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Review Article

Medial femoral plate with cannulated screw for Pauwels type III femoral neck fracture: A meta-analysis

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Abstract.
BACKGROUND: Femoral neck fractures often occur in the elderly, which usually results in hip pain.
OBJECTIVE: The purpose of this study was to evaluate the difference in the treatment of Pauwels type III femoral neck fractures with medial femoral support plate combined with cannulated screws and cannulated screws alone.
METHODS: PubMed, ScienceDirect, China Academic Journals Full-text Database (CNKI), Wanfang Database, Chinese Biomedical Literature Database (CBM), Embase and Cochrane Library were used to collect clinical controlled trials of the medial femoral support plate combined with hollow screw internal fixation and simple hollow screw internal fixation for Pauwels type III femoral neck fracture.
RESULTS: Seven articles ($n = 409$ cases) were evaluated for quality and included in this meta-analysis. Four hundred and nine patients with Pauwels type III femoral neck fractures were included: 202 in the experimental group and 207 in the control group. The results showed that, compared with simple hollow screw internal fixation, the medial femoral support plate combined with hollow screw internal fixation has a longer operation time (*MD* = 23.05, 95% *CI* = 13.86–32.24), and more intraoperative blood loss (*MD* = 91.55, 95% *CI* = 50.72–132.39), shorter healing time (*MD* = −1.48, 95% *CI* (−1.71, −1.26)), lower incidence of complications (*RR* = 0.34, 95% *CI* = 0.19–0.61), lower VAS score (*MD* = −1.28, 95% *CI* (−1.83, −0.72)), and higher Harris score (*MD* = 8.49, 95% *CI* (4.15, 12.83)).
CONCLUSION: Medial femoral plate combined with cannulated screw for Pauwels type III femoral neck fracture can shorten healing time, reduce postoperative complications, and improve the postoperative Harris score.

Keywords: Internal fixation, Pauwels type III, femoral neck fracture, meta-analysis

1. Introduction

Femoral neck fractures often occur in the elderly, which usually results in hip pain [1–3]. In recent years, with the intensification of the population aging process, its incidence rate has been increasing year by year, accounting for about 3.58% of systemic fractures and 54% of hip fractures [4,5]. Good reduction and fixation

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is an important principle for the treatment of femoral neck fractures, and also a basic guarantee to promote patient rehabilitation and joint function recovery [6]. To improve the effect of internal fixation of femoral neck fracture cannulated nails, Filipov reported an F-shaped spatial layout method for internal fixation of femoral neck fracture cannulated nails [7]. In this method, three hollow nails are distributed in an F shape on the femoral neck and the coronal plane of the proximal femur.

The focus of the Pauwels classification of femoral neck fractures is on mechanical angles [8,9]. When the cutting fracture line is 50°, it is classified as type II fracture, which is suitable for treatment with hollow nail internal fixation [10]. According to the coronary fracture line and the angle of the upper edge of the acetabulum $< 30°$, 30°–50°, $> 50°$, it can be divided into Pauwels type I, Pauwels type II and Pauwels type III. There are still many differences in the choice of internal fixation for Pauwels type III fractures. Clinically, internal fixation with hollow nails is often employed, whereas the treatment effect is poor due to large shear stress. Moreover, postoperative complications such as nail withdrawal, nonunion, fracture displacement, and osteonecrosis are very likely to occur [11,12].

Some studies suggest that this type of fracture is treated by using a nail plate system. Hollow nails and medial support plates are an emerging treatment method that can be used to treat Pauwels type III femoral neck fractures [13–15]. At present, a medial femoral neck support plate combined with hollow screw internal fixation is an emerging treatment of Pauwels type III femoral neck fracture in clinical practice [16,17]. However, whether it can accelerate fracture healing and reduce femoral head necrosis is still controversial. Therefore, relevant clinical trials were retrieved for meta-analysis to provide a scientific basis for Pauwels type III femoral neck fractures.

2. Materials and methods

2.1. Search strategy

The following keywords were used for the search: “Pauwels III femoral neck fractures”, “Inner support plate”, “Medial support plate”, “Buttress plate”, and “Cannulated compression screws”. PubMed, ScienceDirect, China Academic Journals Full-text Database (CNKI), Wanfang Database, Chinese Biomedical Literature Database (CBM), Embase and Cochrane Library were used to collect clinical controlled trials of medial femoral support plates combined with hollow screw internal fixation and simple hollow screw internal fixation for Pauwels type III femoral neck fracture. The study was conducted in January 2020 and included literature up to December 2019. There was no limit on the language of document retrieval. In addition, the references of related articles were also searched, and supplemented by a manual search and download of related documents.

2.2. Inclusion and exclusion criteria

2.2.1. Inclusion criteria

Pauwels type III femoral neck fracture. The experimental group used a medial femoral neck support plate combined with hollow screw internal fixation, and the control group used simple hollow screw internal fixation for clinical trials. Outcome indicators included a Harris score of at least one, operation time, intraoperative blood loss, postoperative complications, fracture reduction quality, and hip joint function excellent rate. All patients were followed up.

2.2.2. Exclusion criteria

Non-Pauwels type III femoral neck fractures, animal experiments, missing data, and repeated literature.

2.3. Literature screening and quality evaluation

Two researchers independently used the established inclusion and exclusion criteria to conduct a literature search and screening. After the screening was completed, the results were compared and analyzed. If there were any objections, they were discussed with senior authors. Finally, the literature was incorporated and data was extracted. Two reviewers independently evaluated the included literature, and if there were disagreements, they discussed them with the senior authors to re-evaluate the quality of the literature. The randomized controlled trials were strictly carried out in terms of risk assessment of bias according to the Cochrane Bias Risk Assessment Manual. The improved Jadad scale was used to evaluate the quality of the literature. The full score was 7 points, of which 1–3 were low-quality literature and 4–7 were high-quality literature. The retrospective cohort study used the risk of bias in non-randomized studies of interventions (ROBINS-I) to evaluate the quality of the literature. The final result was scored according to the correlation with the overall risk bias (low, moderate, severe, extremely severe, and no information).

Table 1
General characteristics of the included studies

Study	Year of publication	Study type	Follow-up time (months)	Jadad score	Experimental group			Control group		
					Sample size	Age, years (mean ± SD or min-max)	Male (n)	Sample size	Age, years (mean ± SD or min-max)	Male (n)
Ding WX, 2018 [21]	2018	Randomized controlled study	12	2	12	NA	8	14	NA	8
Li P, 2018 [22]	2018	Randomized controlled study	3	4	31	45.56 ± 8.24	16	31	43.32 ± 8.87	19
Li RH, 2018 [20]	2018	Retrospective cohort study	12–15	2	20	NA	NA	30	NA	NA
Qin YP, 2018 [19]	2018	Randomized controlled study	12–18	4	30	NA	NA	30	NA	NA
Shen DH, 2019 [23]	2019	Randomized controlled study	6	2	35	38.82 ± 7.16	19	35	38.86 ± 7.22	21
Xu YK, 2018 [18]	2018	Randomized controlled study	12	2	25	50.4 ± 10.6	19	20	49.9 ± 18.7	15
Yang B, 2019 [16]	2019	Randomized controlled study	12	2	49	37.86 ± 9.12	35	47	38.05 ± 8.47	32

2.4. Statistical analysis

RevMan 5.3 software was used to perform the meta-analysis on the collected relevant data. Binary variables used were odd ratio (OR) and 95% confidential interval (CI) for data analysis, and continuous variables used were mean difference (MD) and 95% CI for data analysis. When performing the heterogeneity analysis, when $I^2 \leqslant 50\%$ heterogeneity was small, and the data was analyzed by a fixed effect model. When $I^2 > 50\%$ heterogeneity was greater, the data would be analyzed by a random effect model, and the source of heterogeneity would be found and analyzed for the literature with greater heterogeneity. $P < 0.05$ indicates that the difference between the two groups is significant.

3. Results

3.1. Literature search results and basic features

Among the 473 retrieved documents, 458 irrelevant or duplicate documents were excluded. Finally, seven articles were evaluated for quality and included in the meta-analysis [16,18–23], including six randomized controlled trials and one retrospective cohort study. The flow diagram of the included studies is shown in Fig. 1. A total of 409 patients with Pauwels type III femoral neck fractures were included. The Jadad scores included in the literature were all two or above. The follow-up time of the participants was 3–18 months. The basic characteristics of the included studies are shown in Table 1.

3.2. Comparison of operation time between the groups

Six articles compared the operation time between the two treatment methods. After analysis, there was a large heterogeneity between the research results ($I^2 > 50\%$), so a random effect model was used for the meta-analysis. The treatment time of the medial femoral neck support plate combined with hollow screw internal fixation was significantly longer than that of simple hollow screw internal fixation ($MD = 23.05$, 95% $CI =$ 13.86–32.24; $P < 0.05$), as shown in Fig. 2.

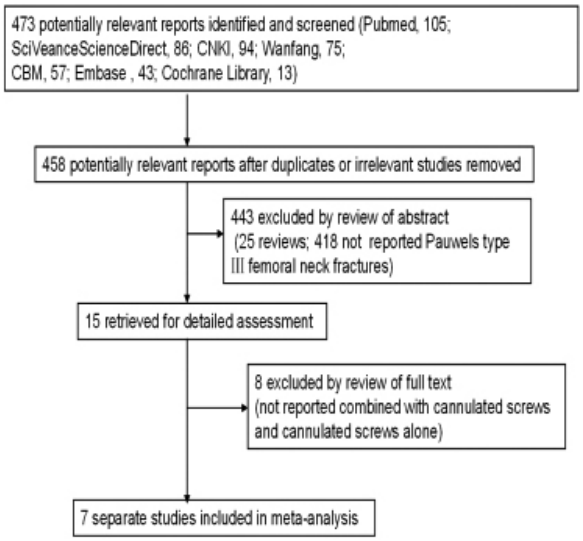

Fig. 1. Flow diagram of the included studies.

3.3. Comparison of intraoperative blood loss between the groups

Six articles compared intraoperative blood loss between the two treatment methods. After analyzing the heterogeneity in the results of various studies ($I^2 > 50\%$), the meta-analysis was carried out through the random effect model. The intraoperative femoral neck support plate combined with hollow screw internal fixation treatment group yielded a significantly larger

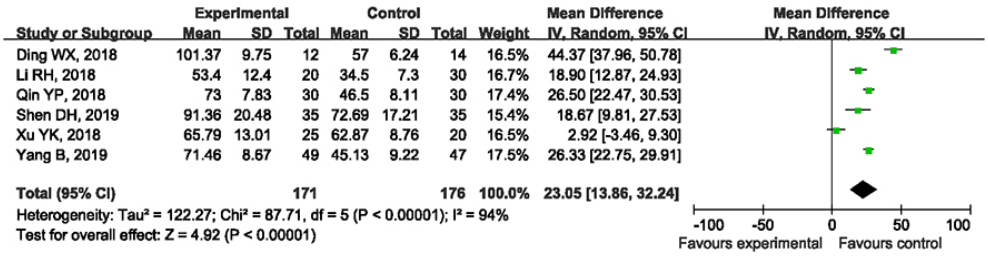

Fig. 2. Forest plot of the operation time.

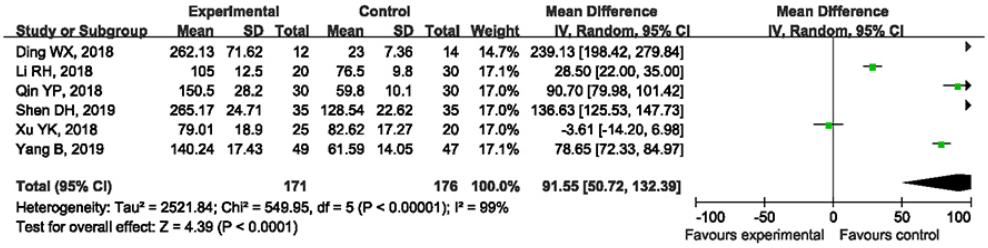

Fig. 3. Forest plot of the bleeding volume.

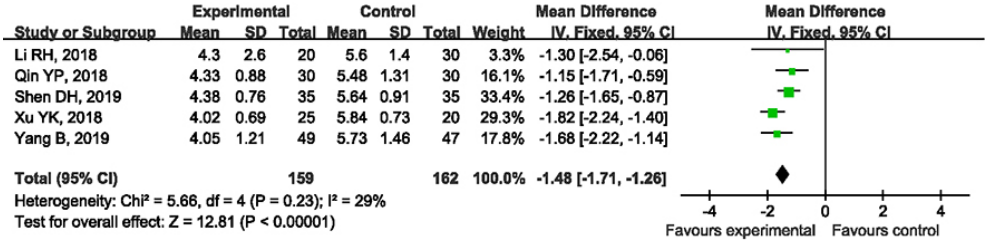

Fig. 4. Forest plot of the healing time.

quantity of intraoperative bleeding than simple hollow screw internal fixation ($MD = 91.55$, 95% $CI = 50.72$–132.39; $P < 0.05$), as shown in Fig. 3.

3.4. Comparison of fracture healing time between the groups

Five articles compared the fracture healing time between the two treatment methods. The heterogeneity between the results of the various studies was small ($I^2 \leqslant 50\%$), so a meta-analysis was performed by a fixed-effect model. The healing time of the femoral neck medial support plate combined with hollow screw internal fixation was remarkably shorter than that of simple hollow screw internal fixation ($MD = -1.48$, 95% CI (-1.71, -1.26); $P < 0.05$), as shown in Fig. 4.

3.5. Subgroup analysis of complication rate

Five articles compared the incidence of complications between the two treatments. Postoperative complications include fracture nonunion rate, femoral head necrosis rate, and internal fixation failure rate. A subgroup analysis was performed on each group of data to determine the incidence of complications. After analysis, the heterogeneity between the results of the various studies was small ($I^2 \leqslant 50\%$), so a meta-analysis was performed by a fixed-effect model. The results showed that the fracture nonunion rate of the treatment group of the medial femoral neck support plate combined with hollow screw internal fixation was lower than that of simple hollow screw internal fixation (relative risk (RR) = 0.33, 95% CI (0.12, 0.96), $P < 0.05$). There was no statistically significant difference in the treatment of femoral head necrosis between the two groups (RR = 0.65, 95% CI (0.27, 1.55), $P < 0.05$). The medial femoral neck support plate combined with hollow screw internal fixation has a lower internal fixation failure rate than simple hollow screw internal fixation (RR = 0.15, 95% CI (0.04, 0.53), $P < 0.05$). The results of the analysis showed that the postoperative complica-

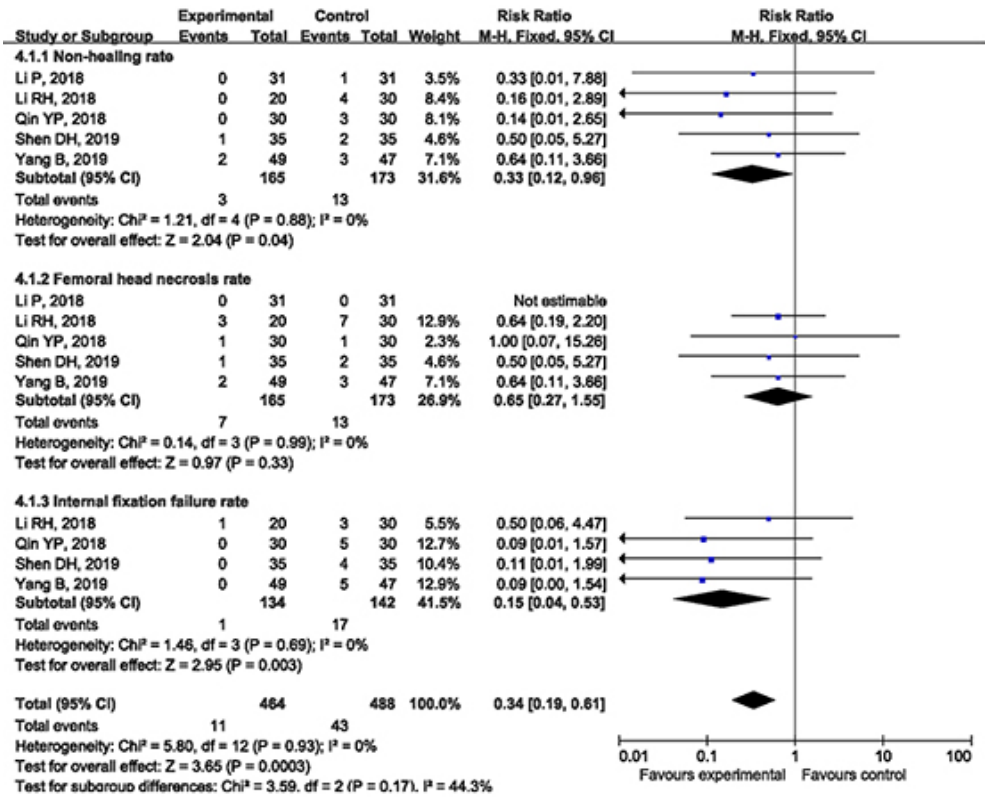

Fig. 5. Forest plot of the complication.

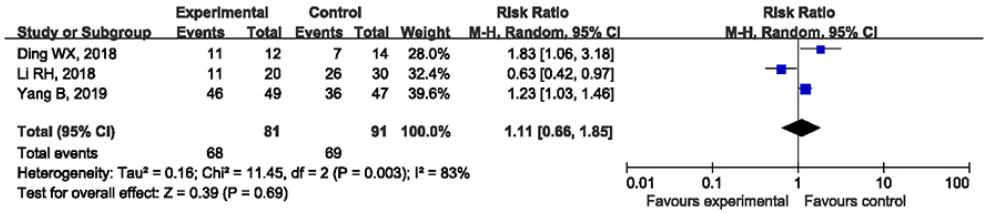

Fig. 6. Forest plot of the xcellent rate.

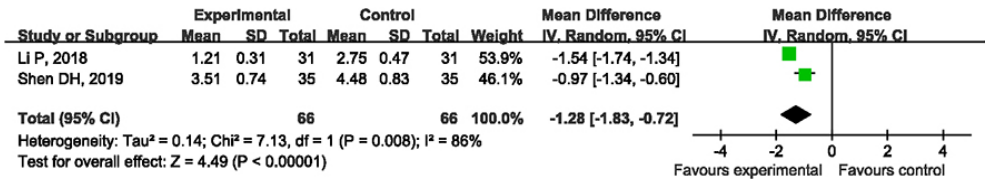

Fig. 7. Forest plot of the VAS score.

tion rate of patients with medial femoral neck support plate combined with hollow screw internal fixation was lower than that of simple hollow screw internal fixation ($RR = 0.34$, 95% $CI = 0.19$–0.61), the difference was statistically significant $P < 0.05$. The results of the statistical analysis are shown in Fig. 5.

3.6. Comparison of excellent rate of hip joint function between the two groups of patients

The three included articles compared the excellent rate of hip joint function with two treatment methods. After analyzing the heterogeneity in the results of vari-

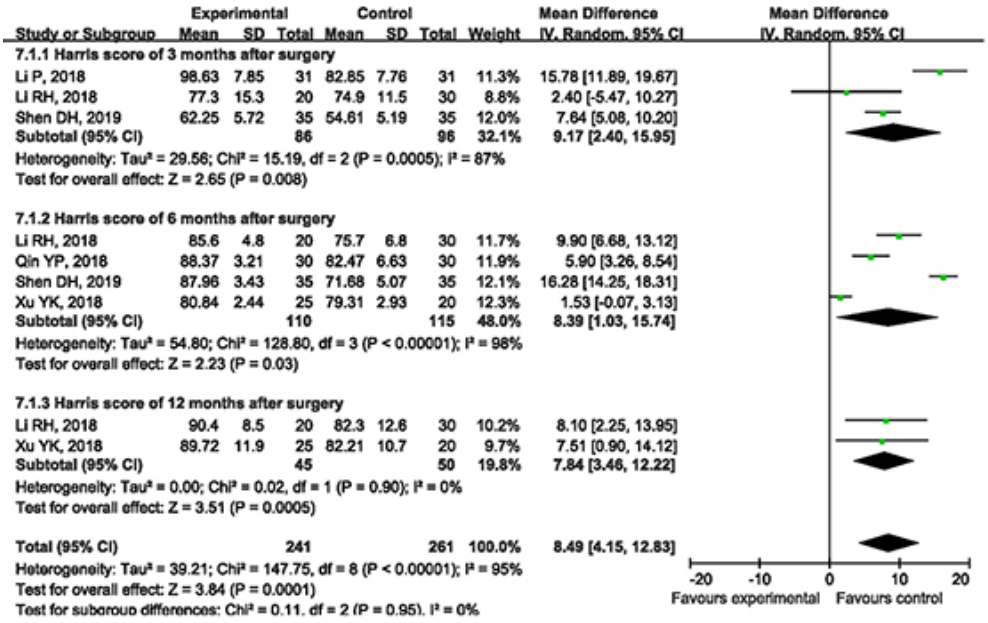

Fig. 8. Forest plot of the Harris score.

ous studies ($I^2 > 50\%$), the meta-analysis was carried out through the random effect model. The difference in the evaluation methods of the excellent rate of hip joint function between the two groups may cause greater heterogeneity between the two groups. The results of the analysis showed that there was no significant difference in the excellent and good rates of hip function between the two treatments ($RR = 1.11$, 95% *CI* (0.66, 1.85), $P > 0.05$). The results of the analysis are shown in Fig. 6.

3.7. Comparison of VAS scores between the two groups of patients

The two included articles compared the VAS scores of the two groups of patients after treatment. After analyzing the heterogeneity in the results of various studies ($I^2 > 50\%$), the meta-analysis was carried out through the random effect model. The analysis showed that the difference in VAS scores between the two treatments was statistically significant ($MD = -1.28$, 95% *CI* (-1.83, -0.72), $P < 0.05$). The results of the analysis are shown in Fig. 7.

3.8. Subgroup analysis of the Harris score

The five included articles carried out the Harris scoring of the hips at different times for the two treatment methods, so a subgroup analysis was used to conduct a comprehensive analysis of the Harris scoring. After the analysis, the heterogeneity between the results of the various studies was relatively large ($I^2 > 50\%$), so a random effect model was used to perform meta-analysis on the data. The results showed that the Harris score of the hip joint at three months after the medial femoral neck support plate combined with hollow screw internal fixation was higher than that of simple hollow screw internal fixation ($MD = 9.17$, 95% *CI* (2.40, 15.95), $P < 0.05$). The Harris score of the hip joint after the medial femoral neck support plate combined with cannulated screw fixation was higher than that of cannulated screw fixation ($MD = 8.39$, 95% *CI* (1.03, 15.74), $P < 0.05$). The Harris score of the hip joint medial femoral neck support plate combined with hollow screw internal fixation after 12 months was higher than that of simple hollow screw internal fixation ($MD = 7.84$, 95% *CI* (3.46, 12.22), $P < 0.05$). The results showed that the hip score of the patients after medial femoral neck support plate combined with hollow screw internal fixation was higher than that of simple hollow screw internal fixation ($MD = 8.49$, 95% *CI* (4.15, 12.83)), the difference was statistically significant ($P < 0.05$). The results of the statistical analysis are shown in Fig. 8.

4. Discussion

Pauwels type III fracture is a vertical fracture of the femoral neck, which occurs after high-energy trauma,

especially in the middle-aged population [15,24–27]. This type of fracture is dominated by shear force, which causes the proximal femur to shift and collapse during varus and is prone to internal fixation failure and other complications [28]. In recent years, the use of medial femoral neck support plate combined with cannulated screw internal fixation has been proposed for the treatment of Pauwels type III femoral neck fracture [16,29,30], which can reduce the incidence of complications, such as nonunion of femoral neck fracture and femoral head necrosis.

Femoral neck fractures are common and serious types of fractures in the clinic, which yields extremely high disability and mortality rates [31,32]. Femoral neck fractures should be treated in a timely manner after proper evaluation of the condition. If it can be effectively reset, internal fixation is the first choice. Pauwels type III femoral neck fracture is a clinically refractory fracture type because of its vertical fracture line and the need to withstand huge shear stress, which can cause high-risk complications, such as broken nails and retracted nails after clinical treatment of hollow nails [23,33]. Nevertheless, from the perspective of biomechanics, its inverted triangular structure can withstand the tensile stress of the fracture and effectively resist the torsional force. It can also produce a compression effect on the fracture site, so it has a certain therapeutic effect. The hollow nail plus the inner support steel plate is a combination of three hollow nails and the steel plate to form an integral fixture. It is not easy to withdraw the nail and is fixed firmly, and will achieve good therapeutic effects. The steel plate combined with the hollow screw is fixed on the basis of the conventional hollow screw and the support plate is placed on the inner side of the femoral neck. It not only retains the good anti-rotation ability of the internal fixation of the hollow screw, but also directly resists the shear force generated by the fracture end.

The results of this study show that, in terms of fracture healing and the incidence of complications, the medial support plate can resist the shear force of the fracture and increase the stability of the internal fixation nail, which can reduce postoperative complications and promote fracture healing. For the postoperative complications of patients, some studies indicate that the surgical method supported by the medial plate not only increases the amount of intraoperative bleeding, but may also damage the blood supply of the femoral neck and femoral head, increasing the risk of postoperative fracture necrosis. The blood supply of the femoral head and neck is mainly provided by the medial femoral artery, which is distributed on the posterior side of the femoral neck. The upper support belt artery of the terminal branch of the internal circumflex femoral artery is divided into the upper lateral and the lower support belt artery is divided into the lower medial. Both through the support belt and reach the head and neck of the femur. In addition, the lateral femoral artery provides blood supply of 20–30% of the femoral head and neck, mainly reaching the femoral neck from the anterior side of the femoral neck. Therefore, placing a support plate on the anterior medial side of the femoral neck during surgery will not damage the main blood supply source of the medial femoral artery. Clinical studies have reported that the blood circulation of the femoral neck will not increase the damage due to the medial support plate, and will not increase the incidence of fracture nonunion, internal fixation failure and ischemic necrosis [34–36].

In terms of the operation time and the amount of bleeding, the internal support steel plate needs to be cut for treatment [37]. The internal fixation of hollow nails is generally closed reduction and internal fixation, so simple hollow nails have advantages in operation time and bleeding volume [38,39]. Therefore, older patients who cannot tolerate long-term surgery and large bleeding should consider internal fixation with hollow nails. In terms of the Harris score, the score of the test group was higher than that of the control group at three, six, and 12 months after surgery. For the recovery of long-term hip function, the included literature did not follow up for a long time, so more clinical long-term follow-up trials are needed to compare the differences in long-term efficacy of the two groups.

The results of this study suggest that there is no statistical difference between the two groups in terms of the excellent rate of hip function. Due to the difference in the evaluation methods used for the excellent rate of hip joint function between the two groups, there is a large heterogeneity between the two groups and there is no statistically significant difference between the groups. However, because of the different surgical methods used in the two groups, the medial support uses open reduction internal fixation, and the hollow screw internal fixation mostly uses closed reduction internal fixation [40].

4.1. Limitations

There are some limitations in this study. First, seven clinical trials were included, with a total of 409 patients. The small number of clinically relevant studies led to limitations in clinical promotion. Second, the evaluation

indicators included in the literature are heterogeneous and have a certain influence on the analysis results. They may be derived from the length of time from injury to operation in different literature, the choice of internal fixation plate, and the method of the surgical approach and reduction of different physicians have an impact on the test results.

5. Conclusion

In conclusion, the medial femoral neck support plate combined with cannulated screw internal fixation for Pauwels type III femoral neck fracture has a low complication rate and better recovery of hip function, but it will increase operation time and intraoperative bleeding. In the treatment of Pauwels type III femoral neck fractures, hollow nails combined with medial support plates have advantages over pure hollow nails in terms of healing time, postoperative complications, postoperative VAS score and Harris score, and have a good clinical application prospect. However, more high-quality and multi-center experiments are needed for in-depth research.

Conflict of interest

None to report.

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