

3D-Printing Preoperative Planning and Radius Osteotomy External Fixation for Adult Acute Plastic Bowing of the Forearm

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Abstract

Background

Acute plastic deformation of forearm is rare in adults, current treatments have different disadvantages. This article to report a new treating to adult acute plastic bowing of the forearm.

Methods

We report one adult case which diagnosis of acute plastic bowing of the forearm, and display a new treatment to this injury, 3D-printing preoperative planning and radius osteotomy external fixation.

Results

The case achieved full range of movement.

Conclusions

3D-printing preoperative planning and radius osteotomy external fixation is more effective, safe, exact and easy to conduct.

Introduction

Acute plastic deformation of forearm is rare in adults, different from the mechanism of this injury in children, its main cause in adults is industrial accident, usually entrapment on moving rollers in machines[1]. Treatment to this injury including manipulation reduction with cast fixation, corrective osteotomy with plate or intramedullary nail fixation. The treatments have different disadvantages. We report in this article a new treatment to this injury, which is more effective, safe, exact and easy to conduct. This specific study was reviewed and approved by ethics committee of our hospital before the study began. We also got the participant's written consent to have data from her medical records used in research.

Case report

A 24-year-old female sustained trauma on a slow moving roller machine. Her left hand entrapped in the roller and her left forearm subsequently was bent over it. She could extricate her limb only after the machine was stopped to slip off the roller which took about 2 minutes. On clinical examination, she presented swollen and tender left forearm. There was significant dorsal bowing deformity in forearm bones. The forearm movements were restricted between 10° pronation and 50° supination. The left forearm was 1.5cm shorter than the contralateral limb. Anteroposterior and lateral radiographs revealed radialis bowing of radius shaft (Fig. 1A, 1B). Closed manipulation was attempted to straighten the forearm bones, but it was proved inadequate in reducing the forearm bowing. We performed three-dimensional printing

preoperative planning and radius osteotomy external fixation to restore her forearm pronation and supination function.

Preoperative 3D-printing planning

We planned the one site osteotomy at radius to correct the rotational axis of the forearm. Surface data for the whole radius and ulnas of left forearm were obtained in Standard Triangulated Language (STL) format from CT Digital Imaging and Communications in Medicine (DICOM) data using surface reconstruction software. We considered that bowing deformity was present at the radius shaft. The osteotomy site was set almost at the peak of the bowing. We rotated the distal part of radius to reduce the distal radius and ulna joint and 3D-printed.(Fig. 2A,2B)

Surgical procedure

The range of pronation and supination remained limited with testing of passive range of motion under brachial plexus anesthesia. This revealed that the rotational axis of the forearm and the distal ulnar radial joints are abnormal. A straight incision about 1cm was applied on the middle part of radial side. Then approached to the radial shaft by a scissor. We determined the osteotomy line with reference to the 3D-printed model. Osteotomy using a drill bit of 2.0 mm diameter. Two parallel holes were drilled with the drill bit directed to the proximal radius. Screwed two screws, connect crossbar and angle adjuster. Next, two distal holes were drilled and two more screws were inserted to the distal radius with fixed-angle locking, the angle with reference to the 3D-printed model. Then remove the angle adjuster, rotated distal radius to open the osteotomy site and correct the rotational axis of the forearm. Range of pronation and supination were improved after the osteotomy procedure, then fixed all screws and crossbar as a whole. Radiography showed normal rotational axis of the forearm and perfect screw position. (Fig. 3A-C)

Post-operation treatment

Antibiotics were administered for 24 hours to prevent infection. We instructed the patient to perform functional exercise 24 hours after operation. External fixation was removed 3 months after operation. Bone union of the whole cortex was achieved (Fig. 4A,4B) and range of motion remained improved as of 10 months postoperatively. Full range of motion was achieved. Supination and pronation were measured at 90° and 60°, respectively (Fig. 5A,5B).

Discussion

Acute plastic deformation of forearm is rare in adults compared to children. Its main injury mechanism in adults is industrial accident[1], most of them entrapment on moving rollers in machines, it is not only transverse force, but also rotation force, while the force is usually longitudinal force in children, always caused by a fall on an outstretched hand. Bowing deformity in children because of the stronger plasticity of immature bone, while in adults it depending on the force applied and the force duration to the bone. Limited range of supination and pronation motion is the significant symptom of this deformity.

Classification systems for diagnosis and treatment remain unavailable. Treatment reported including manipulation reduction with cast fixation, corrective osteotomy with plate or intramedullary nail fixation[2-5]. We report a new surgical method to the present case. We performed three-dimensional printing preoperative planning and radius osteotomy external fixation to restore her forearm pronation and supination function. There are several advantages of this method. First, the surgical procedure is simple. Once the osteotomy site and the rotational angle are identified in 3D preoperative planning, the operator can easily perform osteotomy and decide the rotational angle, as well as the direction and place of the distal screws implanted with reference to the 3D printed model[6]. Second, this method can correct the rotational alignment of forearm more precisely. As one site osteotomy and external fixation can not only correct the bowing deformity, but also the rotational deformity, so the rotational alignment of forearm can corrected more precisely, this can achieve almost full range of supination and pronation motion of the forearm. Third, minimally invasive surgery can protect the soft tissue and the blood supply, so the osteotomy site can healing easier than open surgery. Forth, patients can do exercise early after the surgery, which can achieve better clinical results. Fifth, when the bone union, it is easy to remove the fixation, no need to stay hospital and perform second surgery. And this can save money for patients. But obviously, the shortage of this method is that patients should pay 3D-printing fee.

Conclusions

Adult acute plastic bowing deformity of forearm is rare in clinical. It usually results of industrial accidents with the transverse and rotational force acting upon the limb. Its significant syndrome is bowing deformity and limited range of motion of pronation and supination. Aim of treatment is to correct the rotational axis of forearm to restore supination and pronation function. Our 3D printing preoperative planning and radius osteotomy external fixation achieved excellent clinical results. The surgical procedure was simple and greatly facilitated using a 3D-printed model for reference.

Abbreviations

3D: three dimension

CT: computed tomography

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Figures



Figure 1

3D-printing forearm bones(A) and the planning osteotomy site(B).

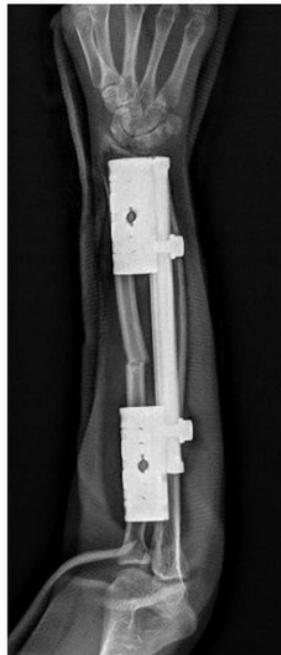


Figure 1

osteotomy and external fixation(A), The postoperative radiography shows that correction of alignment has been achieved (B,C).

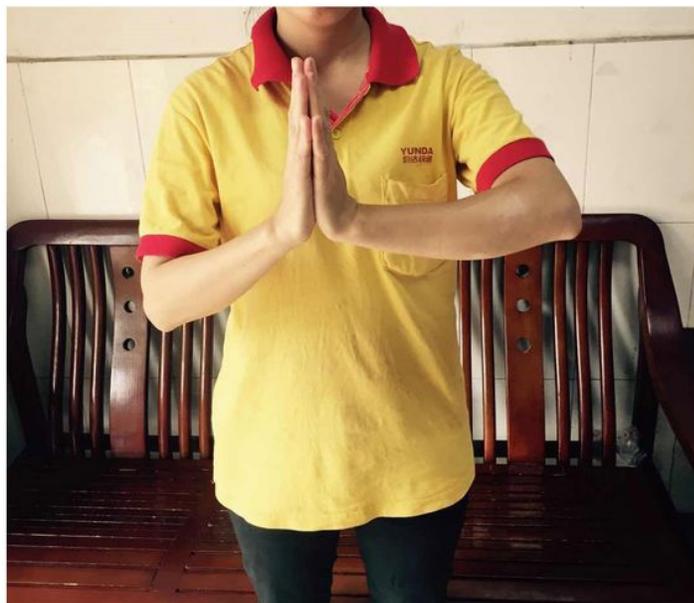


Figure 1

Images at 10 months postoperatively. Full range of motion was achieved.



Figure 1

Images at 5 months postoperatively. Bone union has been achieved and external fixation removed (A. AP view (B. lateral view)).



Figure 1

Radiography shows plastic bowing of the radius (A. AP view (B. lateral view).