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A Clinical Study on Ender's Nailings in Pertrochanteric Fractures

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In elderly patients with pertrochanteric fractures, there are two difficult things encountered in treatment as follows: On the one hand, there occur many associated diseases and very porotic bone and on the other hand, the fracture site is especially subjected to higher stress-bending moment force. These contribute mainly to postoperative complications.

The immobilization for the elderly often leads to severe complications (pneumonia, decubitus etc.) and finally to death within a short time. We regard that earlier mobilization along with internal fixations reduce the mortality much better than conservative treatments up to now.

Before starting treatment using Ender's nailings, we treated trochanteric fractures with the McLaughlin nail-plate or the A-O blade-plate. Those methods required us to open the fracture site in spite of the risk of infections and other surgical damage. We were confronted with complications such as loosening of the nail-plate junction and breaking of the porotic femoral head or cortical bone because of the rigid nail. When medial disaster existed or medial buttress was lost, it was very difficult to determine the timing of full weight bearing.

Dr. Shikita introduced this method to our clinic after studying with Prof. Dossa of Montpellier Medical School of Montpellier Uni. in France^{15,16)}. We confirmed Ender's nailings as suitable for pertrochanteric fractures and gradually extended the treatment to include subtrochanteric fractures and metastatic fractures of the upper femur, pseudoarthrosis caused by other preceding internal fixation devices.

The purpose of this study was to analyze the clinical consequences of the fractures treated by the Ender method and mention some backgrounds for technical errors.

Patients and Method

During the period from September 1974 to September 1981, 112 cases were treated by the Ender method. The median age of the patients was 73.9 years old (range 33-90) and male 29/112 (26%) female 83/112 (74%). The fractures were classified from primary X-rays according

Key words: Internal fixation, Femoral neck, Fracture, Ender's nailing, Femur.

索引語: 大腿頸部骨折, エンダー (Ender) 法, 髓内固定法, 大腿骨, 内固定法.

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to Ender's classification (Ender, 1978)³⁾; Gaping type I, II, III, Impacted type IV. The fractures were followed up until bony union or technical failures occurred. Technical failures and other complications could be listed as early death within one month postoperatively, infection, varus deformity, penetration, backingout of nails and supracondylar fractures. Reoperations and knee discomfort rate were also recorded. In 1978 we were able to get the original instruments and nails. In 1981 we were able to use the bi-plane bending instrument which Kuderna recommended^{1,8)}.

Results

The results of treatment by the Ender method are shown in Table 1. The types of fractures were classified into type I 46/112 (41%) type II 37/112 (33%) type III 5/112 (4.5%) type IV 15/112 (13.5%) and others 9/112 (8%).

Among the others classified, two pseudoarthrosis and two reoperations treated primarily by other devices and one metastatic fracture were contained.

We had no cases with postoperative skeletal traction except for subtrochanteric fractures. There was no non-union in our series. We had no avascular necrosis of femoral head. We used prophylactic antibiotics routinely but no anticoagulants against deep vein thrombosis.

Complications

The complications are listed in Table 2. The mortality was 3/112 (2.7%). Neither superficial nor deep infections were encountered. Varus deformity-secondary displacement mostly with nail's backing out was encountered in 18 cases (16%), and reoperations were performed in 10/18 cases. These consisted of 8 reinsertions and two other methods (T.H.R.). There were

Table 1. The results of treatment by the Ender method

Year	Male	Female	Types of fractures				
			I	II	III	IV	Others
1974	1	4	2	2			1 sub
1975	9	16	10	7	2	4	1 sub* ¹ 1 intracaps
1976	2	10	5	5	1	0	1 sub
1977	4	12	5	6	1	3	1 sub* ²
1978	1	12	7	3	0	3	0
1979	5	8	5	3	1	2	1 sub* ³ 1 meta
1980	4	12	6	7	0	2	1 sub
1981	3	9	6	4	0	1	1 sub* ⁴
Total	29	83	46	37	5	15	9 (7 sub 2)

*¹ PSEUDOARTHROSIS primary operation A-O blade-plate

*² REOPERATION primary operation McLaughlin nail-plate

*³ PSEUDOARTHROSIS primary operation Küntscher nail

*⁴ REOPERATION primary operation Multiple pinning

1974-1981 6 months~6 years follow-up

(sub: subtrochanteric fracture)

Table 2. The complications after Ender's nailing

Cases	Early death	Type	Varus deformity	Backing out	Supra condylar fracture
112	3		18	5	2
	2 myocardial infarct 1 acute pneumonia				
		I 46	6	3	
		II 37	5	2	
		III 5	2		
		IV 15	4		
		others 9	1		

Knee Discomfort (stiffness and motion pain)

Early within first one month postoperation

50%

Persistent discomfort before removal of nails

30%

Mostly diminished after removal

20%

no penetrations through articular surface nor acetabular roof postoperatively (except during operation). In two cases, supracondylar fractures were sustained, one fell down two months postoperatively and the other occurred during operation when the fourth nail was inserted from the medial site. Those reductions were performed with A-O condylar plate.

50% patients complained of pain and stiffness in the knee within first three weeks, and the rate gradually decreased, finally 20% patients remained until the removal of nails. After using the two plane bending instrument and adhering the correct location at the knee strictly, we experienced the decrease of this complaints.

The relationship between fracture types and the complications, and between improvement

Table 3. The chronological results of treatment and complications

Year	Cases	Early death	Infection	Varus deformity	Penetration	Backing out without varus deformity	Supra condylar fracture
1974	5	0	0	1	0	0	0
1975	25	2	0	6/reope 4	0	1	0
1976	12	0	0	3/reope 1	0	0	0
1977	16	0	0	3/reope 1	0	0	0
1978*	13	1	0	3/reope 2	0	2	1
1979	13	0	0	1/reope 1	0	0	0
1980	16	0	0	1/reope 1	0	2	0
1981	12	0	0	0	0	0	1
Total	112	3	0	18/10	0	5	2

* Changed for original nails and instruments
Reoperation

reinsertion 8

T.H.R. 2



Fig. 1. A typical case complaining of knee pain; incorrect location of the driving hole.

in the surgeon's skills and complications are shown in Table 3. During the early stage 1974–1977, the rate of complications was 14/58 (24%), at the middle stage 1978, 6/13 (46%), and during the recent stage 1979–1981, down to 5/41 (12%). Throughout the rate of the complications was 25/112 (22%). In chronological order except for 1978 when we changed the imitation nails for the original nails and instruments, the complication was decreasing step by step.

There was a significant correlation between the fracture types and the complications especially type III, type IV. Also, the relationship between the surgeon's skill and the complications was similar. As far as the former unstable type II (modified Evans classified 3 fragmentary) is concerned, we had better results compared to the former other internal fixation devices.

Most of the complaints about knee was caused by the incorrect location of the driving hole and the distal ends of nails (Fig. 1). A few cases suffered knee discomforts in spite of the correct location.

First of all in analyzing the complications of Ender's nailings, we should mention the importance of the method to achieve the sufficient stability, reduction with using the traction operating table and a c-arm fluoroscope with an image intensifier. This was mentioned by Ender briefly³⁾; the repositioning-rather attainment of good surface contact of the fragments, three such as the head-neck, the shaft and the trochanteric. We would like to describe the equipment problems and the technical problems that we encountered.

In our opinion, Ender's nailing is very suitable for elderly patients, because of minimal operative damage and the immediate weight-bearing stability. The stability given by this flexible elastic intramedullary nailing consists of three points in cooperation. If any errors occurred in these points, the stability should be lost. Therefore the surgeons should adhere very carefully to the original method.

Equipment Problems

Reduction—the combination between an operating table and a fluoroscope with an image intensifier—

It is not common in Japan to use two c-arm fluoroscopes or simultaneous biplane fluoroscopes. Mostly only one c-arm fluoroscope is available. Ender did not mention this combination in detail. In order not only to shorten the operating time, but also to decrease X-ray exposure, the fluoroscope must be positioned to catch sufficiently anteroposterior and lateral images as soon and as simultaneously as possible. We could not obtain any good combination of the traction table and the fluoroscope in Japan. Therefore some of the authors insisted that the opposite non-fractured leg be raised higher and the knee flexed, or placed in a holder with the hip and the knee flexed at a right angle^{2,17}. We can not agree with those methods, because it can not offer the stability of the pelvis that results in the incomplete reduction at the fracture site.

In addition, the size of the image tube should be large enough that the surgeon can scan from the femoral head to the fracture site in the same plane to ensure the top of the nail inserted. Japanese fluoroscopes have too small image tube—six inches, foreign ones—seven inches. Dr. Fukushima made a portable pelvic support (Fig. 2) which he was able to attach to the existing table. This made it possible to scan two planes of the hip without moving the base of the machine.

Some warnings to the imitation nails

We could not get the original nails and instruments, so we had to make the imitations of

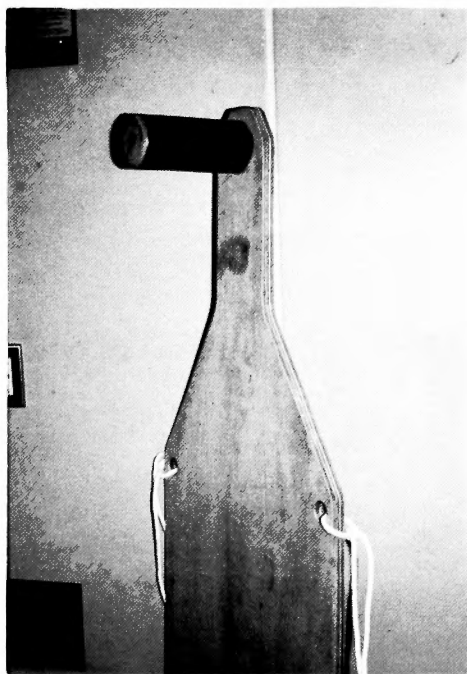


Fig. 2. A portable pelvic support made by Dr. Fukushima



Fig. 3. The distal end of the nails

Rush pins (SMO stainless steel). In the early stage of our series, we were easily encountered to the penetration during operation. After personal communication with Ender in 1977, we changed those for his original ones.

There are now various kinds of condylocephalic flexible “Ender nail” available in Japan. What is very curious, they are quite different designed in some points. As shown in Fig. 3, Fig. 4, the distal end of the nail; U-shaped, flat shaped, the proximal top; sharp edged, moderately blunt, very round without any edge, the proximal portion; valgus and sharp curved, smoothly curved but relatively varus. We agree with the idea that the surgeons should be allowed to give any modification to the original in order to reduce complications and suffering of the patients. We think that there are some problems among those different designs in regard to the elastic fixation conception.

Too sharpened top easily penetrates the articular surface. But “No wedged” Top can not hold the proximal fragment tightly except in very porotic patients¹⁴⁾. Flexibility is produced

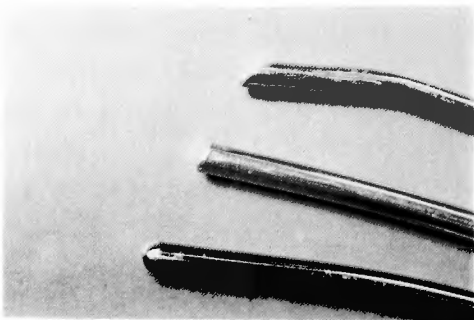


Fig. 4. The proximal portion of the nails
Upper: Sankin Co., Middle: original (Mizuho Co.), Lower: Howmedica Co.

by a proximal portion smoothly curved and moderately holding at the subchondral bone area. On the other site, the distal portion that is sharply curved can produce rigidity against the axial loading stress. The opening position can allow some loosening when the fracture site is impacted. The imitation nails can not adequately cover these points. Sometimes they had the opposite backward effects: danger to the mechanical fatigue fracture at the proximal portion, easy penetration and backing out of the nails etc.

Reduction

We think that the most important thing is closed manipulation never opening the fracture site. When faced with difficult cases, mostly four fragmentary fractures, it was useful to exert direct force upward or medially against the greater trochanter with the assistant surgeon's hand or a crutch.

We tried to obtain a reposition in which the proximal and the distal fragments were in line on the lateral view and a slight valgus positioned on the anteroposterior view in order to make the nails easier to insert. As the leg is abducted and internally rotated, this apparently decreasing of the femoral neck anteversion will be overlooked. A slight valgus reposition is necessary not only for easier inserting, but also to prevent nails from locating in the superolateral area of the femoral head which is weak and results mostly in postoperative varus deformity.

Nail Insertion Technique

Concerning the operative process, certain points were emphasized as follows;

1. The opening hole should be accurately located and the size of the hole needs to be enlarged



Fig. 5. Supracondylar fracture case. (A.H. 90 y.o. female)
Occurred during operation. She was treated with A.O condylar plate.

enough with a small rongeur to insert at least four nails.

A smaller hole makes it difficult to handle nails, and what is worse, there is a danger of its breaking the proximal rim of the hole and this sometimes leads to supracondylar fractures (Fig. 5 case treated with A-Ocondylar plate).

2. In inserting nails, the top of the nail should be understood in combination with the shape of the femur in three dimensional planes. At the beginning, it must be advanced along the ante-curved shaft. As the nail top reaches up to the fracture site, it should be continually driven supinating along the femoral neck and necessarily checked with an image intensifier. At this time, in order to make nails positioned fanwise in the head, the nail holder instrument has to hold the nail satisfactorily.

Attention should be paid by the assistant surgeon not to break the proximal and upper rim of the hole during insertion. It was useful to push the nail downward and inward, because around the opening hole at supracondylar region, the upper part consists of very thin cortical bone and on the other hand, the downward of thick hard corticalis (Fig. 6).

3. The proximal location of nails should reach into the dense cancellous bone area within 5 mm of the head surface. Too short nails which we often experienced at the early stage must not be accepted because of postoperatively varus deformity. Also the position of Ward's triangle and the superolateral region should be avoided. Especially in the elderly these areas are usually widened. So the pathway of the nails had better be aimed nearer or through Adams' arc as possible. Concerning the order of nailing, as Dr. Machida recommended, first the anterolateral, second the medialposterior, and third the middle should be easiest and acceptable¹⁰⁾.

It is necessary to avoid inserting the third or fourth nail into the anterior portion, which is not only difficult but also leads to make already inserted nail's distal end anteriorly located, finally to supracondylar fractures.

4. The medullary canal space must be fulfilled. This is often needed in the elderly osteoporotic patients. Recently in those cases we have used "Blocker nail" which is cut shorter and proximal straightened. As the fourth nail is often difficult in inserting from the medial site, we inserted from the lateral site (Fig. 7a, b, c).

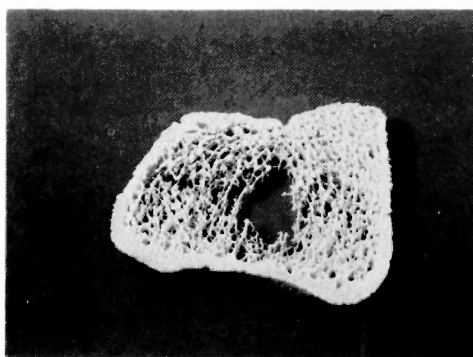


Fig. 6. The transverse section of the supracondylar region of the femur.
Left site: medial, Right site: lateral



Fig. 7a. K.M. 78 y.o. female Type II fracture.
Three nails were correctly inserted except for incomplete fulfilling the medullary canal.

Extended Indications

Through further experiences in treating pertrochanteric fractures, we could confirm that this method produced better stability in the long bone with minimal damage without opening the fracture site nor reaming. We extended to treat the pseudoarthrosis of subtrochanteric fracture treated primarily with A-O blade plate. We did Ender'nailings after removal of A-O blade plate. This case resulted in good bony union (Fig. 8a, b, c, d).

Other authors have reported the extended indications such as the femoral shaft fractures



Fig.7 b. Two weeks later, knee pain, backing out of the nails and secondary displacement of the fracture site occurred.

and the tibial fractures^{11,12,13}. They recommended the advantages of the lesser damage to the bone blood supply and better stability against the rotational stress. We think that this is not always the best way especially in tibial fractures compared to the other intramedullary methods and recent conservative treatments.

The insertion position of the nail should be carefully selected in order to avoid the extended longitudinal cortical fractures. It was useful to insert in the caudal direction and combined cephaladcauda directions similar to the other intramedullary nailings.



Fig. 7c. Reinsertion and an additional nail was inserted from the lateral site.

Discussion

In Japan, we could find the first complete paper on Ender's nailings by Dr. Yano et al (1979 in Japanese)¹⁷⁾. They recommended biomechanical points of view and three dimensional consideration of insertion technique in order to get the exact divergency of nails in the femoral head. We mentioned the contrary effect caused by bending the proximal portion sharply as above. As regards to the opening hole, we disagreed three holes, which fail to stop the backing-out of nails. On the contrary, the opening hole were more enlarged anteriorly and knee discomforts were increased.

Recently some authors have reported a higher occurrence of knee complaint due to backing out of nails^{2,6,8,18)}. They mentioned those complications caused by technical errors mostly. Böhler et al that recommended to use a biplane bending instrument¹⁾. They insisted both the

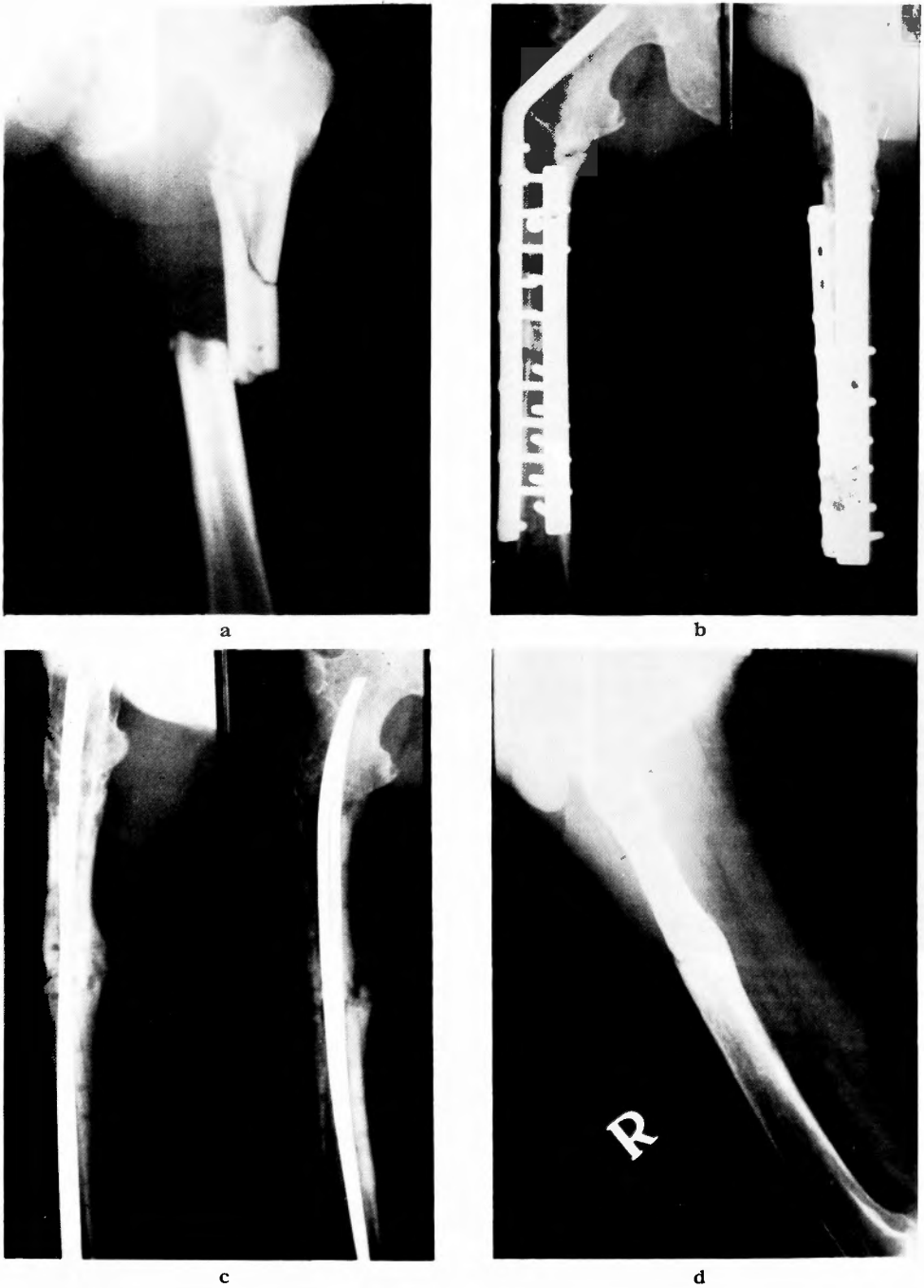


Fig. 8. Pseudoarthrosis case after the A-O method.
 K.S. 56 y.o. male
 a. multiple subtrochanteric fractures
 b. pseudoarthrosis after one year.
 c. He was treated by the Ender method.
 d. good healing was achieved.

distal and proximal portion of nail posteriorly and anteriorly should be bent. Through our series we thought it was sufficient to bend only the distal portion slightly posterior.

Chapman et al mentioned the impaction of the fracture after nailing²⁾. If the pins are too long, they can be cut off. They also advised against replacement of pins with shorter pins, because multiple tracks in the femoral head could result in insufficient purchase and backing-out of the pins. We preferred to confirming whether the length of the nail was proper or not at the first nail inserted. Afterward, the second proper nail was inserted, the first improper nail was removed.

Jensen mentioned that this method was not suitable for the unstable trochanteric fractures⁶⁾. They showed a highly significant relationship between the fracture type and the mechanical stability of the fracture reduction, between mechanically unreliable reduction and the appearance of technical failures.

They recommended a higher rate of knee complaints which need reoperations. The main reason why they considered Ender's nailing as contra-indication was unforeseen distal backing-out of nails which was led by secondary impaction of the fracture especially in the osteoporotic and comminuted types.

In our series, secondary impaction was occurred within first three weeks. Reoperations were more easily done and the fracture was recovered mostly except supracondylar fractures.

So long as analyzing the complicating cases retrospectively even in unstable fractures, there were necessarily some errors in three points, especially in the opening hole region. There is a liable misunderstanding the position of the medial supracondylar line when the leg is internally rotated. It is quite different from the lateral site (Fig. 9).

We think that there remains a great problem in the severe comminuted type IV described by Kyle et al⁹⁾. Since we think that in the comminuted fractures opening the fracture site in itself is contra-indicated for the remaining bone blood supply and fracture healing, we prefer the closed method combined with skeletal traction.

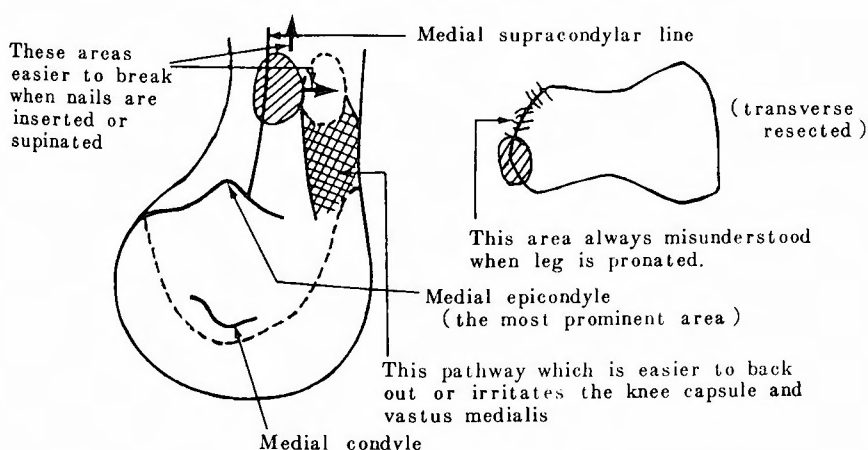


Fig. 9.

Conclusion

We performed a clinical analysis of 112 pertrochanteric fracture cases treated by the Ender's nailing. The results showed mechanical stability and minimal damages to the patients and the fracture healing process. We mentioned some technical considerations especially concerning three points co-working and the causes of knee complaints.

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和文抄録

大腿骨転子部骨折に対するエンダー髓内釘法の臨床成績

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著者らは、1974年以来、1981年までの期間に、転子部骨折に対してエンダー髓内釘固定法による追試を行ない、112例を経験した。その臨床術後成績は、早期死亡率2.7%、感染率0%、内反・釘脱落22%、大腿顆

上骨折1.8%であった。合併症は、追試初期に多発したが、手術手技上の改善によって減少を示した。特に合併症の原因と予防の検討を行なった。