

# 芯钻髓内钉治疗股骨干闭合骨折的并发症防治

蔡骏艺, 陈志达, 丁真奇, 宋超, 黄国峰, 胡晓阳, 黄佳平

(中国人民解放军联勤保障部队第 909 医院暨厦门大学附属东南医院 全军骨科中心, 福建 漳州 363000)

**【摘要】 目的:**总结芯钻髓内钉治疗闭合股骨干骨折的并发症,并探讨其处理策略。**方法:**2014 年 8 月至 2018 年 6 月,215 例股骨干闭合骨折患者采用闭合复位芯钻髓内钉内固定,男 129 例,女 86 例;年龄 18~62(44.2±10.6)岁;受伤到手术时间 3~21 d。其中 102 例 A 型骨折,82 例 B 型骨折,31 例 C 型骨折。记录手术时间、术中出血量、住院时间、骨折愈合时间及末次随访膝关节功能 HSS 评分。并发症观察包括:术中医源性骨折,芯钻断裂,芯钻打卷,术后感染和骨折不愈合等。**结果:**患者手术时间为(63.2±15.6) min,术中出血量为(150.0±34.5) ml。手术切口均达甲级愈合,所有患者获得随访,时间(18.5±3.2)个月,住院时间(4.3±1.2) d,骨折愈合时间(5.6±2.3)个月。末次随访时膝关节 HSS 评分 90.3±4.7。发生相关并发症 37 例,发生率为 17.2%。其中芯钻相关并发症 13 例(6.0%),包括芯钻断裂 5 例(2.3%),采用远端切开取出断裂芯钻 1 例,股骨开槽取出 4 例;芯钻打卷 8 例(3.7%),远端切开剪断内芯,完整取出,改徒手置钉。常规髓内钉类似的并发症:术中医源性骨折 12 例(5.6%);骨折端劈裂 10 例,髓内钉远端周围骨折 2 例。骨折端发生劈裂患者判断其稳定性良好未行处理,远端周围骨折患者术中辅助钢板固定;术后迟发性感染 1 例(0.4%),清创更换外固定并进行骨搬运后愈合;骨折不愈合 11 例(5.1%),其中肥大骨不连 7 例(3.3%),采用附加钢板后愈合;萎缩性骨不连 4 例(1.9%),附加钢板加植骨后愈合。**结论:**芯钻髓内钉治疗股骨干闭合骨折临床疗效佳,并发症包括芯钻相关的并发症及常规髓内钉类似的并发症,精确术前评估、术中仔细操作及术后尽早对症处理可有效降低相关并发症的发生。

**【关键词】** 骨折固定术,髓内; 股骨干骨折; 并发症

中图分类号:R687.3

DOI:10.12200/j.issn.1003-0034.2021.10.015

开放科学(资源服务)标识码(OSID):



**Prevention and treatment of complications in the treatment of femoral shaft closed fracture with core drilling intramedullary nail** CAO Tao-yi, CHEN Zhi-da, DING Zhen-qi, SONG Chao, HUANG Guo-feng, HU Xiao-yang, and HUANG Jia-ping. Department of Orthopaedics, the 909th Hospital of People's Liberation Army, Affiliated Southeast Hospital of Xiamen University, Orthopaedic Center of PLA, Zhangzhou 363000, Fujian, China

**ABSTRACT Objective:** To summarize the complications of core drilling intramedullary nail in the treatment of femoral shaft closed fracture and explore the treatment strategy. **Methods:** From August 2014 to June 2018, a total of 215 patients with closed femoral shaft fractures were treated with closed reduction core drill intramedullary nail, including 129 males and 86 females, aged from 18 to 62 years, with an average of (44.2±10.6) years old. The time from injury to operation was 3 to 21 days. There were 102 cases of AO type A fracture, 82 cases of AO type B fracture and 31 cases of AO type C fracture. The time of operation, the amount of blood loss during operation, the duration of hospitalization, the time of fracture healing and the HSS score of knee joint function at the last follow-up were recorded. The observation of complications included: iatrogenic fracture, core drill broken, core drill twist, postoperative infection, and fracture nonunion. **Results:** The average operation time was (63.2±15.6) min and intraoperative blood loss was (150.0±34.5) ml. All the incisions reached grade A healing. Patients were follow-up for a mean of (18.5±3.2) months, the average hospital stay was (4.3±1.2) days, and the average fracture healing time was (5.6±2.3) months. At the final follow-up, the average HSS score of knee joint was 90.3±4.7. Related complications occurred in 37 cases (17.2%). The core drill related complications occurred in 13 cases (6.0%), including core drill broken in 5 cases (2.3%), core removal in 1 case and slotting in 4 cases; core drill twist in 8 cases (3.7%). After the core was cut, the core was removed. Similar complications of conventional intramedullary nail: iatrogenic fracture was performed in 12 cases (5.6%), including 10 cases of fracture end split and 2 cases of distal perimedullary fracture of intramedullary nail. The patients with

基金项目:全军后勤科研计划(编号:CNJ16C013);漳州市自然科学基金(编号:ZZ2018J12);军事训练伤防治研究专项(编号:21XLS23)

Fund program: Military Logistics Research Project (No. CNJ16C013)

通讯作者:陈志达 E-mail: czd5320@163.com

Corresponding author: CHEN Zhi-da E-mail: czd5320@163.com

cleavage at the fracture end were not treated after judging their stability, and the patients with fracture around the distal end of the intramedullary nail were fixed with auxiliary steel plate during operation; 1 case (0.4%) with delayed infection after operation, debridement and external fixation was replaced and healed after bone transfer; fracture nonunion occurred in 11 cases (5.1%), of which 7 cases (3.3%) were hypertrophic nonunion and healed with additional plate. Atrophic nonunion occurred in 4 cases (1.9%), which healed after additional steel plate and bone graft. **Conclusion:** Core drilling intramedullary nail is an effective method for the treatment of closed femoral shaft fracture, and the complications include core drill related complications and conventional intramedullary nail similar complications. Accurate preoperative evaluation, careful operation during operation and early postoperative symptomatic treatment can effectively reduce the occurrence of related complications.

**KEYWORDS** Fracture fixation, intramedullary; Femoral shaft fracture; Complications

股骨髓内钉是治疗股骨干骨折的金标准，然而远端锁钉定位不准确是困扰临床医生的棘手问题<sup>[1-3]</sup>。芯钻髓内钉固定系统最早由美国明尼苏达大学骨科教授 Ramon Gustilo 首次提出，采用“由内向外”技术由远端锁钉孔穿出芯钻内芯来实现精准定位，可在无透视下一次完成远端锁钉置入，过程中无需安装前方定位杆，锁钉切口大小仅为 0.5 cm，能更好的达到微创的效果<sup>[4-6]</sup>。但目前关于芯钻髓内钉使用并发症报道相对较少。本研究收集了自 2014 年 8 月至 2018 年 6 月我院 215 例单侧闭合股骨干骨折采用闭合复位芯钻髓内钉固定治疗患者的临床资料，对其并发症进行总结，并探讨并发症的防治策略，以期进一步提高芯钻髓内钉的临床疗效。

## 1 临床材料

### 1.1 病例选择

纳入标准：闭合股骨干骨折；年龄 16~65 岁；具有完整的临床资料。排除标准：开放性骨折；病理性或陈旧性骨折；合并严重内科基础疾病，影响手术及受伤后深静脉血栓形成患者；全身多发伤、软组织严重缺损和合并多脏器损伤；无自主行为能力的患者。

### 1.2 一般资料

回顾性分析自 2014 年 8 月至 2018 年 6 月收治的 215 例单侧股骨干骨折患者，其中男 129 例，女 86 例；年龄 16~62(44.2±10.6)岁。骨折 AO 分型<sup>[7]</sup>：A 型 102 例，包括 A1 型 54 例，A2 型 29 例，A3 型 19 例；B 型 82 例，包括 B1 型 53 例，B2 型 18 例，B3 型 11 例；C 型 31 例，包括 C1 型 15 例，C2 型各 9 例，C3 型 7 例。致伤原因：交通事故伤 148 例，高处坠落伤 21 例，摔伤 27 例，挤压伤 4 例，其他伤 15 例。所有病例为闭合骨折，合并颅脑损伤 32 例，胸腹部损伤 25 例。本组患者从受伤到手术平均时间为 3~21 (8.1±0.3) d。

## 2 治疗方法

### 2.1 术前准备

合并脏器损伤患者优先处理脏器伤，待病情平稳后行骨折切开复位内固定。患者入院后均予患肢胫骨结节牵引，并在术前 48 h 逐步加大牵引重量至

床边复查 X 线片显示骨折断端过牵，最大牵引重量 14 kg。全身条件允许下行低分子肝素钠皮下注射抗凝，术前 1 d 行双下肢深静脉彩超检查排除血栓。所有患者术前行双侧股骨正侧位 X 线片检查，了解髓腔大小、股骨全长及前弓角度。

### 2.2 手术方法

患者常规行硬膜外或全身麻醉，肥胖或足踝部皮肤条件不佳患者采用侧卧位，其余患者采用仰卧位牵引床固定。C 形臂 X 线透视监测并调整牵引重量致骨折断端过牵，常规消毒铺单。根据术前测量的股骨弧度确定进钉点，经皮穿入克氏针，透视定位进钉点与术前相符后切开皮肤，套筒保护下在大粗隆顶点或梨状窝动力开口，实心髓腔扩大器开髓。更换空心“T”形手柄控制骨折近端，手法复位或“操纵杆”技术进行闭合复位。C 型骨折尽量穿过大骨折块，C3 型骨折以维持力线及长度为主，不过分强求骨块复位。软钻远端扩髓，根据术前计划选择合适长度髓内钉置入。安装芯钻延长杆，空心髓内钉内插入芯钻控制器，均匀推进内芯，由内向外穿透皮肤。切开皮肤，空心钻套入内芯，内芯退出同时空心钻钻透同侧皮质。芯钻控制器退出后再次向前，空心钻无法前进则表示位置准确。同样方法置入次远端孔横锁钉。常规近端置钉，锁帽；透视满意后逐层进行伤口缝合，术毕。

### 2.3 术中并发症处理

(1)芯钻断裂。芯钻内芯断裂时已穿出股骨远端皮质，切开远端皮肤，暴露断钉后取出。若未穿出皮质时发生断裂，退出芯钻主体，主钉不动，透视定位后远端开槽取出断裂内芯，取出后将主钉打深使远端锁定孔超过开槽部分，安装常规髓内钉外架再次完成锁钉。

(2)芯钻穿出骨面后体内打卷。切开远端皮肤至骨面，将内芯紧贴骨面处剪断后取出，核对芯钻完整性后于芯钻穿出孔进钉完成锁定。

(3)医源性骨折。若术中出现医源性骨折，调整复位力线使髓内钉与股骨长轴一致后继续打入髓内钉，完成远近端锁钉固定后透视骨折端，若距离锁钉

位置大于 5 cm, 则未予特殊处理。若在置钉过程中出现髓内钉远端周围骨折, 术中复位后采用 LISS 钢板辅助进行固定。

### 2.4 围手术期处理

患者术前给予非甾体解热镇痛药口服, 麻醉前常规行患肢股神经阻滞, 术后辅助多模式镇痛将患者疼痛视觉模拟评分 (visual analogue scale, VAS) 评分控制于 4 分以内。常规“三抗”, 康复师全程指导功能锻炼, 术后第 1 天起行主被动股四头肌功能锻炼、踝泵功能锻炼, 术后 1 周内行患肢髋、膝关节伸屈活动, 2 周内行患肢髋、膝关节伸屈活动, 2 周内行患肢髋、膝关节伸屈活动, 2 周内行患肢髋、膝关节伸屈活动, 2 周内行患肢髋、膝关节伸屈活动。

### 3 结果

本组患者手术时间 52~135 (63.2±15.6) min, 术中出血量 80~450 (150.0±34.5) ml, 住院时间 3~10 (4.3±1.2) d。术后 1、6 周、3、6、12、18、24 个月进行门诊随访, 复查患肢股骨正侧位 X 线片, 观察骨折愈合情况。182 例术后 2 周后在双拐保护下离床活动, C 型骨折及 2 例远端附加钢板患者下地时间推迟至 6~8 周。所有患者获得随访, 时间 12~36 (18.5±3.2) 个月, 骨折愈合时间 3~13 (5.6±2.3) 个月。末次随访时, 182 例可完全下蹲, 26 例轻度受限, 7 例下蹲受限。采用纽约特种外科医院 (Hospital for Special Surgery, HSS) 膝关节评分<sup>[8]</sup>评定患者膝关节功能情况, 末次随访患侧膝关节 HSS 评分为 84~95 (90.3±4.7) 分, 其中疼痛 (26.6±5.4) 分, 功能 (18.1±2.1) 分, 活动度 (17.6±0.9) 分, 畸形 (9.7±0.5) 分, 稳定性 (9.5±0.7) 分, 肌力 (9.1±0.2) 分。

并发症情况: 共发生并发症 37 例 (17.2%)。其中芯钻相关并发症 13 例 (6.0%), 包括芯钻断裂 5 例, 采用切开取出断裂芯钻内芯 1 例, 开槽取出 4 例; 芯钻打卷 8 例。切开后剪断内芯, 完整取出后改徒手置钉。常规髓内钉类似的并发症 24 例 (11.2%), 术中医源性骨折 12 例 (5.6%), 包括骨折端劈裂 10 例 (4.7%), 骨折端发生劈裂患者判断其稳定性后未行处理; 髓内钉远端周围骨折 2 例 (0.9%)。术中辅助 LISS 钢板固定。所有患者未发生急性感染, 1 例 (0.4%) 术后 3 个月发生迟发性感染, 清创更换外固定并进行骨搬运后愈合。骨折不愈合 11 例 (5.1%), 其中 7 例 (3.3%) 患者连续观察 12 个月, 骨折端仅见肥大型骨痂生长, 未愈合, 术后 18 个月仍无愈合征象, 采用附加经皮桥接钢板辅助后 3~6 个月愈合; 4 例 (1.9%) 患者术后 8 个月骨折端无愈合征象, CT 三维重建未见骨小梁通过, 行附加钢板及取髂骨植骨后 3~9 个月愈合。典型病例见图 1, 2。

### 4 讨论

髓内钉是股骨干骨折理想的内固定方式, 具有良好的抗旋转、抗压缩能力, 符合生物学固定<sup>[9]</sup>。Park 等<sup>[10]</sup>随访了接受髓内钉或钢板治疗的 45 例成人股骨干骨折患者, 发现两者在临床疗效及并发症发生上无明显差异, 但髓内钉患者完全负重时间明显短于钢板。然而, 髓内钉操作具有一定技术性和复杂性, 适应症选择不当, 手术操作不熟练等因素可能导致骨不连、感染、内植物失效等并发症<sup>[11]</sup>。本组 215 例股骨干骨折患者行芯钻髓内钉固定, 并发症



图 1 患者, 男, 32 岁, 左股骨干骨折, 术中芯钻无法穿透阔筋膜, 出现打卷 1a。术中出现芯钻无法穿透阔筋膜, 出现打卷 1b。连接定位杆定位芯钻尾端的位置 1c。直视下切开组织, 暴露芯钻尾端 1d。取出打卷的芯钻 1e。术后切口外观

Fig.1 A 32-year-old male patient with left femoral shaft fracture, the cored drill was unable to penetrate the fascia lata during the operation, resulting in winding 1a. The cored drill was unable to penetrate the fascia lata during the operation, resulting in winding 1b. The connecting positioning rod locates the end of the mandrel 1c. Cut the tissue directly vision and expose the end of the cored drill 1d. Take out the cored drill 1e. Postoperative incision appearance





**图 2** 患者,男,20 岁,右股骨干骨折,芯钻髓内钉固定术后萎缩性骨不连 2a,2b. 术前正侧位 X 线片示右股骨干骨折 2c,2d,2e. 术后 3 d 正侧位 X 线片示髓内钉固定在位,断端对位对线良好 2f,2g. 术后 3 个月正侧位 X 线片示髓内钉位置良好,断端未见骨痂生长 2h,2i. 术后 9 个月正侧位 X 线片示髓内钉位置良好,骨折线清晰,断端仍为见骨痂生长 2j,2k. 术后 9 个月三维 CT 及骨扫描示断端硬化,未见骨痂生长 2l,2m. 二次手术行髂骨植骨+钢板固定术后 3 d 正侧位 X 线片示钢板及髓内钉位置良好,骨折对位对线良好

**Fig.2** A 20-year-old male patient with right femoral shaft fracture, atrophic nonunion after core drill intramedullary nail fixation 2a,2b. Preoperative AP and lateral X-rays showed fracture of the right femoral shaft 2c,2d,2e. Three days after the operation, AP and lateral X-rays showed that the intramedullary nail was fixed in proper place and the fracture site was in good alignment 2f,2g. Three months after operation, AP and lateral X-rays showed that the position of intramedullary nail was well, and no callus growth was observed 2h,2i. Nine months after the operation, AP and lateral X-rays showed that the position of intramedullary nail was fine, the fracture line was clear, and no callus growth was still observed 2j,2k. 3D CT and bone scan at 9 months after surgery showed that the fracture site was hardened, and no callus growth was observed 2l,2m. After the second operation, ilium graft and steel plate fixation were performed, 3 days after the operation AP X-ray showed that the steel plate and intramedullary nail were in favorable position, and the fracture was in good alignment

发生率为 17%,分析其原因及处理对策如下。

#### 4.1 术中医源性骨折

髓内钉进钉点选择为梨状窝或大转子顶点,大粗隆进钉点由 Gerhard 在 1939 年首先介绍,该进钉点缺点为容易出现骨折内翻,髓内钉远端易偏向内侧出现应力骨折。Winqvist 等<sup>[12]</sup>在 1984 年介绍了梨状窝开口并应用于超过 500 例的股骨干骨折患者,其优点在于能避免骨折端内翻,缺点是进钉点偏内,肥胖患者操作较困难并有损伤旋股内侧动脉深支可能。随着不同外翻角度髓内钉的出现,梨状窝及大粗隆顶点均可作为开口选择,但不同个体股骨外翻及向前弧度变化很大,千篇一律的进钉点使上述并发

症无法避免<sup>[13-15]</sup>。术中医源性骨折的主要原因在于:

(1)髓内钉轴线与股骨轴线未重叠,骨折端或末端存在应力,使用软钻进行扩髓时应力较分散,但置入主钉时应力集中易发生骨折。(2)髓内钉直径过大,加之部分患者术前未行 CT 三维重建,对于隐匿性骨折未发现而在在扩髓或置钉过程中出现骨折。(3)对于 C 型骨折患者,骨折端粉碎,成角不易发现或在复位过程中成角已纠正,但置钉过程中未持续复位,橄榄头通过后主钉进入易卡压于骨折裂隙,此时暴力进钉易出现骨折。特别注意的是阻挡钉技术的成熟,被广泛用于纠正远端的成角,如力线未恢复而仅靠阻挡钉强行复位也可出现医源性骨折。本组 2 例远端



**图 2** 患者,男,20岁,右股骨干骨折,芯钻髓内钉固定术后萎缩性骨不连 **2n,2o**。术后3个月正侧位X线片示钢板及髓内钉位置良好,断端见连续性骨痂生长 **2p,2q,2r**。术后18个月正侧位X线片示钢板及髓内钉位置良好,骨折达到完全愈合 **2s,2t**。术后18.5个月正侧位X线片示完整取出髓内钉及钢板,骨折断端愈合良好

**Fig.2** A 20-year-old male patient with right femoral shaft fracture, atrophic nonunion after core drill intramedullary nail fixation **2n,2o**. Three months after operation, AP and lateral X-rays showed that the steel plate and intramedullary nail were in favorable position, and continuous callus growth was observed **2p,2q,2r**. Eighteen months after operation, AP and lateral X-rays showed that the steel plate and intramedullary nail were in proper position and the fracture was completely healed **2s,2t**. The intramedullary nail and steel plate were completely removed, and the fracture healed well

劈裂及1例末端周围骨折均系阻挡钉使用过程中出现。故术前良好的手术计划,健侧弧度、直径的测定尤为重要,个性化订钉点能有效避免该情况发生。

#### 4.2 远端锁钉失准

远端锁定是髓内钉手术的难点,传统体外定位装置失败率29%~50%,随着软组织逐渐增厚,其准确率越低。芯钻采用高速内芯由髓内钉向外,经过皮质、筋膜穿出皮肤达到准确定位的效果,陶勇等<sup>[5]</sup>报道其准确率为95.27%,远端锁钉时间均<10 min。荆玉峰等<sup>[9]</sup>报道了15例芯钻髓内钉治疗股骨干骨折,优良率达100%。本组215例芯钻在使用过程中较传统锁钉具有操作时间短、准确率高、免透视的优点,但有13例患者出现内芯断裂,体内打折的情况,增加了手术时间及创伤。其原因及对策如下:(1)芯钻内芯在穿透皮质时需要极高的稳定性,轻微的晃动或皮质太厚长时间钻动均易导致内芯在皮质处断裂。内芯前进过程中匀速正钻致穿出皮肤,中途暂停也易使内芯于直角连接处断裂。本组5例中有2例由于皮质超过5 mm,内芯第二次穿皮质时断裂,1例由于电钻连接处未居中而出现晃动断裂;2例操作中暂停再继续时断裂。因此,操作时需严格检查连接杆各处,内芯进入前先在原地高速旋转观察稳定性,如有晃动待原因排除后再进行,芯钻前进过程中避免中途停止。(2)芯钻能轻易穿过皮质,但通过柔韧

的阔筋膜层时易改变方向。本组2例年轻患者术中可见内芯顺阔筋膜深面潜行至膝关节下方,切开后见阔筋膜发达,芯钻未能突破。6例年龄54~62岁患者内芯在突破阔筋膜时发生缠绕,松散的筋膜搅入高速转动的内芯而迅速打结,术中只能增加切口暴露后取出内芯,重新置钉。此外,8例出现内芯打卷的患者中有7例为侧卧体位,术中复位后未持续牵引。避免此并发症出现的方法可在芯钻使用过程中持续牵引保持筋膜紧张,也可体外定位杆确定内芯钻出的大致位置后使用药杯或针盒等局部施压。后期采用此方法后未再出现芯钻内芯偏离情况。

#### 4.3 骨折不愈合

髓内钉治疗股骨干骨折骨不连的发生率报道为0~20%<sup>[16-17]</sup>。闭合复位使骨折端的血运得到保护,但闭合复位或微创复位的理念强调的是复位,在复位前提下在进行微创或闭合操作,常有医生为了微创而忽略复位重要性,导致骨不连发生。Lin等<sup>[18]</sup>报道了50例B2-C3型骨折患者,骨折块距离超过1 cm的患者术后12个月随访仅有20%愈合,而骨折块翻转的患者有45%最后未愈合。应综合考虑患者因素选择复位方案,有限切开缩小骨折块间距离,纠正翻转骨块是必要的。术中选择向前敲击或回敲的方案使骨折端适度加压也有利于愈合。股骨旋转是闭合复位另一难题,Fang等<sup>[19]</sup>报道了88例股骨髓内钉

的 3 年随访,23%患者术后出现超过 10°的旋转,其中 2 例接受了翻修。闭合或微创复位目前主要采用透视法确定旋转,对比双侧股骨髁及小转子影像能大致了解股骨旋转情况,但操作具有局限性并需反复透视。采用标准侧位透视,两端骨皮质厚度相差在 6 mm 以内,术后旋转能控制在 10°内,其敏感性报道可达 98%。有效固定是保障骨折愈合的另一因素,Sanders 等<sup>[20]</sup>认为与髓腔匹配或直径 10 mm 的交锁髓内钉即可提供良好的固定。笔者体会是术前计划与术中扩髓情况相结合,髓内钉直径与术前髓腔最窄处皮质间距离误差不超过 2 mm。远近端骨折线距离锁钉在 5 cm 以内时近端选择股骨颈拉力螺钉,远端选择多平面螺钉并辅助阻挡钉提高稳定性。

综上所述,芯钻髓内钉治疗股骨干骨折能减少手术创伤,方便手术操作,降低术中患者及医护人员放射剂量,是股骨干骨折一种可选的治疗方法。过程中还存在感染、下肢旋转和短缩等并发症,其发生与普通髓内钉无异,术前详细计划、术中认真操作及术后尽早对症处理可降低其发生率。

参考文献

[1] 范克杰,陈柯,马文龙,等.器械辅助复位联合带锁髓内钉内固定术治疗复杂股骨干多段骨折[J].中国骨伤,2018,31(5):472-476.  
FAN KJ, CHEN K, MA WL, et al. Treatment of multi-segment fracture of complex femoral shaft with instrument-assisted reduction combined with intramedullary interlocking nail fixation[J]. Zhongguo Gu Shang/China J Orthop Trauma, 2018, 31(5):472-476. Chinese with abstract in English.

[2] Fan Y, Li YW, Zhang HB, et al. Management of humeral shaft fractures with intramedullary interlocking nail versus locking compression plate[J]. Orthopedics, 2015, 38(9):e825.

[3] Liu Y, Zheng Y, Shen Z, et al. Interlocking intramedullary nail fixation with additional bone grafting from trochanter via a femoral hollow trephine in the treatment of femoral shaft fractures: design and clinical application[J]. Int Orthop, 2017, 41(2):397-402.

[4] 蔡弢艺,陈志达,黄国锋,等.由内向外芯钻髓内钉技术治疗股骨干骨折[J].中国矫形外科杂志,2018,26(18):1643-1647.  
CAI TY, CHEN ZD, HUANG GF, et al. Core drilling intramedullary nail with inside-out technique for femoral shaft fracture[J]. Zhongguo Jiao Xing Wai Ke Za Zhi, 2018, 26(18):1643-1647. Chinese.

[5] 陶勇,江淳,田克超.芯钻远端锁定系统在髓内钉治疗股骨干骨折中的作用[J].中国组织工程研究,2019,23(36):5800-5805.  
TAO Y, JIANG T, TIAN KC. Effect of distal locking system with core drill in the treatment of femoral shaft fracture with intramedullary nail[J]. Zhongguo Zu Zhi Gong Cheng Yan Jiu, 2019, 23(36):5800-5805. Chinese.

[6] 陈志达,蔡弢艺,丁真奇,等.股骨髓内钉芯钻瞄准系统与体外瞄准架系统的远端锁定效果比较[J].骨科,2020,11(1):23-29.  
CHEN ZD, CAO TY, DING ZQ, et al. Comparison of core drilling intramedullary nail vs. in vitro targeting system for distal locking of femoral shaft fractures[J]. Gu Ke, 2020, 11(1):23-29. Chinese.

[7] Meinberg E, Agel J, Roberts C, et al. Fracture and dislocation clas-

sification compendium-2018[J]. J Orthop Trauma, 2018, 32(Suppl 1):S1-S170.

[8] 张占丰,闵继康,王丹,等.膝关节单髁置换术后隐性失血的结果分析[J].中国骨伤,2017,30(11):1013-1017.  
ZHANG ZF, MIN JK, WANG D, et al. Analysis on the occult blood loss after unicompartment knee arthroplasty[J]. Zhongguo Gu Shang/China J Orthop Trauma, 2017, 30(11):1013-1017. Chinese with abstract in English.

[9] 荆玉峰,刘京敏,叶发刚,等.芯钻髓内钉治疗股骨干骨折的疗效分析[J].实用骨科杂志,2017,23(3):265-266.  
JING YF, LIU JM, YE FG, et al. Analysis of the curative effect of cored drill intramedullary nail for femoral shaft fracture[J]. Shi Yong Gu Ke Za Zhi, 2017, 23(3):265-266. Chinese.

[10] Park KC, Oh CW, Byun YS, et al. Intramedullary nailing versus submuscular plating in adolescent femoral fracture[J]. Injury, 2012, 43(6):870-875.

[11] 吴峰,卢绍燊,叶志军,等.带锁髓内钉治疗股骨干骨折的并发症原因分析及预防[J].中国骨伤,2005,18(8):531-533.  
WU F, LU SS, YE ZJ, et al. Cause analysis and prevention of the complications of the femoral shaft fractures treated with interlocking nails[J]. Zhongguo Gu Shang/China J Orthop Trauma, 2005, 18(8):464-465. Chinese.

[12] Winquist RA, Hansen ST Jr, Clawson DK. Closed intramedullary nailing of femoral fractures. A report of five hundred and twenty cases[J]. J Bone Joint Surg Am, 1984, 66(4):529-539.

[13] Antonelli L. Closed intramedullary nailing of diaphyseal fractures of the femur. Problems related to anatomical variations of the greater trochanter[J]. Ital J Orthop Traumatol, 1989, 15(1):67-74.

[14] Ricci WM, Gallagher B, Haidukewych GJ. Intramedullary nailing of femoral shaft fractures: current concepts[J]. J Am Acad Orthop Surg, 2009, 17(5):296-305.

[15] Sadic S, Custovic S, Smajic N, et al. Complications and functional recovery in treatment of femoral shaft fractures with unreamed intramedullary nailing[J]. Med Arch, 2014, 68(1):30-33.

[16] Shroeder JE, Mosheiff R, Khoury A, et al. The outcome of closed, intramedullary exchange nailing with reamed insertion in the treatment of femoral shaft nonunions[J]. J Orthop Trauma, 2009, 23(9):653-657.

[17] Basumallick MN, Bandopadhyay A. Effect of dynamization in open interlocking nailing of femoral fractures. A prospective randomized comparative study of 50 cases with a 2-year follow-up[J]. Acta Orthop Belg, 2002, 68(1):42.

[18] Lin SJ, Chen CL, Peng KT, et al. Effect of fragmentary displacement and morphology in the treatment of comminuted femoral shaft fractures with an intramedullary nail[J]. Injury, 2014, 45(4):752-756.

[19] Fang C, Gibson W, Lau TW, et al. Important tips and numbers on using the cortical step and diameter difference sign in assessing femoral rotation-Should we abandon the technique[J]. Injury, 2015, 46(7):1393-1399.

[20] Sanders RW, Hassan RM, Allen Gorman, et al. Effect of nail size, insertion, and D canal-nail on the development of a nonunion after intramedullary nailing of femoral shaft fractures[J]. J Orthop Trauma, 2019, 33(11):559-563.