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Updated Three-Column Concept in surgical treatment for tibial plateau fractures – A prospective cohort study of 287 patients

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ABSTRACT

Purpose: This study introduces an updated Three-Column Concept for the classification and treatment of complex tibial plateau fractures. A combined preoperative assessment of fracture morphology and injury mechanism is utilized to determine surgical approach, implant placement and fixation sequence. The effectiveness of this updated concept is demonstrated through evaluation of both clinical and radiographic outcome measures.

Patients and methods: From 2008 to 2012, 355 tibial plateau fractures were treated using the updated Three-Column Concept. Standard radiographic and computed tomography imaging are used to systematically assess and classify fracture patterns as follows: (1) identify column(s) injured and locate associated articular depression or comminution, (2) determine injury mechanism including varus/valgus and flexion/extension forces, and (3) determine surgical approach(es) as well as the location and function of applied fixation. Quality and maintenance of reduction and alignment, fracture healing, complications, and functional outcomes were assessed.

Results: 287 treated fractures were followed up for a mean period of 44.5 months (range: 22–96). The mean time to radiographic bony union and full weight-bearing was 13.5 weeks (range: 10–28) and 14.8 weeks (range: 10–26) respectively. The average functional Knee Society Score was 93.0 (range: 80–95). The average range of motion of the affected knees was 1.5–121.5°. No significant difference was found in knee alignment between immediate and 18-month post-operative measurements. Additionally, no significant difference was found in functional scores and range of motion between one, two and three-column fracture groups. Twelve patients suffered superficial infection, one had limited skin necrosis and two had wound dehiscence, that healed with nonoperative management. Intraoperative vascular injury occurred in two patients. Fixation of failure was not observed in any of the fractures treated.

Conclusion: An updated Three-Column Concept assessing fracture morphology and injury mechanism in tandem can be used to guide surgical treatment of tibial plateau fractures. Limited results demonstrate successful application of biologically friendly fixation constructs while avoiding fixation failure and associated complications of both simple and complex tibial plateau fractures.

Level of evidence: Level II, prospective cohort study.

Introduction

The treatment of complex tibial plateau fractures (TPF), especially those caused by high-energy trauma, remains a challenge in many respects. Historically, the Schatzker and AO/OTA classification systems, both of which are based on radiographic assessment of fracture pattern [1,2], have been widely used to help guide treatment. Limitations in these classification systems, particularly in identifying information about the integrity of the posterior articular surface or posterior column [3–6] can lead to an incomplete treatment plan. This may result in failure of restoration of alignment and incongruence of the articular surface, which can lead to early osteoarthritis, pain and disability in the long-term [7].

With advancements in CT imaging and 3-D reconstruction technology, TPF can be better evaluated in a multiplanar fashion [5,8–12]. A Three-Column Classification (TCC) based on CT imaging

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has been introduced for improved assessment of TPF [9–12]. Fracture configurations that may involve two or three columns with varying degrees of articular depression and displacement can be well recognized and more accurately classified [4,11,12]. Additionally, the incidence of complex TPF involving the posterior column is higher than expected according to recent studies [4].

It is well known that open reduction and internal fixation (ORIF) is a preferred treatment method for most TPF [13–15]. Advancements in fracture imaging, in addition to newly developed CT-based classification systems aid in the understanding of TPF [3,4,11,12] however, confusion remains as to the optimum fixation strategy. Specifically, whether all fracture columns need fixation, which surgical approach(es) to utilize and which implants function in the most biomechanically efficient way. The "updated Three-Column Concept" is a fixation strategy that has been created to address these difficult questions regarding TPF and successfully guide clinical practice.

In this article, we report the results of TPF treatment via an updated Three-Column Concept (uTCC), best thought of as a "3-D morphology injury mechanism based protocol to surgical approach(es) and implant fixation" (Fig. 1). The purpose of this study is to determine the effectiveness and complication rates of this new protocol in the treatment of complex TPF.

Methods

From September 2008 to August 2012, 439 consecutive patients with operatively treated TPF using the "uTCC" were prospectively enrolled at a single Level 1 trauma centre. The approval of institution's ethical review board was obtained prior to initiation of the study. Patients were excluded based on the following criteria: (1) pre-existing deformity; (2) multiple trauma with an injury severity score of >16; (3) open fracture classified as Gustilo Grade IIIc requiring plastic or vascular surgeries [16]; (4) skeletal immaturity (age < 16 years); (5) additional fracture in the ipsilateral leg except proximal fibula; (6) fracture older than 4 weeks. 355 patients met inclusion criteria, and 287 were available for the minimum 18-month follow-up (Fig. 2). Demographic and injury-related data are listed in Table 1.

Preliminary management of fractures

Provisional stabilization of injuries with skeletal traction or knee-spanning external fixation was performed in instances of high-energy fractures or compromised soft tissue. Open fractures underwent initial irrigation in the emergency department and subsequent irrigation and debridement in the operating room when deemed necessary. Definitive stabilization of fractures was performed when soft tissues were amenable to surgical intervention.

On admission, all patients were evaluated following a standard imaging protocol consisting of radiographic plain films and CT modalities. Injuries were classified into different fracture categories according to the previously described "TCC". In this classification system the tibial plateau is divided into three parts, individually defined as the lateral, medial and posterior columns as seen on axial plane CT images and 3-D reconstructions [10]. A column is considered fractured if there is any disruption of the corresponding extra-articular cortical bone. Injuries are subsequently further classified into zero and one-column fractures which are relatively simple and more complex two-column and three-column fractures [9,10] (Table 1). All fractures where classified by resident physicians under the surveillance of attending surgeons.

Pre-operative planning with application of the updated Three-Column Concept

The updated Three-Column Concept consisting of the initial fracture classification as noted above in addition to further assessment of injury mechanism was applied to all fractures to formulate the surgical plan. The theory functions on the premise that the residual deformity present on evaluation of TPF is a result of the injury mechanism. Through careful evaluation of specific radiographic parameters, the position of the knee (flexion/extension) at time of injury and the direction of the deforming force (varus/valgus) causing fracture can be identified. This information can be further used to guide preoperative planning and surgical stabilization of the fracture.

A tibial plateau column fracture results from an applied axial load with the knee in a specific position in conjunction with a varus or valgus directed deforming force. The flexion/extension position

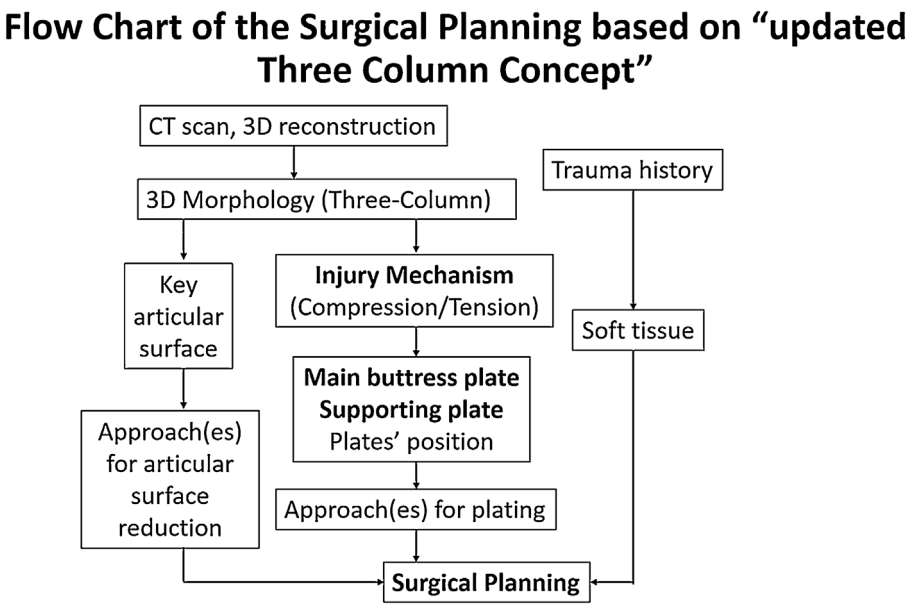

Fig. 1. Flow chart of surgical planning based on updated Three Column Concept.