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Kyoto University
A Comparative Study of Biomechanical Property of Küntscher Nail and Otte-Plansee Nail.

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Introduction

The disadvantages of the conventional intramedullary nail caused OTTE’s impulse to think over the principle of nailing7,8). The purpose of his work was to develop a nail of higher rotation stability with a modified geometrical shape. Besides, the fracture healing should be improved by the appropriated selection of implant material and the operation process should be simplified by the development of new tools2,3,6,10,11). By selecting a closed cross section with 6 sharp-edged longitudinal slides each representing 1/12 of a circle, the rotation stability should be improved against the conventional steel nail. The grooves between the longitudinal slides permit a quick revascularisation of the endosteal bone. By selecting this geometrical shape, KÜNTSCHER’s principle9 of elastic clamping in sense of a transverse clamping was consciously given up for the following reasons while keeping us the longitudinal clamping:

To achieve a sufficient stability of the nail, trephining the medullary space and the subsequent driving-in of the nail is today considered as favorite method. An elastic transverse clamping of the KÜNTSCHER intramedullary nail after trephining the medullary space is only in the area of distal metaphysis theoretically possible, as a complete trephining in the distal spongious area is not performed usually. According to our test data, an elastic transverse clamping requires a range in which the spongious bone would be destroyed; this means that the spongious bone is not able to resist sufficiently against the cloverleaf-shaped KÜNTSCHER nail during the driving-in to make an elastic transverse clamping possible.

Material and Method

To examine the rotation stability, the right and left femur of cadavers were removed in pairs. After roentgenological examination, the trephining of the medullary space was performed in the typical way. Subsequently an osteotomy was done in the medium third of the shaft; on the one side an Otte Plansee nail8,9) and on the other side a Künitscher nail were intramedullary driven in.

Key words. Femoral fracture, Künitscher nail, Otte-Plansee nail, Niob, Rotation stability.

索引語：骨折，髖内釘，Niob，回旋安定性

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Fig. 1. Scheme of total apparatus for the recording.

Fig. 2. Scheme of the fixator of the nail.
Both nails showed the same circumference measured with a slide gauge. The medullary space was trephined up to a diameter corresponding to the driven-in nails. To insert the preparation into the measuring device, the femur was completely embedded in plaster cast so that a square block resulted from which the proximal medullary nail protruded 6 cm.

The square gypsum block was now tightly inserted. The proximal free end of the medullary nail was also tightly inserted and additionally connected to a motor-driven lever rotating the medulla nail within the femur. The system was connected to a recorder which drew the path covered by the lever in mm related to the required force in N.

Results

The authors recorded two diagrams from each test where the force expressed in Newton was related to the path covered by the lever in mm.

The torque $M$ is the distance $r$ from the center of rotation, multiplied with the applied force $F$ and the sinus value of the twisting angle $\zeta$.

The resulting measured values are shown on figures 3–9.

Then the torque at the moment of the first relevant nail rotation in the medullary space was calculated. Here the covered path is neglectable small. Also, the fact that the distance to the center of rotation changes with longer pathes is not to be considered so that the torque at the first relevant nail rotation is calculated by the following formula:

$$M = Fr \sin \zeta$$

Fig. 3. Experiment 1 and result.
Fig. 4. Experiment 2 and result.

Fig. 5. Experiment 3 and result.
Fig. 6. Experiment 4 and result.

Fig. 7. Experiment 5 and result.
Fig. 8. Experiment 6 and result.

Fig. 9. Experiment 7 and result.
Table 1. Results of each experiment.

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<tr>
<th>EXPERIMENT NO.</th>
<th>STRENGTH (N)</th>
<th>ROTATION MOTOR (N, cm)</th>
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<tr>
<td></td>
<td>Küntscher</td>
<td>Otte</td>
</tr>
<tr>
<td>1</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
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<td>3</td>
<td>75</td>
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<td>5</td>
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<td>108</td>
</tr>
<tr>
<td>6</td>
<td>72</td>
<td>110</td>
</tr>
<tr>
<td>7</td>
<td>80</td>
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\[ M (N^0 m) = F (N)^{−0.7} r (m) \] (Table 1)

Discussion

During the forty years of experiences with the intramedullary nailing, as it was inaugurated by Küntscher in 1940, precise indications have been worked out so that optimum results can be achieved with this method of fracture treatment.

In the sense of a strict indication for medullary nailing, transverse fractures with a small wedge in the medium third of the shaft of the lower extremity are to be considered. The indication can be extended to comminuted fractures, bending fractures with a long wedge as well as stepwise fractures in the medium third of the shaft, fractures which are proximal and distal of the medium third and open fractures of second and third degree. With the extended indication for intramedullary nailing, some disadvantages, especially as far as stability is concerned, are accepted, in order to benefit from the advantages of intramedullary nailing. These are: minimalization of the operative invasion by closed and fracture remote procedure. Recent reviews of the medullary nailing principle mainly deal with technical modifications in the field of nail geometry and tools in order to achieve improvements concerning the stability of the fracture to be treated and simultaneous minimalization of the operative invasion.

By OTTE’s introduction of nail geometry with 6 longitudinal slides on the surface digging themselves into the bone, an essential precondition for stability—the bone-material contact—is set, even for cases done without trephining of the medullary space, as it is propagated especially by Arends. The biomechanical examinations on rotation stability show a considerable range of the resulted data which indicate that beside the nail geometry especially the operation technique and the nail strength have a relevant influence on the stability to be achieved. Although there are only particular points available, there is an evident tendency that the longitudinal slide nail holds tight again in the bone after a certain rotation which can be seen from the continuous increase of the curve. After a rotation of the cloverleaf-shaped nail, the risk of stronger twisting seems to be higher than with the longitudinal-slide nail which can be seen from the curve parallel to the path axis. For the practice, this means that the danger of rotation falses is about the same with both kinds of nails. The risk of a clinically relevant rotation failure,
however, seems to be higher with the cloverleaf-shaped nail. Not considered is the fact that because of inserting the longitudinal slides into the bone it is unnecessary to trephine it by 1 mm over the nail’s diameter which increases the stability without taking the higher risk of breaking the shaft.

A basic principle which was claimed by KÜNTSCHER—minimalization of the operative invasion—can be fulfilled by using the longitudinal-slide nail with simultaneously improved stability.

This can be useful especially in cases of the so called extended indication, as we have seen with stepwise fractures and fractures with a larger wedge in the medial third of the femur.

References
和文抄録

髄内釘固定法における生体力学的研究 —Küntscher 釘および Otté-Plansee 釘との比較検討—

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髄内釘のデザインを改良して骨折固定部に働く回旋力に対して強い幾何学的特徴を持ち, 生体内における組織反応のより少ない, そして長期使用に耐えられるような髄内釘の開発を試みた. 使用した材料は Niob という純金属であり, 元素記号 Nb, 原子番号41. 周期律表第V族の金属元素でニオビウムともいわれる. 天然にはコロンブ石, タンタル石などにタンタルとともに産出する. 展延性に富み, 腦・アルカリ・王水に安定で, 耐熱合金材料や不鏽鋼の成分金属として利用され, 原子炉にも使われる. われわれの研究では生体内の異物反応が少なく, かつ金属腐食による変化がほとんどないことが証明されている. 本実験ではMünchen大学 Biomechanik研究室との協同により大髄骨モデルを作成して従来のKünscher 釘と本髄内釘とを挿入し, 回旋力を加えてその抵抗力を記録した. 本髄内釘の面は閉鎖されており, 6 個の滑走路をもち, それぞれの滑走路には円の1/12の辺を有し, その辺線は銳い角を作っている. 各々の滑走路の間には円形に窪んだ滑り溝を作り, 骨髄海綿質内において髄内釘の血管を含む組織の再生のための余地を作っている. これは回旋力に対する安定性を得るための形態である. 本実験によると, 本髄内釘はクローバ型のKünscher 釘と比較して, 回旋力に対するかなりの高度の安定性があることを認めた. デザインと材質の改良により髄内釘の適応拡大を計り, 実験的に良好な固定性と素材性を有していることを証明した.