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Meta-analysis of the clinical efficacy of the Gamma3 nail vs Gamma3U-blade system in the treatment of intertrochanteric fractures

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Abstract

BACKGROUND

The traditional Gamma3 nail is a mainstream treatment for femoral intertrochanteric fractures. Literature reports that the Gamma3U-blade system can increase the stability of the Gamma3 nail and reduce complication incidence. However, comparative studies between the Gamma3U-blade and Gamma3 systems are limited; hence, this meta-analysis was performed to explore the clinical efficacy of these two surgical methods.

AIM

A meta-analysis of the clinical efficacy of Gamma3 and Gamma3 U-blade for intertrochanteric fractures.

METHODS

A computerized search for Chinese and English literature published from 2010 to 2022 was conducted in PubMed, Cochrane, CNKI, Wanfang, and VIP databases. The search keywords were gamma 3, gamma 3 U blade, and intertrochanteric fracture. Additionally, literature tracking was performed on the references of published literature. The data were analyzed using Revman 5.3 software. Two individuals checked the inputs for accuracy. Continuous variables were described using mean difference and standard deviation, and outcome effect sizes were expressed using ratio

OR and 95% confidence interval (CI). High heterogeneity was considered at ($p < 0.05$, $I^2 > 50\%$), moderate heterogeneity at I^2 from 25% to 50%, and low heterogeneity at ($p \geq 0.05$, $I^2 < 50\%$).

RESULTS

Search results

Following a comprehensive literature search, review, and analysis, six articles were selected for inclusion in this study. This selection comprised five articles in English and one in Chinese, with publication years spanning from 2016 to 2022. The study with the largest sample size, conducted by Seungbae in 2021, included a total of 304 cases.

Statistical Analysis

A total of 1063 patients were included in this meta-analysis. The main outcome indicators were:

Surgical time: The Gamma3U blade system had a longer surgical time compared to Gamma3 nails ($p = 0.006$, $I^2 = 76\%$).

TAD: No statistical significance or heterogeneity was observed ($p = 0.65$, $I^2 = 0\%$).

HHS: No statistical significance was found, and low heterogeneity was detected ($p = 0.26$, $I^2 = 22\%$).

Union time: No statistical significance was found, and high heterogeneity was detected ($p = 0.05$, $I^2 = 75\%$).

CONCLUSION

Our study indicated that the Gamma3 system reduces operative time compared to the Gamma3 U-blade system in treating intertrochanteric fractures. Both surgical methods proved to be safe and effective for this patient group. These findings may offer valuable insights and guidance for future surgical protocols in hip fracture patients.

INTRODUCTION

Intertrochanteric fractures are commonly seen lower limb fractures in elderly patients [1-4], with an increasing incidence [5]. Previous studies have indicated that early surgical intervention for intertrochanteric fractures can reduce mortality [6,7]. The prevalent clinical classification for these fractures includes the Evans and AO types [8,9]. Intramedullary fixation, characterized by its minimally invasive approach, reduced soft tissue damage, and high healing rate, has become the preferred surgical method for intertrochanteric fracture treatment [10].

Key representatives of this approach are the Gamma Nail, proximal femoral nail (PFN), proximal femoral nail antirotation (PFNA), TriGen InterTan hip fracture nailing system (InterTan), and trochanteric fixation nail advanced (TFNA) [11]. PFNA is particularly suitable for elderly patients with osteoporosis, but its usage has been extending to younger patients. During penetration, the PFNA spiral blade anchors in pressurized cancellous bone, but penetration can be challenging in patients with robust bone. PFNA surgery does not allow for pulp enlargement, and in cases of marrow cavity stenosis, there's a risk of shifting the fracture end during insertion, thus increasing operation time. The InerTAN system, with its superior anti-rotation capability, might not be appropriate for patients with small or thin bone marrow cavities. The use of two interlocking nails in InerTAN can lead to more bone loss at the femoral neck, leaving a large residual cavity post-fixation and heightening the risk of refracture. Additionally, the InerTAN system demands high technical skill and has a steep learning curve. The Gamma nail, designed by Halder in 1988, is considered a pioneering product for modern pulp nails. The Gamma3 nail, however, does not possess the robust anti-pulling effect of the PFNA spiral blade. To enhance this aspect of the Gamma3 nail, Lenich introduced the "U" type blade pull screw for Gamma nails, known as the Gamma3U-Blade system [12]. As the third-generation Gamma nail, the Gamma3U-Blade has distinctive features: it uses self-tapping tension screws to bolster fixation stability and mitigate the risk of cutting out. Its anti-screw nails are engineered

to assist in compressing the fracture end, and it offers the choice between dynamic lock and static force lock [13,14].

The conventional Gamma3 nail remains the primary treatment for femoral intertrochanteric fractures. However, reports in the literature [15] suggest that the Gamma3U-blade system enhances the stability of the Gamma3 nail and lessens complication rates. Yet, comparative studies between the Gamma3U-blade and Gamma3 systems are sparse. This meta-analysis was thus conducted to investigate the clinical efficacy of these two surgical methods.

MATERIALS AND METHODS

Inclusion criteria

This study included Chinese and English clinical studies comparing the Gamma3 nail and Gamma3U blade in treating femoral intertrochanteric fractures, published between 2010 and 2022. The focus was on adult cases of femoral intertrochanteric fractures. The literature considered provided measurements such as operation time, intraoperative blood loss, postoperative hip function Harris score, postoperative tip-apex distance value (TAD), and functional recovery.

Exclusion criteria

Excluded from the study were cases involving pathologic fractures, polytrauma combined with intertrochanteric fractures, treatment measures integrated with other surgical methods, repeatedly published literature, reviews, systematic evaluations, case reports, letters, basic research, and finite element analysis models.

Statistical indicators

General information: authors, year of publication, sample size.

Main outcome indicators: Operative time, Harris Hip score (HHS), TAD, and union time.

Literature search

Data collection and analysis

The PRISMA statement guidelines were adhered to for conducting and reporting meta-analysis data. The data were analyzed using Revman 5.3 software. Two reviewers ensured the accuracy of data input. Continuous variables were reported using mean difference and standard deviation, and outcome effect sizes were expressed using ratio OR and 95% confidence interval (CI). High heterogeneity was defined as ($p < 0.05$, $I^2 > 50\%$), moderate heterogeneity as I^2 ranging from 25% to 50%, and low heterogeneity as ($p \geq 0.05$, $I^2 < 50\%$).

KEY (“Gamma3” or “Gamma3 nail” or “Gamma3 U-blade” or “U-blade”) and Femoral intertrochanteric fractures (“Femoral intertrochanteric fractures” or “intertrochanteric fractures”)

RESULTS

Search results

After a thorough search, review, and analysis of the literature, six articles were ultimately included in this study. These comprised five articles in English and one in Chinese, published between 2016 and 2022 (Table 1, Figure 1). The study with the largest sample size, authored by Seungbae in 2021, encompassed a total of 304 cases (Figure 2, Figure 3).

Statistical results

The meta-analysis included a total of 1063 patients. The primary outcome indicators were as follows:

Surgical time: The surgical time for the Gamma3U blade system was longer compared to Gamma3 nails ($p = 0.006$, $I^2 = 76\%$).

TAD: No statistical significance or heterogeneity was observed ($p = 0.65$, $I^2 = 0\%$).

HHS: No statistical significance was found, with low heterogeneity ($p = 0.26$, $I^2 = 22\%$).

Union time: No statistical significance was noted, accompanied by high heterogeneity ($p = 0.05$, $I^2 = 75\%$) (Figures 4-7).

DISCUSSION

The limited availability of controlled studies on Gamma3 and Gamma3 U-blade has restricted the number of comparisons in this meta-analysis. Variations in the focus of comparative follow-up across existing references also impacted the number of comparisons. Additionally, regional differences in fracture diagnosis among clinicians pose a risk of inclusion bias in the study.

Elderly patients are particularly susceptible to osteoporotic intertrochanteric fractures. Early surgical intervention for these fractures, along with hip joint functional exercises, can reduce complications like deep vein thrombosis, pressure ulcers, and joint stiffness [16]. Intramedullary fixation of intertrochanteric fractures offers effective anti-rotational stability. For unstable fractures (31-A2, 31-A3), intramedullary nailing fixation is the preferred treatment, a consensus in clinical practice [17]. Gamma3 nails, an evolution from Gamma nails for treating intertrochanteric fractures, address some limitations of the earlier design. However, some clinical studies have noted that the head nail of Gamma3 screws demonstrates poor stability and a higher risk of screw withdrawal [18]. The Gamma3 U-blade system incorporates a U-shaped blade, increasing the contact area between the femoral head, neck, and the screw, thereby enhancing head nail stability and reducing the risk of nail dislodgement. This meta-analysis revealed that the Gamma3 U-blade method required longer operative time compared to the Gamma3 nail method ($I^2=76\%$, $p=0.006$).

The observed differences in operative time were statistically significant. However, no statistically significant difference was found in fracture healing time between the two internal fixation systems ($p=0.05$). Presently, no literature conclusively states that the postoperative stability of the Gamma3 U-Blade system surpasses that of Gamma3 nails [19]. Therefore, patients undergoing intertrochanteric fracture treatment with intramedullary nailing can commence early functional exercises of the affected limb to reduce complications like joint stiffness. The literature selected for this meta-analysis did not systematically analyze when patients began functional exercises or their limb

function scores, nor did it provide specific clinical analysis of functional exercise impacts. Patients with intertrochanteric femur fractures often have associated osteoporosis, necessitating further clinical analysis to determine if postoperative anti-osteoporosis treatment can expedite fracture healing and influence the timing of functional exercise commencement. This meta-analysis indicates that the Gamma3 U-blade system has a longer operative time compared to Gamma3 nails, with a statistically significant difference ($p=0.006$). Gamma3 nails are preferable for frail patients with multiple underlying conditions who cannot withstand lengthy surgery. However, the Gamma3 U-blade offers superior postoperative stability and a lower risk of revision surgery due to internal fixation loosening and nail withdrawal, making it more suitable for elderly patients who can tolerate extended surgery.

Intertrochanteric fractures are susceptible to screw cutting after intramedullary nail fixation, which is closely related to three factors: the TAD, the greater trochanter, and the posterolateral wall. Literature suggests that a TAD value of 20-25 mm is safest, but debates on the optimal TAD value persist. The average TAD value in the literature included in this study ranged from 19.1-20.3 mm, with patients showing favorable clinical outcomes during follow-up. It can be inferred that an average TAD of 20 mm can yield good clinical results, but further large-scale studies are required to ascertain the precise upper and lower limits of this value.

This meta-analysis revealed no statistically significant difference in postoperative fracture healing time between the two surgical methods. Intertrochanteric fractures, primarily unstable, benefit from the abundant vascularity at the fracture ends, leading to a low rate of nonunion. The literature ^[20] highlights that effective reduction is key to the healing of intertrochanteric fractures. Both Gamma 3 nails and Gamma U-blade nails proficiently restore the force line at the fracture end and maintain stability of the fracture ends. Consequently, it can be inferred that both surgical methods positively impact fracture healing.

Clinical studies have determined that elderly and underweight patients, having lower bone mineral density (BMD), are more susceptible to intertrochanteric femur fractures

[21]. These patients often present with preoperative anemia, while obese patients tend to experience more intraoperative blood loss. This study found no statistically significant difference in BMI and BMD values, possibly due to the wide age range of the patients involved, leading to non-significant differences in comparisons. Patients from different age groups exhibit varying metabolic rates, and their BMI and BMD values differ accordingly. For enhanced clinical relevance, dividing patients into age groups for comparative analysis could yield more significant insights.

The literature included in this meta-analysis indicates that operations using the U-blade tend to have longer durations compared to those with Gamma3, attributed to the additional steps required in the Gamma3U-blade procedure. Given that the Gamma3U-blade has been in use for a shorter time than Gamma3, advancements in clinical procedures and increased clinical experience may address the issue of prolonged surgical time. However, further statistical analysis regarding operation time necessitates a substantial number of clinical samples for a robust research foundation. Limitations of the Included Research Articles: While surgical intervention enhances survival quality in patients with intertrochanteric fractures, reports [22] indicate that the one-year postoperative mortality rate for these patients ranges from 11.9%-18.5%. It is plausible that long-term follow-up data may be skewed due to postoperative mortality, particularly in older patients, contributing to statistical bias in the study. Large-sample studies are required to minimize data bias related to mortality. Union time and TAD, vital scoring criteria post-intertrachanteric fracture, were accounted for in only two articles each, with no statistically significant differences observed in comparisons ($p=0.05$ for Union time and $p>0.05$ for TAD). Given the limited number of articles included, the data on Union Time and TAD may be biased. Currently, no prospective studies compare these two types of internal fixation methods. Therefore, the aim of this study is a meta-analysis of the efficacy of femoral trochanteric surgery, limited to clinical efficacy indicators for surgical outcome assessment. To ascertain whether significant differences exist in comparing Union Time and TAD between the two surgical methods, further statistical analysis with large samples is warranted.

CONCLUSION

Our study demonstrated that the Gamma 3 system is associated with reduced operative time in comparison to the Gamma 3 U-blade for treating intertrochanteric fractures. Both surgical approaches are safe and effective for this patient group. These insights may offer valuable recommendations and information for future surgical protocols in hip fracture patients. Nevertheless, to enhance the evidence base, further extensive multicenter prospective trials are necessary. A randomized controlled trial focusing on documented and quantified osteoporosis patients with extended follow-up periods is required.

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