Evaluation of the trauma and bone metabolism after internal absorbable screw and metal screw fixation treatment of tibia–fibula fracture

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Objective: To study the trauma and bone metabolism after internal absorbable screw and metal screw fixation treatment of tibia-fibula fracture. Methods: 78 patients with tibia-fibula fracture who received internal fixation surgery in our hospital between May 2013 and October 2015 were selected and randomly divided into absorbable group and metal group (n=39) who accepted internal absorbable screw fixation and internal metal screw fixation respectively. 3 d after operation, serum was collected to determine the levels of inflammatory factors, pain mediators, stress hormones and bone metabolism indexes. Results: Serum inflammatory mediators procalcitonin (PCT), Resistin, C-reactive protein (CRP), interleukin-6 (IL-6), and tumor necrosis factor-α (TNF-α), pain mediators substance P (SP), prostaglandin E2 (PGE2) and NPY, stress hormones norepinephrine (NE), epinephrine (E) and cortisol (Cor) as well as bone resorption marker molecules C-terminal telopeptides of type I collagen (CTX-I) and C-terminal telopeptides of type II collagen (CTX-II) levels of absorbable group were significantly lower than those of metal group (P<0.05) while bone formation marker molecules N-MID osteocalcin (N-MID) and N-terminal propeptide of procollagen type I (PINP) levels were significantly higher than those of metal group (P<0.05). Conclusions: The trauma degree of internal absorbable screw fixation treatment of tibia-fibula fracture is weaker than that of internal metal screw fixation, and the bone metabolism activity is better than that of internal metal screw fixation.

1. Introduction

Tibia-fibula fracture is a more severe type of clinical limb fracture, it is mostly accompanied by talar-ankle fracture or damage, and surgical reduction and internal fixation are needed for treatment. Metal screw is the most common internal fixation material for internal fixation treatment of tibia-fibula fracture, which can effectively reconstruct the anatomical structure of the fracture end and maintain the stability of the talar-ankle joint[1,2]. Tibia-fibula itself, however, has poor blood supply and less soft tissue coverage, the trauma caused by the internal metal screw fixation will further cause blood supply and soft tissue injury, and the risk of postoperative screw breaking or loosening is bigger; in addition, another operation is needed to take out the metal screw after internal fixation, and it will cause the local secondary trauma, and is not conducive to fracture healing. Absorbable screw is a new internal fixation material developed in recent years, it is with good biocompatibility and exact fixation strength, the internal fixation material will be degraded and absorbed in the process of fracture healing, and there is no need for secondary surgery to take it out[3,4]. In the following study, the differences between internal absorbable screw and metal screw fixation treatment of tibia-fibula fracture were analyzed from the perspectives of the trauma degree and bone metabolism.

2. Materials and methods

2.1. Research subjects
78 patients with tibia-fibula fracture who received internal fixation surgery in our hospital between May 2013 and October 2015 were selected as the research subjects, and all patients had a clear history of trauma, were clearly diagnosed with tibia-fibula fracture united instability by imageological examination after admission, and met the surgical indications of open reduction and internal fixation. Random number table was used to divide the included patients into absorbable group and metal group, 39 cases in each group. Absorbable group received internal absorbable screw fixation, including 28 male cases and 11 female cases that were 22–63 years old; metal group received internal metal screw fixation, including 27 male cases and 12 female cases that were 21–65 years old. The two groups of patients were not significantly different in general information \((P>0.05)\).

### 2.2. Treatment methods

Both groups of patients accepted internal fixation surgery performed by the same group of doctors, operation opportunity was selected according to the local body situation after admission, those without significant local soft tissue swelling accepted emergency surgery, those with obvious swelling accepted external traction in advance and receive surgery after the swelling subsided. The methods are as follows: patients received surgery under the general anesthesia or continuous epidural anesthesia, the affected-side hip was slightly lifted, tourniquet was applied, a posterior margin fibula incision was made in lateral malleolus and a posterior margin arc incision was made in medial malleolus to expose the fracture end, then manual reduction and temporary fixation were performed, inline fixation was performed after intraoperative X-ray fluoroscopy showed that the reduction was good, poly lactide all-thread absorbable screws were applied in absorbable group, titanium alloy all-thread cortical bone screws were applied in metal group, X-ray fluoroscopy was conducted again after the exact fixation, drainage was placed and the incision was closed after fixation materials were in place.

### 2.3. Serum index detection methods

3 d after operation, 5 mL of peripheral blood sample was collected from two groups of patients and centrifuged to separate serum, and then the enzyme-linked immunosorbent assay kits were adopted to determine procalcitonin (PCT), Resistin, CRP, IL-6 and TNF-\(\alpha\) between two groups of patients is as follows: serum inflammatory mediators PCT, Resistin, CRP, IL-6 and TNF-\(\alpha\) levels of absorbable group were significantly lower than those of metal group \((P<0.05)\) (Table 1).

### 3. Results

#### 3.1. Postoperative serum inflammatory mediator levels of two groups of patients

3 d after operation, analysis of serum inflammatory mediators PCT, Resistin, CRP, IL-6 and TNF-\(\alpha\) between two groups of patients is as follows: serum inflammatory mediators PCT, Resistin, CRP, IL-6 and TNF-\(\alpha\) levels of absorbable group were significantly lower than those of metal group \((P<0.05)\) (Table 1).

#### 3.2. Postoperative serum pain mediator levels of two groups of patients

3 d after operation, analysis of serum pain mediators SP, PGE2 and NPY between two groups of patients is as follows: serum pain mediators SP, PGE2 and NPY levels of absorbable group were significantly lower than those of metal group \((P<0.05)\) (Table 2).

#### 3.3. Postoperative serum stress hormone levels of two groups of patients

3 d after operation, analysis of serum stress hormones NE, E and Cor between two groups of patients is as follows: serum stress hormones NE, E and Cor levels of absorbable group were

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**Table 1**

Comparison of serum inflammatory mediator levels between two groups of patients after operation \((n=39, \pm x)\).

<table>
<thead>
<tr>
<th>Groups</th>
<th>PCT (ng/mL)</th>
<th>Resistin (ng/mL)</th>
<th>CRP (μg/mL)</th>
<th>TNF-α (pg/mL)</th>
<th>IL-1β (ng/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absorbable group</td>
<td>1.00±0.24</td>
<td>17.68±2.03</td>
<td>7.51±0.93</td>
<td>14.59±1.58</td>
<td>3.89±0.56</td>
</tr>
<tr>
<td>Metal group</td>
<td>1.52±0.15</td>
<td>30.35±4.58</td>
<td>12.38±1.45</td>
<td>22.32±3.09</td>
<td>7.76±0.91</td>
</tr>
<tr>
<td>(t)</td>
<td>7.039</td>
<td>8.798</td>
<td>9.019</td>
<td>8.273</td>
<td>10.336</td>
</tr>
<tr>
<td>(P)</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

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**Table 2**

Comparison of serum pain mediator levels between two groups of patients after operation \((n=39, \pm x)\).

<table>
<thead>
<tr>
<th>Groups</th>
<th>SP (μg/mL)</th>
<th>PGE2 (pg/mL)</th>
<th>NPY (pg/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absorbable group</td>
<td>5.92±0.77</td>
<td>132.52±16.96</td>
<td>175.32±22.03</td>
</tr>
<tr>
<td>Metal group</td>
<td>8.75±0.92</td>
<td>203.69±26.71</td>
<td>242.36±29.16</td>
</tr>
<tr>
<td>(t)</td>
<td>7.938</td>
<td>8.691</td>
<td>7.115</td>
</tr>
<tr>
<td>(P)</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>
significantly lower than those of metal group ($P<0.05$) (Table 3).

Table 3
Comparison of serum stress hormone levels between two groups of patients after operation ($n=39, \overline{x} \pm s$).

<table>
<thead>
<tr>
<th>Groups</th>
<th>NE (ng/mL)</th>
<th>E (ng/mL)</th>
<th>Cor (ng/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absorbable</td>
<td>42.32±6.86</td>
<td>33.45±5.61</td>
<td>11.32±1.63</td>
</tr>
<tr>
<td>Metal group</td>
<td>79.15±9.25</td>
<td>57.86±7.14</td>
<td>18.69±2.05</td>
</tr>
<tr>
<td>$t$</td>
<td>8.598</td>
<td>8.183</td>
<td>9.038</td>
</tr>
<tr>
<td>$P$</td>
<td>$&lt;0.05$</td>
<td>$&lt;0.05$</td>
<td>$&lt;0.05$</td>
</tr>
</tbody>
</table>

3.4. Postoperative serum bone metabolism index levels of two groups of patients

3 d after operation, analysis of serum bone metabolism indexes N-MID, PINP, CTX-I and CTX-II between two groups of patients is as follows: serum N-MID and PINP levels of absorbable group were significantly higher than those of metal group while CTX-I and CTX-II levels were significantly lower than those of metal group ($P<0.05$) (Table 4).

4. Discussion

Internal metal screw fixation is commonly used in the clinical treatment of tibia-fibula fracture, the internal fixation strength of metal screw is exact, but its biocompatibility is poor and a second surgery is needed to remove the internal fixation materials, and therefore, the overall level of trauma is big and fracture healing process would also be affected. Absorbable screw is the newly developed internal fixation material, its fixation strength is weaker than that of metal screw, but it is enough to meet the needs for internal fixation of tibia-fibula fracture; compared with metal screws, absorbable screws are made of biomedical polymer materials, they are with good biocompatibility and can be gradually degraded and absorbed in the process of fracture healing, and no secondary surgery is required to take out the internal fixation materials, which avoids the secondary trauma[5,6]. Studies have shown that the effect of absorbable screws for internal fixation of tibia-fibula fracture combined with talar-ankle fracture is better than that of metal screw, fracture healing is faster and the complications are fewer[7,8]. However, the change trend of related molecule levels in fracture healing process is not yet clear at present after absorbable screw and metal screw fixation treatment of tibia-fibula fracture.

In the study, the differences between internal absorbable screw and metal screw fixation treatment of tibia-fibula fracture were analyzed from the perspectives of the trauma degree-related molecules and bone metabolism-related molecules.

Operation trauma and the rejection reaction caused by internal fixation material indwelling in the body will activate the body’s inflammatory response to different extent, and cause the secretion and release of a variety of inflammatory mediators into the blood circulation. As a result, serum inflammatory mediator levels can reflect the trauma degree after internal fixation with different materials. Resistin is derived from the activated mononuclear macrophages, which significantly increases in the process of acute inflammatory response and can activate the inflammatory response mediated by NF-κB; PCT is the inflammatory medium synthesized and secreted by thyroid parafolicular cells, and it can sensitively reflect the degree of inflammation reaction; CRP is nonspecific acute phase reaction protein that reflects inflammatory reaction degree, and external trauma factors can stimulate the synthesis and secretion of CRP; TNF-α and IL-1β play a proinflammatory role in the process of inflammation, and can activate a variety of inflammatory cells and cause the cascade activation and amplification of the inflammatory response[9,10]. In the study, analysis of the serum inflammatory mediator levels between two groups of patients after treatment showed that serum PCT, Resistin, CRP, IL-6 and TNF-α levels of absorbable group were significantly lower than those of metal group ($P<0.05$). This means that absorbable screws cause a lesser degree of trauma in internal fixation, and besides, the material has good biological compatibility, and the degree of postoperative rejection reaction is also lighter.

In the fracture healing and recovery process after the internal fixation surgery, the good biocompatibility between internal fixation materials and the body's soft tissue is conducive to fracture end healing, and it reduces the local soft tissue swelling and pain caused by poor compatibility. Under the continuous action of internal fixation materials, SP, PGE2, NPY and other peripheral neurotransmitters that are synthesized and secreted in local tissue can transmit pain signals to the central nervous system and increase the peripheral tissue sensitivity to pain signals. In the study, analysis of the serum pain neurotransmitter levels showed that serum SP, PGE2 and NPY levels of absorbable group were significantly lower than those of metal group[11]. This means that after the absorbable screw fixation, the stimulation to local soft tissue is smaller, and the

Table 4
Comparison of serum bone metabolism index levels between two groups of patients after operation ($n=39, \overline{x} \pm s$).

<table>
<thead>
<tr>
<th>Groups</th>
<th>Bone formation indexes (ng/mL)</th>
<th>Bone resorption indexes (pg/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N-MID</td>
<td>PINP</td>
</tr>
<tr>
<td>Absorbable</td>
<td>15.52±1.89</td>
<td>37.65±5.61</td>
</tr>
<tr>
<td>Metal group</td>
<td>8.93±0.94</td>
<td>22.04±2.95</td>
</tr>
<tr>
<td>$t$</td>
<td>8.498</td>
<td>8.182</td>
</tr>
<tr>
<td>$P$</td>
<td>$&lt;0.05$</td>
<td>$&lt;0.05$</td>
</tr>
</tbody>
</table>
synthesis and secretion of pain neurotransmitters are less, which is helpful to reduce the level of pain in local fracture. The pain in local fracture and the incision can increase the body’s stress response, characterized by the increased sympathetic nervous system activity and HPA axis activity. Sympathetic activation can cause adrenal medulla to secrete NE and E, HPA axis activation can cause adrenal cortex to secrete Cor, and analysis of the stress hormone levels in the study showed that serum NE, E and Cor levels of absorbable group were significantly lower than those of metal group (P<0.05). This means that the body’s stress response after internal absorbable screw fixation is weaker than that after internal metal screw fixation.

Fracture healing process depends on the bone formation process mediated by osteoblasts and the bone resorption process mediated by osteoclasts, and when bone formation is more than bone resorption, new bone tissues are continuously formed and promote the fracture end healing[12]. The main feature of osteoblast-mediated bone formation process is continuous formation and accumulation of collagen and non-collagen in bone tissue, N-MID is a specific non-collagen secreted by osteoblasts, and it deposits in the fracture end and forms new bone tissue; PINP is the by-product when osteoblasts secrete collagen fibers and accumulate in bone matrix, and it can reflect the activity of bone formation[13,14]. Osteoclasts mainly mediate the degradation of collagen in bone matrix, CTX-I and CTX-II are the degradation products of collagens in different parts, and they can reflect the activity of bone resorption mediated by osteoclasts[15,16]. In the study, the analysis of the bone metabolism index levels showed that serum N-MID and PINP levels of absorbable group were significantly higher than those of metal group while CTX-I and CTX-II levels were significantly lower than those of metal group (P<0.05). This means the activity of osteoblast-mediated bone formation process after internal absorbable screw fixation is higher than at after internal metal screw fixation, and the activity of osteoclast-mediated bone resorption process is weaker than that after internal metal screw fixation.

To sum up, the trauma degree after internal absorbable screw fixation treatment of tibia-fibula fracture is weaker than that after internal metal screw fixation. Fracture fixation devices.

References