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Surgical Technique

Screw and Suspension Fixation for Bennett Fractures

David J. Graham, MBBS, B.Phty(hons), [*,†,‡] Anna Watson, B.Phty, MBBS, [*,§] Fraser Taylor, MBChB, [†] Brahman Sivakumar, MBBS, MS [*,‖,¶]

[*] Australian Research Collaboration on Hands, Mudgeeraba, Queensland, Australia
[†] Department of Musculoskeletal Services, Gold Coast University Hospital, Southport Queensland, Australia
[‡] Griffith University School of Medicine and Dentistry, Southport Queensland, Australia
[§] Department of Orthopaedic Surgery, Northern Beaches Hospital, Frenchs Forrest, New South Wales, Australia
[‖] Department of Hand and Peripheral Nerve Surgery, Royal North Shore Hospital, New South Wales, Australia
[¶] Department of Surgery, Faculty of Medicine, The University of Sydney, Camperdown, New South Wales, Australia

A R T I C L E I N F O

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Bennett fractures are inherently unstable partial articular fractures of the base of the first metacarpal, often resulting from an axial load applied to a partially flexed metacarpal. Multiple options are available for the surgical stabilization of Bennett fractures; each option has associated drawbacks. We present a technique of fixation with headless compression screw(s), combined with suspension fixation, to overcome some of these limitations, with good results.

A Bennett fracture is the eponymous name for a partial articular fracture involving the base of the thumb, often associated with subluxation or dislocation of the first carpometacarpal joint. Bennett fractures are the most common fractures of the thumb base, and can result in significant functional impairment when not appropriately managed.[1] These fractures typically result from an axial load to a partially flexed metacarpal and are inherently unstable, with poor outcomes associated with nonsurgical management. Griffiths[2] reported that more than half of his series of 44 Bennett fractures treated with closed reduction and cast immobilization went on to displace. Gedda[3] demonstrated diminished radiographic displacement, improved functional capacity, and reduced long-term arthritis in fractures managed via operative stabilization compared with those treated with closed reduction and cast immobilization. A range of treatment modalities have been described for the stabilization of Bennett fractures, including closed reduction with percutaneous K-wire pinning, open reduction and K-wire pinning, open reduction with internal fixation, external fixation, tension band wiring and arthroscopic-assisted reduction.[4] Here, we describe an approach of augmenting fixation of these fractures with a minimally invasive internal brace to facilitate early motion and report short- and medium-term satisfactory outcomes.

Surgical Anatomy

The first carpometacarpal joint is a biconcaveoconvex saddle joint, allowing for a wide range of motion to permit hand function. The bony architecture provides little intrinsic stability, which is instead conferred via static (ligamentous) and dynamic (muscular) supports.[5]

The Bennett fracture is an intra-articular 2-part fracture of the first metacarpal base. Despite an occasionally innocuous radiographic appearance, Bennett fractures are inherently unstable. The proximal volar-ulnar fragment remains in situ because of the attachment to the volar oblique (beak) ligament and continues to articulate with the trapezium. The radial articular fragment and the remaining first metacarpal shaft classically displace dorsally and radially due to the deforming forces applied. Brown and Rust[6] described these as the abductor pollicis longus (APL) proximally imparting a radial force; the adductor pollicis resulting in first metacarpal adduction; and the extensor pollicis longus leading to

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Corresponding author: David J. Graham, MBBS, B.Phty(hons), Australian Research Collaboration on Hands, 4/75 Railway St, Mudgeeraba, QLD 4213, Australia.

E-mail address: drgraham@mudgeerabahand.com.au (D.J. Graham).

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dorsal translation. Cooney[7] demonstrated in a cadaveric biomechanical model that most of the force during pinch is transmitted in a proximal and dorsoradial fashion.

Indications/Contraindications

A combination of headless compression screw fixation and suspensory augmentation can be utilized for Bennett fractures. In addition, isolated suspensory fixation may be useful in first carpometacarpal (CMC) joint dislocations. In the setting of Bennett fractures where screw fixation is not possible due to a small volar-ulnar fragment, or in the management of isolated first CMC joint dislocation, we screen the stability of the reduction under fluoroscopy after suspension, and augment the construct via the insertion of a single K-wire from the first metacarpal to the trapezium if needed.

Care should be taken to exclude a more complex Rolando fracture pattern, whereby the radial articular epiphysis is separate from the metaphysis of the first metacarpal. Preoperative imaging with computed tomography is recommended if the fracture pattern cannot be clearly appreciated on plain radiographs.

Pearls and Pitfalls

Ideally, surgery should be performed with minimal delay to increase the likelihood of achieving a satisfactory closed reduction. As time passes, callus formation may prevent closed reduction and necessitate open debridement to achieve satisfactory reduction of the fracture. Patients should be counseled that if satisfactory closed reduction cannot be achieved, open reduction via an alternative or more extensile approach may be required. A preoperative computed tomography scan can help plan the correct trajectory of the screw to capture the fragment.

Surgical Technique

The patient is positioned supine on a radiolucent arm table with an above-elbow tourniquet. A closed reduction of Bennett fracture is initially attempted under fluoroscopic guidance, using a combination of longitudinal traction, metacarpal extension, pronation, and abduction (Fig. 1).

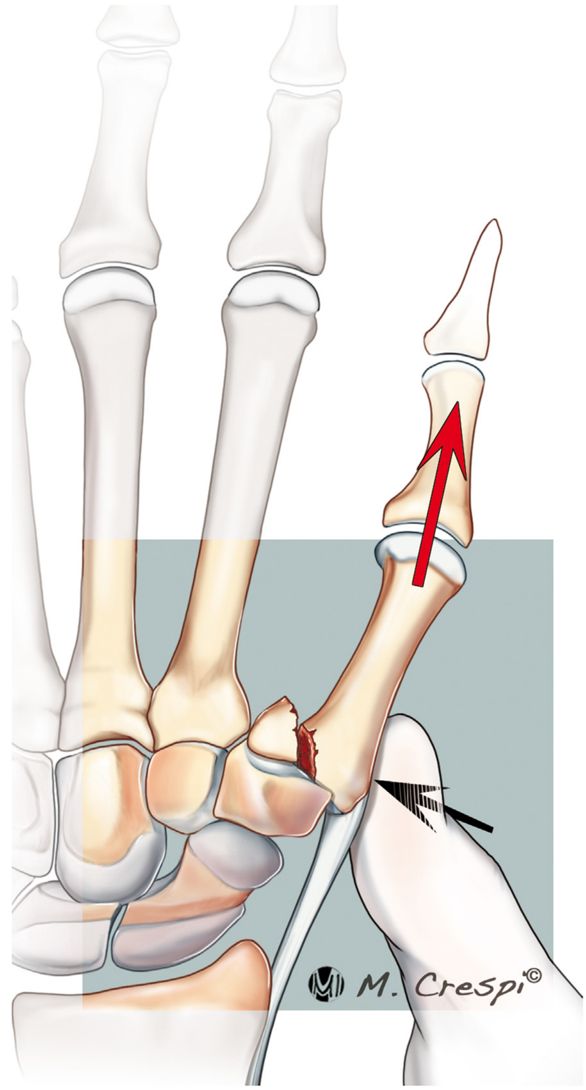

Figure 1. Bennett fracture treated with the reduction method. Red arrow indicate longitudinal traction. Black arrow indicate pressure over the base of the first metacarpal.

Assuming a satisfactory closed reduction can be obtained, a 2-cm incision is made over the dorsoradial margin of the first metacarpal base, just radial to the APL tendon. Care is taken to avoid damage to the branches of the superficial radial nerve. With an assistant performing the reduction maneuver on the thumb, a guide wire for a headless compression screw is inserted. We prefer to use one to two 1.7 -mm headless Cannulated Compression Screw (Medartis AG). Intraoperative fluoroscopy is used to check the wire position and to ensure that the volar-ulnar fragment is adequately captured. If a satisfactory closed reduction cannot be achieved or adequate screw purchase is not ascertained, a volar Wagner approach at the border of the glabrous and nonglabrous skin can be used to perform an open fracture reduction and check fracture stability.

Once satisfactory fixation is achieved, a suspensory construct is inserted - our preference is the TightRope (Arthrex). A second, similarly sized incision is created dorsally over the ulnar aspect of the second metacarpal base. Care should again be taken as a branch of the superficial radial nerve often courses through this region. The intrinsic musculature is dissected off, and the second metacarpal is exposed to allow for suspensory button placement. The curved end of a McDonald periosteal elevator may be useful in identifying the volar margin of the second metacarpal and retracting the soft tissues.

The TightRope jig (C-clamp targeting guide) is then inserted, with the assistant surgeon positioning the jig at the desired exit point on the second metacarpal base. We aim to ensure that the exit point is volar to the midlateral axis on the metacarpal, so that the button has sufficient soft tissue coverage from the second dorsal interosseous muscle to prevent dorsal irritation. The barrel on the jig is positioned on the radial base of the first metacarpal, approximately 3 mm distal to the articular surface. The looped K-wire is then inserted in a radial-to-ulnar direction. The exit point is confirmed using both direct visualization and fluoroscopy. The 1.1-mm thick portion of the graduated wire is advanced with the driver until the 0.86-mm thin portion has exited the second metacarpal. The CMC TightRope is then looped through the eyelet of the guide wire and manually passed, securing a button against the radial base of the first metacarpal. An alternative method that can be used is a freehand “two-pass” technique, whereby the guide wire (and TightRope) is passed through the first metacarpal, retrieved in the second incision, and then passed through the second metacarpal.

Once the TightRope spans the first and second metacarpals, the double-loop synthetic FiberWire suture is cut, and a second

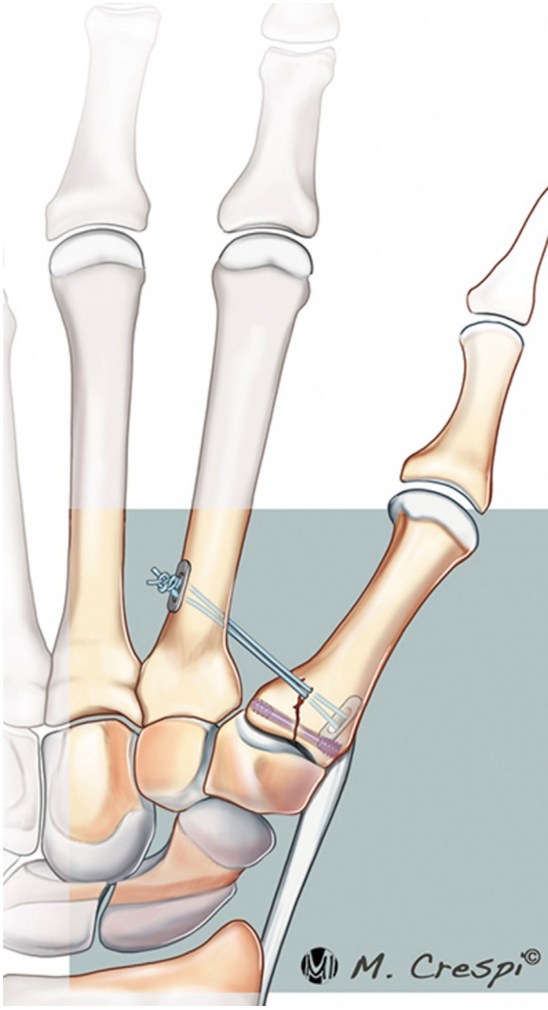

Figure 2. Fixation with 1 headless compression screw and TightRope suspension.

metallic button is passed over the suture ends and nestled against the second metacarpal base. The TightRope is tightened and tied, with the assistant surgeon applying longitudinal traction and pressure over the radial base of the first metacarpal (Fig. 2). Anatomical reduction and stable fixation are confirmed under fluoroscopic assessment, with dynamic assessment under axial load used to assess the maintenance of reduction (Fig. 3).

The suture ends are cut short, and soft tissue coverage is attempted over both buttons to minimize irritation. Following meticulous hemostasis, the wounds are closed with a dissolvable suture. The hand is immobilized in a thumb spica cast, which is removed at the initial follow-up appointment within a week of the surgery. Our preference is to permit early gentle motion in a thermoplastic orthosis following this visit unless a K-wire is required to supplement fixation, in which case it is removed at postoperative week 4. We review the patient at 6 weeks after surgery and perform a repeat radiograph before weaning the thermoplastic orthosis.

Expected Outcomes

Dual fixation via a percutaneous headless compression screw and suspensory fixation has advantages over traditional methods such as K-wire stabilization. Dual fixation eliminates the risk of pin site infection that is inherent to exposed K-wires, as well as the need for secondary operations in the setting of buried wires. This method also allows for densensitization and scar massage in a removable thermoplastic orthosis, compared with casts covering wires. Dual fixation also has theoretical advantages compared with screw fixation alone, with the suspension opposing the pull of the APL. Further elucidation of the biomechanical characteristics of the dual construct on cadaveric models will be beneficial. Complications include iatrogenic fracture from the passage of the suspensory fixation; loss of reduction if screw fixation does not achieve adequate capture of the volar-ulnar first metacarpal fragment; and irritation from palpable buttons.

Figure 3. Intraoperative fluoroscopy – anteroposterior/lateral/Robert view.

Discussion

It is well accepted that Bennett fractures are unstable, with poor outcomes following nonsurgical management. Conjecture exists as to which method of fixation is optimal, with treatment largely guided by surgeon preference.

Kjaer-Peterson et al[8] demonstrated that secondary arthritis after Bennett fracture is much less likely when an excellent reduction is achieved. The investigators found that 86% of patients with an anatomical reduction (defined as less than 1-mm step-off) had no residual symptoms, whereas only 46% of patients with good or poor

Figure 4. Preoperative radiograph showing Bennett fracture.

Figure 5. Postoperative radiographs.

reduction (greater than 1-mm step-off) remained asymptomatic. They also commented that an excellent reduction was achieved in only 45% of patients undergoing closed reduction with plaster immobilization, but 66% of those treated with percutaneous K-wire fixation and 69% with an open reduction achieved an excellent reduction. In terms of long-term sequelae, Thurston[9] studied 21 patients who had Bennett's fractures at an average of 7 years post injury, and found that patients with an articular step of 1mm or less had superior outcomes when compared to those with greater steps. Similarly, equivalent results following either percutaneous or open fixation have been reported by other authors. Lutz et al[10] found no difference in pain or grip and pinch strength, and although a macroscopic abduction deformity was more common in those undergoing percutaneous pinning, this did not translate into poorer clinical outcomes. Pavić and Malović[11] also concurred that there was no advantage of open reduction over percutaneous pinning.

A recent systematic review of outcomes following surgical treatment of Bennett fractures has suggested that closed reduction with percutaneous K-wire fixation should be considered first-line management, with open reduction reserved for situations where closed reduction is not possible.[4] Open reduction was found to require secondary surgery in up to 20% of patients, with up to 28%

Figure 6. Clinical photographs 3 months after surgery.

experiencing persistent paresthesia.[4] However, there are problems inherent to K-wire fixation. Infection rates in wires left proud can be as high as 17.6%, compared with 8.7% in buried wires - buried wires, however, require secondary surgery for removal prior to mobilization.[12]

Our technique of dual-construct fixation obviates the risk of pin site infection inherent to proud K-wire fixation, and allows for an earlier mobilization and desensitization. Suspensory fixation directly opposes the radial pull of the APL, which is one of the primary deforming forces. Suspensory fixation has been previously used to stabilize joints in the hand, with Shah et al[13] reporting on the use of the TightRope to augment the dorsal ulna ligament in a patient with recurrent thumb carpometacarpal joint instability following attempted ligament reconstruction via a tendon graft and Shenouda et al[14] incorporating suspensory fixation in the management of a complex trapezial fracture.

Although no cost analysis has been performed, it is likely that there are higher operative costs, with the use of adjunct suspensory fixation when compared with closed reduction and percutaneous pinning. However, this may be offset by a potential earlier return to work, and future comparative studies are required to elucidate the financial differences.

Case Illustration

A 46-year-old man who works in digital media presented complaining of left base of thumb pain and swelling following a fall. Plain radiographs revealed a minimally displaced Bennett fracture of the left first metacarpal (Fig. 4). The patient underwent percutaneous fixation with a 1.7-mm Cannulated Compression Screw headless compression screw, and augmentation with a TightRope. The patient's recovery was uneventful, and he was managed in a forearm-based thumb spica thermoplastic orthosis until week 6. Twelve weeks after surgery, the patient reported no pain and was able to return to all activities. His Disabilities of the Arm, Shoulder, and Hand score was 6.8 at 12 weeks after surgery, and radiographs taken at 3 months revealed satisfactory positioning and healing (Figs. 5, 6). Patient informed consent was obtained for publication of patient results and images.

Conclusion

The optimal management of Bennett fractures remains controversial. Fixation using closed reduction with a percutaneous headless compression screw and suspensory fixation offers advantages over conventional methods, with excellent early clinical, radiographic, and patient-reported outcomes. Further studies are needed to investigate the biomechanical characteristics of this treatment modality compared with traditional methods.

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