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# Pressure distribution in carpometacarpal joint, due to step-off in operatively treated Bennett's fractures

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ABSTRACT

*Introduction:* The purpose of the current study was to investigate the effects of residual articular incongruity after Bennett's fracture on load distribution of the joint surface. Our aim was to investigate whether a residual joint step and the altered load distribution led to negative clinical outcomes or symptomatic degenerative osteoarthritis of the trapeziometacarpal joint.
*Patients and methods:* Twenty-four patients were available for long-term follow-up examination and were contacted by phone, and they returned for follow-up examination. Computed tomography (CT) scans of both carpometacarpal (CMC) joints were performed. CT scans were taken in the sagittal plane of the forearms with a slice thickness of 0.625 mm for three-dimensional reconstruction. The CMC joints were analysed due to a residual step in the joint. Only patients with a residual step-off were included in this study. To determine the areas of maximum density in the joint, CT-osteoabsorptiometry was performed.
*Results:* Ten patients had the maximum loading area radial and two patients central. The second major position of mineralization was detected central in four patients, volar–ulnar in two patients, radial in one patient, dorso-radial in one patient, volar in one patient and volar–radial in two patients.
*Conclusion:* Finally, no higher loading in the area of the beak fragment could be found.
The Wagner technique, even if it results in a persistent 1–2-mm intra-articular step-off of the beak fragment, is still the favourable method for the treatment of Bennett's luxation fractures.


## Introduction

The Bennett fracture or Bennett's fracture dislocation, first described by Bennett in 1882, is the most common intra-articular injury involving the trapeziometacarpal joint [1]. During the 1950s, two common methods of treatment were described: first, the open reduction with internal fixation and, second, closed reduction followed by percutaneous pinning of the metacarpal shaft fragment to the trapezium [2,3].

Against a widely held belief in surgery of other intra-articular fractures, where restoration of normal joint surface congruency was the main goal, it became apparent that closed reduction and percutaneous pinning, followed by a post-operative step-off, led to good clinical results [4].

Cullen et al. (1997) described that a post-operative step-off did not lead to end-stage post-traumatic osteoarthritis by itself. Furthermore, it may even provide an overriding beneficial effect by unloading the primary contact area of the metacarpal beak (the volar articular prominence = beak fragment) while maintaining ligamentous support [5].

Computed tomography (CT)-osteoabsorptiometry (OAM) is a non-invasive tool for the examination of subchondral bone mineralization patterns of diarthrodial joints. In contrast to conventional techniques, it provides a reproduction of an area in living subjects to interpret load patterns in the joint surface [12]. The distribution of mineralization of the subchondral bone plate (DMSB) represents the loading history of a joint and is, therefore, a useful supplement to direct measurements of loads and theoretical models [6,7]. Inspired by Wolff and Pauwels [8,9], who first showed that morphologic changes of the bones are stress dependent, other authors confirmed a relationship between stress and the subchondral bone of diarthrodial joints [7,11]. The age and the shape of a joint and the geometry of the articular surface were

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discussed as factors of influence on DMSB of normal diarthrodial joints [11,12]. Other joints have been well studied by Müller-Gerbl (1998) with this method.

The purpose of the current study was to investigate the effects of residual articular incongruity after Bennett's fracture on loading of the joint surface. A long-term follow-up was conducted in human carpometacarpal joints by CT-OAM examination to investigate whether a post-operative step-off leads to an unloading of the primary osteoarthritic contact area in the metacarpal beak. Our aim was to investigate whether a residual joint step and the altered load distribution led to negative clinical outcomes or symptomatic degenerative osteoarthritis of the trapeziometacarpal joint.

## Patients and methods

### *Patients*

Between 1983 and 1998, 46 patients with Bennett's fracture with a large fracture fragment (Gedda Type 1) were identified from our trauma unit files and clinical charts as well as preoperative and post-operative radiographs were collected. Out of these 46 patients, 22 could not be included in this study. Fifteen patients changed their home address and were not reachable. Four patients refused to attend the hospital for a follow-up investigation. Three patients died of unrelated conditions and were excluded. The remaining 24 patients were contacted by phone and were available for long-term follow-up examination. The inclusion criterion for this study was a mal-united fracture fragment in apposition with a residual step-off in the articular surface at the region of the beak fragment as described by Cullen [5]. Twelve patients (two women and 10 men) with a mean age of 56.5 years (from 33 to 84 years) were identified to match the inclusion criterion. The primary treatment consisted of reduction and casting in three patients. Operative treatment was performed by closed reduction with percutaneous pinning in five patients (Wagner technique: Fig. 1) and open reduction with pinning in two patients. In two cases, the operative treatment consisted of using lag screw fixation after open reduction.

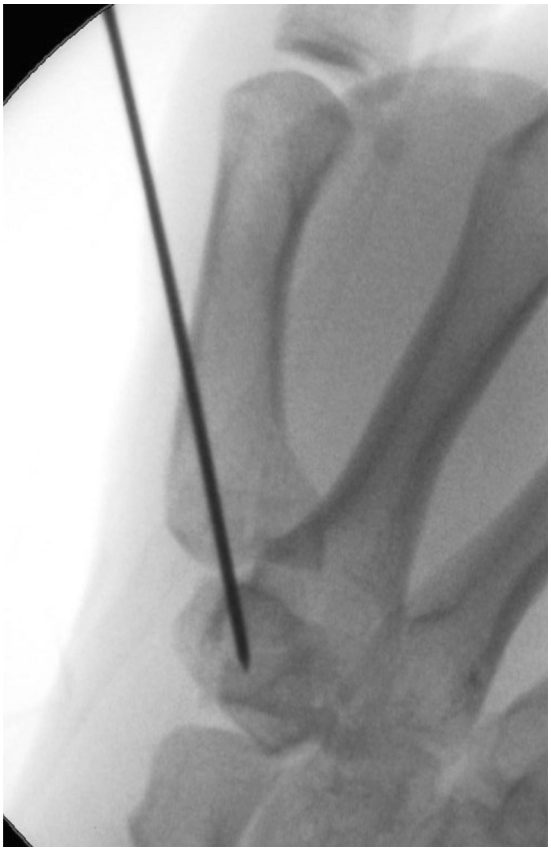

**Fig. 1.** Percutaneous K-wire fixation as described by Wagner.

The study was approved by the institutional review board in Innsbruck, Austria (AN2848).

## Methods

### *Clinical assessment*

All patients underwent clinical examination and questionnaire testing. To ensure consistency, the same examiner who was not part of the surgical team conducted data collection throughout the entire study. Measuring radial adduction and palmar adduction of the thumb assessed the range of motion (ROM) of the joint. The mobility of the thumb in opposition (0–10) was graded by the Kapandji index [13]. We measured grip strength using a calibrated dynamometer (Hand and Wrist Evaluator, Biometrics-LTD, Newport, UK). Furthermore, we determined key pinch strength and pinch grip of the thumb towards the tip of the index finger in kilograms using a calibrated pinch-grip metre (Hand and Wrist Evaluator, Biometrics-LTD, Newport, UK). These measurements were carried out in a standardized manner for both hands. Each hand was measured three times. All patients answered the questions of the functionality part of the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire (30 questions; 0 points = no complaints; 100 points = worst possible outcome). A visual analogue scale (VAS) was used to assess the intensity of pain in the hands (VAS pain). It ranges from 0 (no pain) to 100 (maximum pain) and was recorded by the patients. Obtained results were compared to the uninjured contralateral side.

Anterior–posterior and lateral radiographs were obtained to assess degenerative changes. Osteoarthritis of the trapeziometacarpal joint was classified according to the Eaton and Littler system (Table 1) [14].

CT scans of both carpometacarpal joints were performed with the patients lying in a neutral position with both arms maximally abducted in the shoulder joint and positioned parallel to the body axis. CT scans were taken in the sagittal plane of the forearms (Lightspeed VCT, GE Healthcare, Vienna, Austria) with a slice thickness of 0.625 mm for three-dimensional reconstruction. The CMC joints were analysed due to a residual step in the joint. Only patients with a residual step-off were included in this study.

**Table 1**
Classification of osteoarthrosis of the trapeziometacarpal joint according to the modified Eaton and Littler system [14].

| | |
|---|---|
| Stage 1 | This stage precedes any joint degeneration. Articular contours are normal. The joint space may be widened if an effusion is present. It is assumed that the intra-articular cartilage is normal. |
| Stage 2 | Slight narrowing of the thumb metacarpal–trapezium joint space is present, but the articular contours are maintained. Joint debris, when it is present, is <2 mm in size. Mild to moderate intra-articular cartilage attrition is assumed. |
| Stage 3 | Significant thumb metacarpal–trapezium joint destruction is present. Sclerotic or cystic changes are observed in the subchondral bone. Osteophytes are >2 mm in size. The scapho-trapezium articulation, however, appears normal. |
| Stage 4 | In both metacarpal–trapezium and scapho-trapezium articular surfaces exhibit significant degenerative changes. Multiple diseased articular surfaces are in evidence. |