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Correlative Factors Research of Tibial Shaft Fracture with Ipsilateral Posterior Malleolar Crack Fractures

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ABSTRACT

Background: Missed diagnosis rate of spiral tibia shaft fracture with posterior malleolus crack fracture (PMCF) is high in the clinical. However, the mechanism and related factors of fracture are still unclear. Moreover, PMCF has been observed in other types of tibial shaft fractures. Objective: To explore the correlative factors of tibial shaft fracture with ipsilateral PMCF, decrease the rate of clinical missed diagnosis, strengthen the effective fixation of PMCF, and reduce the incidence of traumatic arthritis. Methods: From September 2014 to May 2019, we collected 137 tibiofibular fracture. Only 68 cases involved in ankle joint CT examination and were retrospectively analyzed. The patients were divided into posterior malleolus group (30 cases) and non-posterior malleolus group (38 cases) according to whether come up PMCF or not. The posterior malleolus group contained 24 males and 6 females, 27-77 (47.57±11.79) years old, the non-posterior malleolus group contained 23 males and 15 females, 18-85 (48.71±13.84) years old. The gender, age, location, fibula fracture and tibial shaft fracture classification were observed for univariate and multivariate analysis. Results: The probability of PMCF was higher with right tibial shaft fracture (OR=3.69 95%CI:1.13-12.08 P<0.05); the probability of PMCF following distal fibular fracture was higher than that without fibular fracture (OR=11.36 95%CI:1.72-75.05 P<0.05); the probability of PMCF with type A tibial shaft fracture was higher than type C (OR=4.82 95%CI:1.19-19.58 P<0.05). Conclusion: Right type A tibial shaft fracture accompanied by distal fibular fracture are very important factors related to PMCF, which needs highly attention to avoid clinical missed diagnosis.

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1. Introduction

Spiral fracture of the lower 1/3 of tibia combined with posterior malleolar crack fracture (PMCF), also known as Z-H fracture, was firstly reported by the team of Academician Yingze Zhang in China. This type of fracture has a special injury mechanism. It is reported that the clinical missed diagnosis rate can reach as high as 67.9%-91.2% [1]. The missed diagnosis of Z-H fracture could result in longer rest in bed and occurrence of traumatic arthritis of the posterior ankle for patients. We have observed many cases of non-spiral tibial shaft fracture with PMCF in the recent years. Interestingly, the related risk factors of tibial shaft fracture with PMCF are still unclear.

So, we started researching according to our previous observations on September 2019. This research retrospectively observed 137 cases of tibia and fibula fractures treated in our hospital from September 2014 to May 2019, including 30 cases of tibia shaft fracture with PMCF. The specific reports are as follows.

2. Basic Information

2.1 Case Collection

According to the ICD code of our hospital’s electronic case diagnosis, 9 diagnoses were retrieved by inputting the diagnosis with "tibia" as the key word. 363 patients were retrieved through the selection one by one. There were tibia fractures 144 cases, open tibia fracture 3 cases, tibia fracture involving the ankle joint 25 cases, tibia shaft fracture 9 cases, upper tibia fracture 3 cases, lower tibia fracture 11 cases, tibia and fibula closed fracture 37 cases, tibia and fibula shaft fracture 120 cases and lower tibia and fibula fracture 11 cases. The inclusion criteria are: (1) middle or middle and lower tibial fractures; (2) preoperative CT plain scan and three-dimensional reconstruction imaging data of the ipsilateral ankle joint; (3) CT sagittal position indicating PMCF, see Figure 1. The exclusion criteria are: (1) Tibial plateau fracture, ankle fracture and pilon fracture; (2) No posterior ankle CT scan image. Finally, 30 cases of tibial shaft fractures with PMCF were called posterior malleolus group, and 38 cases of tibial shaft fractures without PMCF were called non-posterior malleolus group for analysis according to the inclusion and exclusion criteria.

![Figure 1. CT Sagittal scan shows PMCF](image)

*Note: The red arrow is the crack fracture in posterior malleolus.*

2.2 General Situation

30 cases (male: 24 cases, female: 6 cases) in the posterior malleolus group, aged 27-77 (47.57±11.79) years old. Among the 30 cases, the left side fracture were 12 cases and the right side fracture were 18 cases, 28 cases combining fibula fracture (proximal: 13 cases, middle: 3 cases, distal: 12 cases), 2 cases without fibula fracture. According to the OA fracture classification, 18 cases were type 42-A (type 42-A1: 13 cases, type 42-A2: 5 cases), 5 cases were type 42-B (type 42-B1: 3 cases, type 42-B2: 1 case, type 42-B3: 1 cases) and 7 cases were type 42-C (type 42-C1: 5 cases, type 42-C3: 2 cases).

38 cases (male: 23 cases, females: 15 cases) in the non-posterior malleolus group, aged 18-85 (48.71±13.84) years old. Among the 38 cases, the left-side fracture were 25 cases and the right-side fracture were 13 cases, 27 cases combining fibula fracture (proximal: 9 cases, middle: 4 cases, distal: 12 cases), 11 cases without fibula fracture. In terms of classification, 17 cases were 42-A type (type 42-A1: 9 cases, type 42-A2: 4 cases, type 42-A3: 4 cases), 13 cases were 42-B type (type 42-B1: 8 cases, type 42-B2: 2 case, type 42-B3: 3 cases) and 8 cases were 42-C type (type 42-C1: 6 cases, type 42-C2: 0 case, type 42-C3: 2 cases).

2.3 Treatments

All included patients were treated with plate and screws.
Preoperative CT showed PMCF in 18 patients in the posterior malleolus group, 17 cases received effective internal fixation, 15 cases were fixed with distal tibial anatomical plate, 2 cases were fixed with hollow screws, the reason of why 1 case was not fixed is unknown. 12 cases with PMCP were not found before but after operation, which were lack of effective internal fixation. The rate of missed diagnosis is as high as 40%.

2. Research Methods

Related factors and occurrence of PMCF were analyzed by appropriate methods. Firstly, the gender, age, side of fracture, tibial fracture classification and fibula fracture location of cases in two groups were analyzed one by one. Secondly, based on the above results, the side of fracture, tibia fracture classification, fibula fracture location were analyzed by multi-factor correlation analysis.

3. Statistical Analysis

The research used SPSS 22.0 software to process the data and set P<0.05 as statistically significant, set 0.05/6 as statistically significant at 2*C chi-square test. The independent-sample t test was used for the analysis of continuous variables. The chi-square test was used for the defined variables. The binary logistic regression equation was used for multivariate analysis.

4. Results

We found the primary results through the univariate in two groups. There was no significant difference in age, gender, fibula fractures, and tibial fracture types between the two groups (all P>0.05), see Table 1, Table 2 and Table 3. In the posterior malleolus group, 18 cases (60%) occurred on the right side in the 30 case. However, only 13 (34.2%) right-side cases were seen in non-posterior malleolus fractures group. The difference between the left and right sides of the patients with whether posterior malleolus fractures was statistical significance (χ²=4.50, P=0.03), see Table 1. Multivariate regression analysis showed that the probability of occurrence of PMCF on the right side was higher (OR=3.69 95%CI: 1.13-12.08). That the rate was 3.69 times that of the left side, which was statistically significant. Furthermore, it is found that the probability of PMCF for type 42-A fractures is higher (OR=4.82 95%CI: 1.19-19.58) from the classification. PMCFs for type A are 4.82 times type C, which has statistics significance, see Table 4.
Table 4. Multivariate Analysis of fracture side, fibula fracture and tibial shaft fractures classification

<table>
<thead>
<tr>
<th>Factor</th>
<th>P</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side</td>
<td>0.03</td>
<td>3.69</td>
<td>1.13-12.08</td>
</tr>
<tr>
<td>No</td>
<td>0.09</td>
<td>1</td>
<td>NA</td>
</tr>
<tr>
<td>Distal</td>
<td>0.01</td>
<td>11.36</td>
<td>1.72-75.05</td>
</tr>
<tr>
<td>Middle</td>
<td>0.39</td>
<td>1.74</td>
<td>0.50-6.09</td>
</tr>
<tr>
<td>Proximal</td>
<td>0.73</td>
<td>1.39</td>
<td>0.23-8.84</td>
</tr>
<tr>
<td>Tibial fracture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type A</td>
<td>0.02</td>
<td>4.82</td>
<td>1.19-19.58</td>
</tr>
<tr>
<td>Type B</td>
<td>0.20</td>
<td>2.55</td>
<td>0.60-10.76</td>
</tr>
<tr>
<td>Type C</td>
<td>0.08</td>
<td>1</td>
<td>NA</td>
</tr>
</tbody>
</table>

Note: P<0.05/3 means statistically significant. NA means that the data is not obtained.

5. Discussion

Tibial shaft fractures and ankle fractures are clinically more common, but tibial shaft fractures combined with posterior malleolus crack fractures (PMCF) are relatively rare and have not attracted the enough attention of clinicians. It is reported that missed diagnosis rate is as high as 67.9%-91.2% [6][8][9]. PMCF, without significant displacement, appears as an independent bone. Its fracture line extends into the articular surface, which is not continuous with the tibial shaft fracture. In 2006, Hou et al reported 5 cases of missed PMCF in 7 tibial shaft fracture cases for the first time in China. The missed diagnosis rate was 71.4% [9]. In 2007, Zhang et al. [11] reported 28 PMCF cases in a retrospective study of 1685 adult tibia and fibula shaft fractures. The missed diagnosis rate of radiology department was 67.9% (19/28), and the missed diagnosis rate of orthopedists was 53.6% (15 /28). Since it was observed that the PCMF was a single part that stay away from tibia fracture, this feature fracture was named as Zhang-Hou fracture, or Z-H fracture by Professor Zhang [7]. The main reason for the high missed diagnosis rate of Z-H fractures is the insufficient understanding and more concentration on the displaced tibial fractures. Therefore, the hidden crack fractures of the posterior malleolus are ignored.

At present, it is believed that the mechanism of PMCF is mainly as follows: the first, posterior tibiofibular ligament is pulled strongly by an internal rotation force to cause the fracture; the second, after foot is fixed, posterior malleolus shears with talus to cause the fracture when body continues to move forward due to inertia; the third, once ankle joint is subjected to torsional stress and vertical stress, which contribute to talus hits the posterior ankle backward and upward to cause the fracture [6][8][9]. However, it is difficult to evaluate the characteristics and mechanism of violence according to the patient’s description. Among the 30 patients with PMCF in our study, 12 cases were not fixed that bring about the forty percent missed diagnosis rate. In order to conduct a controlled study, all the patients included underwent CT examination of the ankle joint. we firmly believe the rare of missed PMCF who did not undergo CT examination may be higher. Therefore, in order to help reduce the missed cases of Z-H fracture, it is very necessary to evaluate the related factors about the occurrence of tibial shaft fractures with ipsilateral PMCF by multi-factor statistical method.

It is a common state that the line's level of fibula fracture is higher than that of tibia fracture that shows spiral pattern by the simple rotational violence that passes from the inside to the outside along the tibia. Different from the usual sense, Hou et al. [6] reported level of fibula fracture line of 4 cases were lower than tibial fracture line, and another 3 cases’ level of fibula fracture line were higher than that. It is also reported that the level of fibula fractures was different in 17 cases (Wang et al. [10]), 20 case (Tsai et al. [13]) and 96 cases (Hou et al. [12]). This study defined the area 6 cm above the Syndesmosis as the distal fibula, the area 6 cm below the fibula head as the proximal fibula and the remaining part as the middle fibula. Through the multivariate regression equation, it was found that the tibial shaft fracture with distal fibula fracture had a higher probability of PMCF. Therefore, we assume that the mechanism of PMCF does not rule out the relationship with the distal fibula fracture, which requires further confirmation by biomechanical studies certainly.

Z-H fracture represents tibial spiral fracture. There is an internal relationship between tibial spiral fracture and posterior malleolus fracture. The contact could be found from many literatures about this topic. Wang et al. [10] reported that 17 PMCF cases were seen in all tibial spiral fractures; Jung et al. [13] reported 71 cases of tibial shaft fracture, of which 47 (64.7%) had posterior malleolus fractures at the same side. It is statistically significant that tibia spiral fracture happened with posterior malleolus fractures more easily. Tsai et al. [11] reported 20 cases of posterior malleolus fracture, of which 19 cases had tibial spiral fractures at the same side. Hou et al. [12] reported that 96 tibial fractures combined with posterior malleolus fractures were spiral fractures, of which 82 cases (85.4%) were type 42-A1 and 14 cases (14.6%) were type 42-B1. This study reported 30 cases of tibial fractures with PMCF, of which 13 cases (43.3%) were type 42-A1, 3 cases (10%) were type 42-B1. Spiral tibial fractures accounted for 53.3%. Mitchell et al. [14] recently reported 122 cases of tibial shaft spiral fractures, of which 84 cases (68.9%) extended to ankle joint and 59 cases (48.4%) occurred posterior malleolus fractures, nearly half of them. However, none of the above-mentioned literatures have observed that tibia fractures were related to PMCF.

The observation of tibial shaft fractures was only re-
ported by Huang et al. [3], who pointed out that the site, length and morphology of tibial shaft fracture have an impact on posterior malleolus fractures. In this study, AO classification was used to classify tibial shaft fractures for analysis. Through multivariate regression analysis, it was found that simple type of tibia fracture has a higher probability of ipsilateral PMCF. Simple type fracture mostly originates from low-energy violence such as rotational or torsional violence. Studies have confirmed that PMCF is mostly caused by low energy and indirect violence [4,7,15], so indirect violence caused by rotation and torsion may be one of the causes of PMCF. The authors believe that PMCF requires violence or external force with a long duration or long range of action. However, this study cannot explain that spiral tibial fractures are statistically significant compared to other types with PMCF based on the conditions of the included patients. This may be different from the results of other literature. At the same time, this study found that the right tibia fracture caused a higher probability of PMCF, which was statistically significant. Based on the above research results, the authors propose that patient with simple tibial shaft fractures and distal fibula fractures should be recommended to make the CT Scan of ankle joint. Doctors are better to learn to judge whether it combines PMCF. If there is PMCF, strong internal fixation would be required to prevent traumatic arthritis. In addition, pay attention to the situation of posterior malleolar fracture when the right tibia fractures.

This study also has the following shortcomings: (1) there may be some bias in the results because of the retrospective single-center study; (2) The inadequate cases may have a bias impart on the results of research. The reason of inadequate cases derives from the strict inclusion and exclusion criteria in order to assure the comparability of cases in two groups.

References