaft, suggests "form generates function". The metacarpal shaft has three longitudinal surfaces: volar-radial and volar-ulnar for the origin of dorsal and volar interossei muscles, and a flat surface for extensor tendons. Metacarpals exhibit a volar concavity and dorsal convexity; the volar concavity accommodates lumbrical muscles and flexor tendons, and is mechanically resistant to compression, while the dorsal convexity or shaft arc is resistant to tension. The shaft's shape and bone density imply compressive forces are borne on the volar side, and tensile forces on the dorsal, generated by the extensor digitorum communis tendons dorsally and by the lumbricals, interossei, and flexor tendons volarly.

3. Conservative treatment

Metacarpal fractures can be treated non-surgically or surgically, with the former often preferred to avoid complications such as localized edema and subsequent stiffness. Most single metacarpal fractures are closed, simple, or slightly displaced, and stable, making them suitable for conservative treatment with reduced orthoses and controlled active mobilization. Feehan [4] proposed two zones for treatment approach: white (stable fractures suitable for uncontrolled mobilization, like transverse fractures) and gray (tending to displace fractures like oblique, spiral, and comminuted, requiring controlled mobilization). For conservative treatment of all metacarpal fractures, immobilization of joints proximal and distal to the fracture site and early controlled active mobilization is recommended, despite some differing views [3,7,8,11,17,18]. A crucial aspect of our treatment strategy is flexion of the MCP joints. A study by Tavassoli [16]compared three immobilization techniques, concluding no significant differences in outcomes between flexion and extension immobilization. We choose flexion for several reasons: it reduces extension stiffness risk, narrows the joint space limiting edema infiltration, and reduces intrinsic muscles' action, potential fracture displacement drivers. Our approach utilizes a minimally invasive plastic thermomoldable orthosis, the modified Brace, which includes the CMC (proximal) and flexed MCP joints (>70° as distal joints), allowing movement of the radiocarpal and interphalangeal (IP) joints. Usually, the affected and adjacent fingers are immobilized, with adjustments based on fracture location or potential extension stiffness.

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4. Base fractures

Base fractures are classified as either articular or extra-articular. The fourth and fifth rays are most commonly involved in articular fractures due to the higher mobility of their carpometacarpal (CMC) joints. These fractures usually result from significant axial loads. On the fifth metacarpal, the load causing the fracture, combined with the action of the Extensor Carpi Ulnaris (ECU) and Flexor Carpi Ulnaris (FCU), can lead to a displacement known as a “reverse Bennett” fracture. These fractures are typically treated with a radial or ulnar orthosis that maintains the wrist in a neutral position, the MCP joints flexed at 70°, and the interphalangeal (IP) joints free. The immobilization is usually maintained for 3–4 weeks [5,14]. Surgery is indicated for severe displacement or instability, particularly when involving the carpometacarpal joint.

5. Shaft fractures

Shaft fractures are divided into transverse and oblique types. Transverse fractures can result from axial loads along the metacarpal or direct trauma to the back of the hand. They tend to displace dorsally under the action of the volar interossei muscles. Treatment involves applying a modified Brace with MCP joints flexed at 70°/90° and active mobilization of the IP joints, continuously worn for 3–4 weeks [2,4,20]. Oblique fractures, often caused by torsional trauma, are prone to shortening and rotation, potentially leading to significant digital overlap. The bilateral action of the intermetacarpal ligament reduces shortening in the third and fourth metacarpals. Conservative treatment includes a modified Brace with flexed MCPs at 70°/90°, free IP and radiocarpal joints, and syndactyly between the affected and adjacent fingers to control malrotation. Immobilization varies between 3 and 6 weeks [1,6]. Surgical intervention is considered for cases with substantial shortening, rotational deformities, or when multiple fractures are displaced.

6. Neck fractures

Neck fractures are the most common hand fractures, often involving the fourth and fifth metacarpals and known as "Boxer’s fractures” [10,11]. They typically occur in young individuals, not necessarily boxers, who hit a hard surface with a clenched fist, transferring force to the metacarpal neck. Jhass’s maneuver is used for fracture reduction when angular displacements exceed those described in literature. Excessive neck displacement can lead to pseudo clawing, limited MCP flexion, metacarpal head depression, and palm tenderness during grasping due to excessive anterior rotation of the head. Immobilization is a recommended treatment for neck fractures despite literature indicating satisfactory results even without it. A 2005 Cochrane review by Poolman [12] examined five studies on non-surgical treatment of closed neck fractures of the fifth metacarpal, concluding there’s no significant difference between cast immobilization, orthosis, or simple taping. Our treatment involves a modified Brace orthosis immobilizing the affected metacarpal and adjacent one. The MCP joints are fully flexed, and the IP joints are free. The CMC joints are included in the orthosis while the radiocarpal remains free. Syndactyly between the affected and adjacent fingers controls malrotation. The MCP flexion creates a “shelf” effect using the base of the first phalanx to support the metacarpal head. These fractures heal quickly, with immobilization varying from 3 to 4 weeks [15]. Surgery is generally reserved for fractures with extreme angulation or displacement that impairs function.

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