Journal of Orthopaedics, Trauma and Rehabilitation 23 (2017) 34–38

Contents lists available at ScienceDirect

Journal of Orthopaedics, Trauma and Rehabilitation

Journal homepages: www.e-jotr.com & www.ejotr.org

Research Study

Reduced Incision Surgical Fixation of Diaphyseal Forearm Fractures in Adults through a Minimally Invasive Volar Approach
通過微創前側進路來進行小切口手術固定成人的前臂骨幹骨折

Ng Li Wen Nathaniel, Lim Zongwei Joel Louis, Xu Roland Weixiang, Hey Hwee Weng Dennis*

Department of Orthopaedic Surgery, National University Health System, Singapore

ARTICLE INFO

Article history:
Received 17 May 2015
Received in revised form
30 June 2016
Accepted 5 July 2016

Keywords:
fracture fixation
internal
minimally invasive surgical procedures
radius fractures

ABSTRACT

Purpose: The study aimed to describe and evaluate the minimally invasive volar approach to the forearm for open reduction and internal fixation of diaphyseal radius fractures.
Methods: This is a matched case-control study involving patients with diaphyseal forearm fractures operated by one orthopaedic surgeon over 2 years. Cases underwent a minimally invasive volar approach, whereas controls underwent a standard Henry's approach. In total, 17 cases and 17 controls were studied based on patient demographics, injury patterns, and surgical outcomes.
Results: The duration of surgery was significantly shorter for cases than for controls in combined radius and ulna fracture fixation (58.8 minutes vs. 84 minutes; $p = 0.03$). There was no significant difference in operative time for isolated radius fractures, hospitalisation duration, and time to return to work. No malalignment or complications were observed.
Conclusion: The minimally invasive volar approach to the forearm is as safe and efficacious as traditional approaches in the fixation of diaphyseal radius fractures.

中 文 摘 要

目的: 描述和評估通過微創前側進路來進行開放性復位和內固定手術,以治療成人的前臂骨幹骨折。
方法: 這是一個為期兩年的前臂骨幹骨折患者的匹配病例對照研究,所有手術由單一骨科醫生進行。治療組患者接受微創進路手術,而對照組患者接受標準的亨利進路方法。當中共有17名治療組患者和17名對照組患者,並根據患者人員特徵,損傷模式和手術結果作研究。
結果: 在單獨的橈骨骨折,治療組的手術時間和對照組相約(54分鐘vs 63分鐘; P = 0.60)。在橈骨與尺骨同時骨折的情況,治療組的手術時間比對照組明顯縮短(58分鐘vs 84分鐘; P = 0.03)兩組的住院時間和恢復工作時間沒有顯著差異。當中並未觀察到有畸變或併發症。
結論: 在治療成人的前臂骨幹骨折,微創前側進路和傳統方法一樣安全和有效,並且可以具有較短時間進行手術。

Introduction

Minimally invasive surgery (MIS) in orthopaedics has been associated with numerous benefits. In fracture fixation, the commonly used techniques include intramedullary nailing, percutaneous pinning/wiring, and minimally invasive plating osteosynthesis (MIPO). With smaller incisions and reduced soft tissue stripping, MIS is believed to be associated with faster healing, reduced complication rates, reduced primary or secondary grafting requirements, and in some cases, shorter operative time.

Existing MIS techniques are now commonly used to fix various long bone fractures. However, open surgical fixation is still the preferred method for the management of diaphyseal forearm fractures as it provides direct visualisation, facilitating anatomical reduction of the fracture.[1–5] Anatomical fracture reduction is important as the forearm is a joint that allows supino-pronation via articulations at the proximal and distal radioulnar joint. Failure to

* Corresponding author. *E-mail:* dennis_hey@nuhs.edu.sg.

http://dx.doi.org/10.1016/j.jotr.2016.07.001
2210-4917/

achieve adequate reduction leads to a reduced range of motion and functional incapacity. Thus, an open approach is commonly employed.[6–8]

While current surgical approaches to the forearm are safe and effective, they involve more extensive surgical incision and soft tissue damage associated with dissection. We now seek to propose an alternative technique that provides adequate access for good anatomical open reduction while minimising soft tissue damage. This study aims to describe the minimally invasive volar approach to the radius and demonstrate its efficacy and safety in the fixation of radial shaft fractures.

Materials and methods

This is a case-control study of patients who had forearm fractures presenting to a single institution. Patients involved in the study were recruited over a period of 2 years. The first 17 patients were cases, and the latter 17 were controls that were selected to match the cases with regards to age, sex, bones involved, site of fracture, and AO classification. To ensure that the cases matched the controls, the Mann–Whitney U test was used to compare the age of the cases and controls, and the Fisher's exact test was used for the remaining categorical variables. All patients were operated within 48 hours of presentation as per our institution workflow. None of our patients had clinically significant swelling or soft tissue damage that required delayed or staged surgery. The controls had a standard Henry's approach measuring approximately 8–10 cm long, followed by layered intermuscular plane elevation; the cases had a minimally invasive volar approach followed by en masse retraction and subperiosteal dissection to expose the underlying bone before open reduction and fixation. All patients were operated by a single orthopaedic trained surgeon (senior author) experienced in the fixation of forearm fractures. The study involved patients with isolated, displaced fractures of the radius (4 cases and 4 controls) and combined radius-ulna shaft fractures (13 cases and 13 controls). Patients with pathological fractures secondary to bone infection or malignancy were excluded from the study. The selection of matched controls was based on age, sex, bones involved, site of fracture, and AO classification (Table 1). The cases had to be operated within 6 months of the controls. No patients in our study had associated fracture-dislocation of the elbow or wrist.

All patients were identified via the surgeon's logbook and confirmed using hospital electronic records. The information collected included prospective data regarding patient demographics (age, sex), open or closed injury, preoperative neurovascular deficits, operative time, quality of fracture reduction and fixation (fracture alignment, fracture gap, screw cortical purchase, screw location), length of hospitalisation, early and late complications (postoperative neurovascular deficits, wound infection, hardware failure, reoperation), forearm range of supino-pronation, time to return to work, and time to bony union. AO classification was used to describe the fracture configuration.[8] Interpretation of X-rays was performed by two independent, blinded specialists (1 radiologist and 1 orthopaedic surgeon). Fracture gap postsurgical fixation was measured directly using Radweb software (Centricity Enterprise Web V3.0 (8.0.1400.128) (GE Medical Systems Information Technologies, Barrington, IL, USA)). Malalignment was defined as an angulation of more than 10 degrees and 2 mm of displacement. Bony union was determined based on X-ray findings of bridging bone involving three cortices in two orthogonal views during follow-up visits.

Data entry was performed using a spreadsheet application (Excel 2003, Microsoft Corp., Redmond, WA). Statistical analyses were performed using SPSS version 16 (SPSS Inc., Chicago, IL, USA). Categorical variables were presented as proportions, and continuous variables were presented as median where appropriate. Univariate analyses were performed using Fisher's exact test between categorical data and Mann–Whitney U test between continuous variables. Statistical significance was taken as $p < 0.05$. An approval by the Institutional Review Board and appropriate consent was taken prior to commencement of the study.

Table 1
Patient demographics and injury details

	Cases	Controls
	$N = 17$	$N = 17$
Duration		
Mean age, y (range)	27.2 (17–47)	28.3 (18–47)
Sex (male:female)	14:3	14:3
Fracture location(s)		
Radius + Ulna	13	13
Radius	4	4
Proximal 1/3 of radial shaft	6	6
Middle 1/3 of radial shaft	6	6
Distal 1/3 of radial shaft	5	5
Fracture AO Classification		
22A2	3 (17.6%)	3 (17.6%)
22A3	3 (17.6%)	3 (17.6%)
22B2	1 (5.9%)	1 (5.9%)
22B3	4 (23.5%)	4 (23.5%)
22C2	2 (11.8%)	2 (11.8%)
22C3	4 (23.5%)	4 (23.5%)

Description of surgical technique

Under general anaesthesia, the patient was placed supine and the injured forearm was allowed to rest on a radiolucent table in full supination. Tourniquet was applied to the upper limb at the arm and cuffed up to 250mmHg. The fracture was palpated and a 4-cm longitudinal incision was placed over the volar aspect of the forearm above the marked fracture site and along the ulna border of the mobile wad (Figure 1A).

Unlike the traditional approach, which involves layered dissection to the fracture site, blunt dissection was performed using the index finger down to the fracture site along the borders of encountered muscles, with no elevation of intermuscular planes (Figure 1B). The soft tissue was then retracted en masse. During the approach, the border of the mobile wad was first encountered and pushed laterally together with the superficial radial nerve underneath which was not routinely exposed. The radial artery and its venae commitantes if encountered were retracted laterally. Depending on the extent of fracture and required implant length, limited subperiosteal elevation of the deep muscle was subsequently performed with a periosteal elevator to allow sitting of the plate later (Figure 1C). This was done by displacing the supinator laterally at the proximal third, the pronator teres medially at the middle third, and flexor pollicis longus medially at the distal third of the radius.

Fracture reduction was performed under direct vision with the aid of reduction clamps and confirmed using fluoroscopy. A 3.5-mm nonlocking, limited contact dynamic compression plate (6–7 holes) was then applied on the radius by sliding the plate through the incision along the tract, proximally and then distally in a sequential manner (Figure 1D). Indirect compression was achieved via eccentric placement of screws at holes nearest to the fracture site, and an additional screw was placed on each side of the fracture using the same primary incision. A stab incision was placed on each side of the primary incision to apply the remaining screws percutaneously. A minimum of three nonlocking cortical screws with six cortical purchases were ensured for all fixations, both proximally and distally. Four patients had fracture site compression achieved