Injury, Int. J. Care Injured 46 (2015) 1161–1166

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Possible predictors for difficult removal of locking plates: A case-control study

Yun Fei Hou, Fang Zhou *, Yun Tian, Hong Quan Ji, Zhi Shan Zhang, Yan Guo, Yang Lv

Orthopedic Trauma, Peking University Third Hospital, No. 49, North Garden Rd, HaiDian District, Beijing 100191, China

ARTICLE INFO

Article history:
Accepted 9 March 2015

Keywords:
LCP
LISS
Difficult removal
Correlated factors
Prevention

ABSTRACT

Introduction: Difficult removal of locking plates including less invasive stabilisation systems (LISSs) and locking compression plates (LCPs) sometimes occur. However, investigations of the mechanisms and correlated factors of complicated removal remain scant. This study aims to identify correlated factors for the difficult removal of locking plates and to propose suggestions for decision making regarding implant removal and the prevention of complicated removal.

Materials and methods: In total, 308 consecutive patients who underwent LCP/LISS removal from Sep. 2004 to Nov. 2013 were assessed. Using the Mann–Whitney *U* test, we analysed the correlation between difficult removal and the duration between open reduction and internal fixation (ORIF) and implant removal as well as the correlation between difficult removal and the patients' age. Using Chi Square test, we assessed the correlations between complicated removal and the size, location, insertion technique and cortical purchase of the locking head screw (LHS). Correlated factors were separately determined in upper and lower extremities. Rates of difficult removal in different fracture locations were evaluated, and postoperative complications were documented.

Results: Of the total 308 patients, thirty-seven had intra-operative difficulties, and six patients experienced postoperative complications. Six out of fifteen patients with peri-elbow fractures and five out of seventeen patients with femur fractures suffered difficult removal, while four out of one hundred patients with malleolar fractures had intra-operative difficulties. Difficulties were experienced with 30 of 338 LCPs, 7 of 32 LISSs, 67 of 1533 small-diameter ($\leq$3.5-mm) LHSs, and 12 of 442 large-diameter ($\geq$4.5-mm) LHSs. Three LCPs and seventeen small-diameter LHSs were retained. A longer interval between ORIF and removal, younger age and bicortical screws correlated with difficult removal in the upper extremities, and a longer duration before removal, small-diameter LHS and minimally invasive insertion of LHS were predictors in the lower extremities.

Conclusions: Complications occur with LCP/LISS removal, and it should not be a routine procedure. If removal is indicated, performing surgery as soon as radiographs show fracture healing is recommended. Different considerations should apply when making decisions and removing implants from patients with different fracture sites.

Introduction

Since their introduction, less invasive stabilisation systems (LISSs) and locking compression plates (LCPs) have gained popularity in fracture management. In minimally invasive percutaneous plate osteosynthesis (MIPPO), LCPs [1] and LISSs [2,3] could preserve blood supply, provide sound fixation and a good biological environment for bone healing and thus improve clinical outcome, particularly in comminuted fractures and osteoporotic fractures. However, removal of LCPs and LISSs can be difficult. Occasionally, surgeons have no choice but to make larger incisions [4] for clearer exposure or to damage the locking head screw (LHS)'s head or the bone, leaving patients at higher risks for refracture [5–7], infection [7] or retained implants [8].

Overall, investigations of the mechanisms for difficult removal remain scarce. Several studies [9–12] have proposed that surgical error is the main cause of difficult removal of LCPs and LISSs; osteointegration [13] and cold welding [11] have also been

* Corresponding author. Tel.: +0086 010 8226 7380; fax: +0086 010 8226 7380.
E-mail addresses: houyf@bjmu.edu.cn (Y.F. Hou), zhouf@bjmu.edu.cn (F. Zhou), tiany@bjmu.edu.cn (Y. Tian), jihq@bjmu.edu.cn (H.Q. Ji), zhangzs@bjmu.edu.cn (Z.S. Zhang), drguoy@bjmu.edu.cn (Y. Guo), lvy@bjmu.edu.cn (Y. Lv).

http://dx.doi.org/10.1016/j.injury.2015.03.027
0020–1383/

proposed as correlated factors. We conducted this study to investigate possible factors related to the difficult removal of LCPs/LISSs and to provide information and suggestions for orthopaedic surgeons with respect to decision making regarding the removal of locking plates and the prevention of complicated removal.

Patients and methods

Term definition, inclusion and exclusion criteria and operation details

Intra-operative difficulties were defined as any one or more of the following conditions: (1) screwdriver slipping; (2) LHS recess jamming; (3) LHS cross-threading; (4) device breakage during surgery; (5) impossibility of removal with a normal screwdriver and the requirement of specially designed devices; and (6) implant retention.

In total, 333 patients with extremity fractures (including fractures of the clavicle, humerus, forearm, femur, tibia and fibula) who underwent LCP/LISS removal at our institution from Sep. 2004 to Nov. 2013 were included. Twenty-five patients who underwent open reduction and internal fixation (ORIF) at other hospitals were excluded.

ORIFs and implant removals were performed by five orthopedic trauma surgeons who had at least 6 years (at most, 24 years) of experience in performing ORIF by 2013. Most of the operations on the upper extremities were performed using an open approach, whereas a number of ORIFs in the lower extremities were performed using minimally invasive surgery (MIS). All implants were from Depuy Synthes (Paoli, PA, USA) and made of titanium. As recommended by the manufacturer, we inserted each LHS using a torque limiter and an aiming drill sleeve to avoid over-tightening and off-axis insertion.

Data extraction

We extracted the patients' demographics, chief complaints before removal and any post-operative complications from the patients' medical records. Data regarding the implants used, any intra-operative difficulties and resolutions, the date of ORIF and implant removal, and the size, position, cortical purchase and insertion method (through an open approach or using the MIPPO technique) of the LHSs were extracted from the operation records. According to the plate design, we determined the positional relationship between the plate and the screw (mutually orthogonal or non-orthogonal).

Statistical analysis

Data were analysed using SPSS 19.0 (IBM Corp., Armonk, NY). The level of significance was set to $p < 0.05$. Means and ranges were used to describe the age and implant time in situ (months). We classified all LHSs into 2 groups: the group removed with difficulty and the group removed without difficulty. The patients were classified into 2 groups using the same method. Comparisons between the two patient groups were made using the Mann–Whitney *U* test. Chi-squared tests were used to compare the 2 LHS groups for screw position, size, cortical purchase, insertion technique and positional relationship between the screw and plate. Factors that correlated with difficult removal in the upper and lower extremities were considered separately.

Results

Clinical data

In total, 308 patients were studied, including 190 males and 118 females. The median age was 34.0 years old (inter-quartile range, 25–48), and the median implant duration was 16.0 months (inter-quartile range, 13–20). Most implants were removed without difficulty (Tables 1 and 2), and 1 LCP reconstruction Plate 3.5, 1 LCP distal tibia Plate 2.7/3.5, 1 LCP T distal radius Plate 2.4, sixteen 3.5-mm LHSs and one 2.4-mm LHSs were retained. According to Figs. 1 and 2, it was shown that the incidence of difficult removal was the highest in distal humerus fracture patients (41.7%). Patients with fractures of the proximal forearm (33.3%), proximal femur (33.3%) or femur diaphysis (33.3%) also had high risks of suffering complicated removal of locking plates. The rate of difficult removal was quite low (4%) in ankle fracture patients. Of the 308 patients, 231 (75.0%) underwent removal without any complaints, whereas the remaining 77 patients had implants that caused symptoms (Fig. 3).

Table 1
Implants removal in upper extrimities.

Location	Cases	Plates removed	Plate (difficult plate)	Difficult locking head screws	
				Small-diameter (≤3.5 mm)	Large-diameter (≥4.5 mm)
Proximal humerus	24	PHILOS	24(5)	7	
Humerus, diaphysis	5	LCP3.5	1(0)		
		RLCP3.5	3(1)	1	
		DH (lat)	1(0)		
Distal humerus	12	DH (lat)	5(1)	2	
		DH (med)	3		
		RLCP3.5	11(4)	7	
Proximal forearm	3	LCP	1(1)	2	
		RLCP3.5	1		
		Olecranon Plate	1		
Forearm, diaphysis	25	LCP3.5	34(3)	8	
		RLCP3.5	5(2)	2	
		DRS	11		
Distal radius	15	DRS	16		
Clavicle	24	Clav Hook	15		
		RLCP3.5	10		
Clavicle plus distal radius	1	RLCP3.5	1		
		DRS	1		
Total	109		144(17)	29	

Abbreviations: RLCP3.5: LCP reconstruction Plates 3.5; DH (lat): LCP distal humerus Plates 2.7/3.5 (dorsolateral, with or without lateral support); DH (med): LCP distal humerus Plates 2.7/3.5 (medial); Olecranon Plate: LCP olecranon Plates 3.5; DRS: LCP distal radius system; 2.4Clav Hook: LCP clavicle hook Plates 3.5.