ORIGINAL ARTICLE

RECONSTRUCTION OF THE TROCHANTERIC ZONE IN PRIMARY ARTHROPLASTY OF UNSTABLE PERTROCHANTERIC FRACTURES

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ABSTRACT

The aim: To justify the concept and features of acetabular reconstruction during primary endoprosthesis for transcatheter fractures from the standpoint of radiological data, biomechanical calculations and intraoperative observations.

Materials and methods: A retrospective analysis of the use of primary cement arthroplasty for osteoporotic fractures of the trochanteric zone in 52 elderly and senile patients was conducted. Before implantation of the femoral component, fragments of the proximal metaphysis were fixed with cerclage tightening loops which depended on the type of fracture. For fractures 31-A2.1, 31-A2.2, 31-A2.3, reconstruction of the destroyed trochanteric zone and the walls of the bone marrow canal opening was performed using our own methodology. Finite-element modeling with the SolidWorks program was used to investigate the influence of the reconstruction of the trochanteric zone on the distribution of strain on the bone tissue around the implant under osteopenic conditions and load during single-support standing.

Results: Clinical and X-ray results were studied in 39 (74.36%) operated patients within 3 to 33 months. There were no complications associated with reconstruction of the proximal part of the femur and implantation of endoprostheses. Restoration of movements in the hip joint and full loading of the operated limb was allowed the day after surgery, depending on the patients` physical condition. The results of finite-element modeling indicate a significant reduction of the strain on the proximal metaphysis in the zone of predominant destruction of the medial and posterior walls of the bone marrow canal of the trochanteric zone reconstruction and ensuring the stability of the femoral component.

Conclusions: Clinical results and biomechanical calculations confirm the possibility and feasibility of using primary arthroplasty in unstable osteoporotic fractures of the trochanteric zone with the aim of early restoration of the support function of the damaged limb in individuals with limited physical capabilities. Reconstruction of the intertrochanteric area with a ring-shaped autograft contributes to the achievement of primary stability of the femoral component, restoration of the total femoral offset and stabilizing function of muscles around the joints.

KEY WORDS: pertrochanteric fractures, osteopenic fractures, endoprosthesis, hip arthroplasty

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INTRODUCTION

The constant increase in the number of elderly and senile people in the world is accompanied by an increase in cases of osteoporotic fractures in the area of the hip joint [1]. About 45% of them are fractures of the trochanteric zone [2, 3]. Due to the presence of concomitant diseases in patients of this age category, the treatment of trochanteric fractures represents a complex medical, social and economic problem. In China, they are called "the last injury in life", due to the high rate of complications and mortality. Without surgical intervention, the mortality rate reaches 34.6% [4].

Modern technologies of osteosynthesis are a generally recognized standard for the treatment of fractures of the trochanteric zone, because they are efficient and relatively less traumatic [5].

However, with unstable fractures (31-A A2.2, 31-A2.3, 31-A3.3 according to the OA classification) after osteosynthesis, a high level of complications is observed (from 0.5 to 56%) depending on the type of fracture, patients' condition, quality of the reposition and fixation. The most common, about 20%, are migration of fixing structures, complications of osteosynthesis, destruction (cut out effect) of the proximal fragment by the fixator, secondary displacement of fragments, and in 2.8% of cases infectious complications are observed [1, 6]. The possibility of repeated restorative or reconstructive operations is limited due to the comorbid condition of patients, risks of complications and increased mortality [1, 7].

According to research data, primary hemiarthroplasty with unstable pertrochanteric fractures

provides more guarantees of early restoration of function of the damaged limb and, therefore, is used as an alternative to osteosynthesis [2, 8]. However, if osteoporosis and a destroyed proximal metaphysis is present, the implantation of the femoral component requires careful mechanical evaluation to ensure the primary stability of the femoral component and the entire artificial hip joint. The expediency of preliminary restoration of the acetabular area by fixing fragments of the posterior, medial (area of the calcarus and small trochanter) and external surfaces using wire, tension tapes or plates or bone plastic remains under consideration considered [9, 10].

THE AIM

The aim of this study was to justify the concept and features of acetabular reconstruction during primary endoprosthesis for transcatheter fractures from the standpoint of radiological data, biomechanical calculations and intraoperative observations.

MATERIALS AND METHODS

The study is based on the results of a retrospective analysis of the implementation of primary arthroplasty for trochanteric fractures in 52 patients aged 72 to 89 years (mean age – 76.34 ± 3.28 years). Among them were 38 women aged 72 to 88 years (mean age - 74.18 ± 3.46 years) and 14 men aged 73 to 89 years (mean age - 76.4 ± 4.14 years). The periods of hospitalization for patients in the traumatology departments were 1 to 5 days after the injury. The injuries were of low-energy - as a result of falling on the thigh while walking or from a standing position.

As per the radiographic examination data according to the OA classification, 17 of the injured had fractures of the proximal part of the femur belonging to type 31-A1 (31-A1.2, 31-A1.3), 28 had multifragmentary fractures of type 31-A2 (31 -A2.1, 31-A2.2, 31-A2.3), and 7 – type 31-A3 fractures (31-A3.1, 31-A3.3).

For fractures 31-A2.2 and 31-A2.3, spiral computed tomography (SCT) of the hip joints was performed before arthroplasty.

The criteria for selecting patients were age, the presence of an osteopenic condition, the severity of the comorbid condition due to concomitant diseases (including the presence of two or more osteoporotic fractures of different localization for 12 patients), which determined the impossibility of mechanical unloading the damaged limb after surgery. Among the selection criteria in 13 patients, we included excessive body weight according to the body mass index - the average value was 27.31 ± 2.41 (from 26.18 to 32.33).

Arthroplasty was performed 3-9 days after the injury (average time 5.2 ± 1.4 days). In all cases, external-anterior surgical access to the hip joint and cement fixation of the femoral component were used. Endoprostheses with a standard stem were used for hemiarthroplasty in 36 patients, and with an extended stem in 16. In 5 patients, due to the presence of destructive-dystrophic changes in the damaged joint that occurred before the injury, total arthroplasty was performed.

In addition to hemiarthroplasty of the hip joint, 6 patients underwent simultaneous interventions in connection with concomitant injuries during a single anesthetic procedure: osteosynthesis for fractures of the proximal metaphysis of the humerus – 2, distal metaepiphysis of the forearm bones – 3, ulnar condyle – 1.

For all patients, fragments of the proximal metaphysis were fixed with cerclage tightening loops, the nature of which depended on the type of fracture, before the implantation of the femoral component. In case of fractures 31-A2.1, 31-A2.2, 31-A2.3, in order to ensure the primary stability of the stem of the endoprosthesis, as well as to restore the optimal alignment between the proximal part of the femur and the pelvis, before the implantation of the femoral component, the destroyed trochanteric area section of the calcar and bone walls of the entrance to the bone marrow canal were reconstructed. By means of numerical analysis on a mathematical 3D model, the stress-deformed state in the proximal part of the femur around the leg of the endoprosthesis was investigated under the conditions of the presence of an osteoporotic pertrochanteric fracture and in due to the functional load of the limb. According to the modeling conditions, the bone fragments of the trochanteric area are pre-connected with a cerclage wire followed by cement fixation of the implant. In the first option, implantation is performed without restoration of the intertrochanteric area and calcar (Fig. 1b). The second option includes the reconstruction of the intertrochanteric area with a ring-shaped autograft taken from the base of the proximal fragment, which is removed in accordance with the proposed method of surgery (Fig. 1c). The models were built in the SolidWorks program [11]. The stress state analysis was carried out in the ANSYS Workbench [GMN] program. The Mises stress test was chosen to evaluate the stress state.

The impact of the body mass without the investigated limb (single-support standing) and the impact of the muscular-ligamentous apparatus in

Table I. The value of the strained-deformed state (Mises stress) at the control points of the calculation models

Types of calculated models with an implanted femoral component of an endoprosthesis during single-support standing	Value of SDS (Mises stress) at control points (MPa)							
	1	2	3	4	5	6	7	8
	the dissection of the femur in the frontal plane				on the surface of the femur			
Fracture-free model for intact bone tissue	10	2.2	1.9	10	11.2	13.5	16.2	14.3
Model with osteoporotic bone tissue, trans-acetabular fracture, implanted femoral component without inter-acetabular reconstruction	14.7	6	13.5	13.8	8.3	12.8	9	6.9
The model with osteoporotic bone tissue, with a transtrochanteric fracture, with reconstruction of the intertrochanteric area with a ring-shaped graft	6.3	4.9	12.7	13.8	4.2	11.5	8.9	6.7
Changes in the strain level (%)	42.9	18.3	5.3	0	49.4	10.2	1.1	2.9

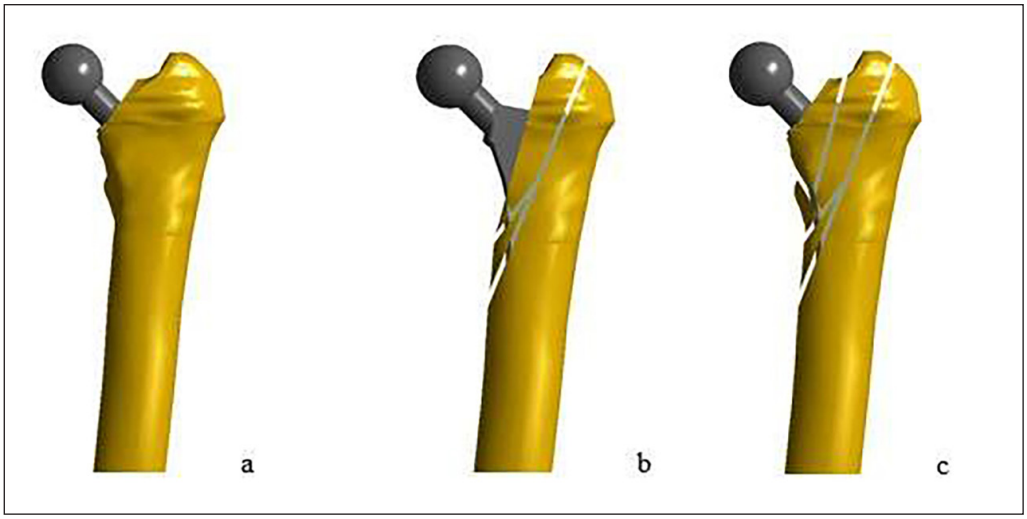

Fig. 1. Calculation models of the left femur: a) model of the femur without fracture, unchanged bone; b) a model of a multifragmentary pertrochanteric fracture, osteoporotic bone, endoprosthesis implantation without restoration of the intertrochanteric area; c) model of a multifragmentary pertrochanteric fracture, osteoporotic bone, implantation of an endoprosthesis with plasty of the intertrochanteric area, Adams's arch and calcar with a ring-shaped graft.

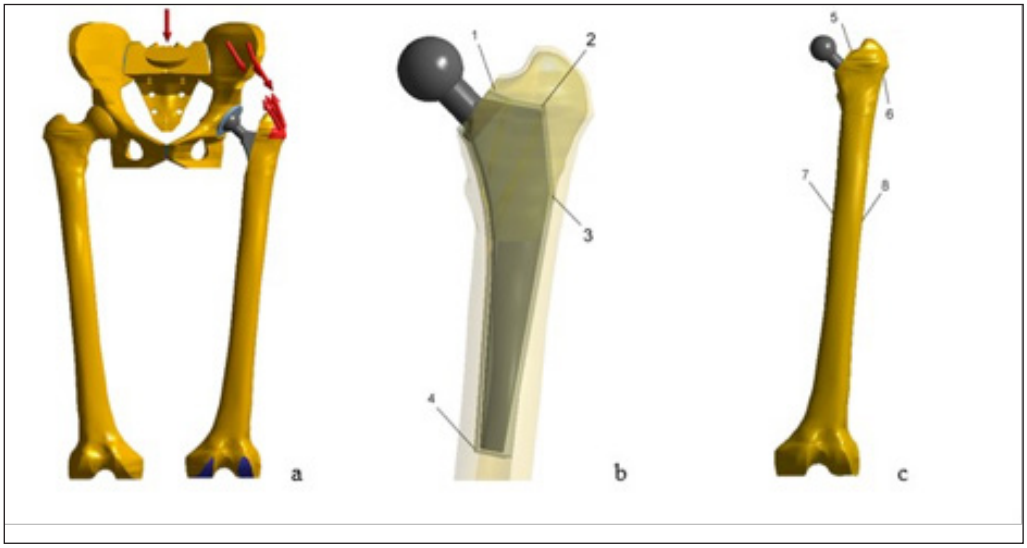

Fig. 2. Calculation model: a) Direction of action of forces and fixation of the model; b) control points in the frontal section of the femur; c) control points on the surface of the femur.

the vertical position of the body were chosen as the load. The total load is reduced to a set of equivalent forces. The points of application of forces, their magnitudes and directions of action are taken from references [12].

The comparative analysis was carried out according to the stress values at the control points - on the inner surface of the bone marrow canal in the places of contact with the lower endoprosthesis (Fig. 2b), as well as on the outer surface of the femur (Fig. 2c).

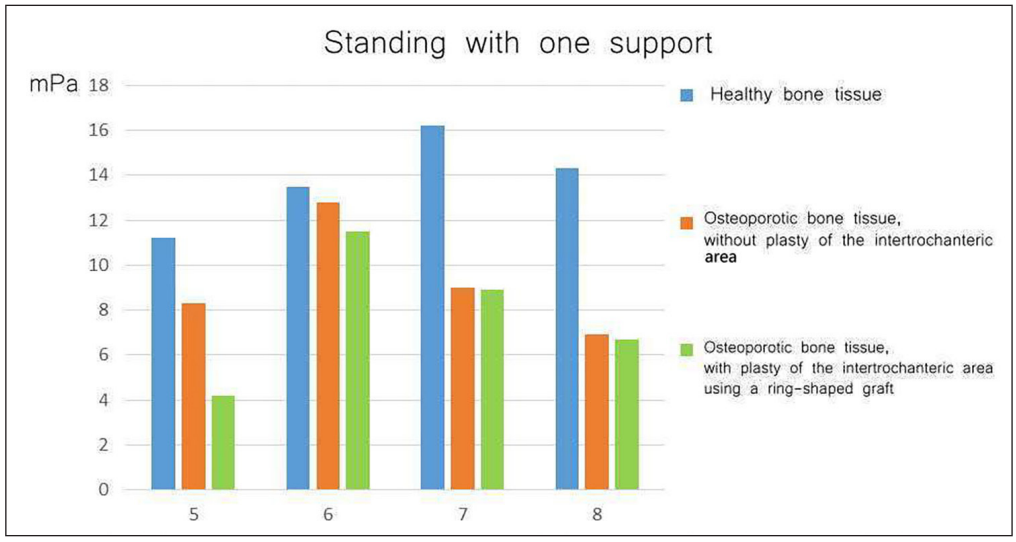

Fig. 3. Mises stress values - the surface of the femur at control points 5, 6, 7, 8.

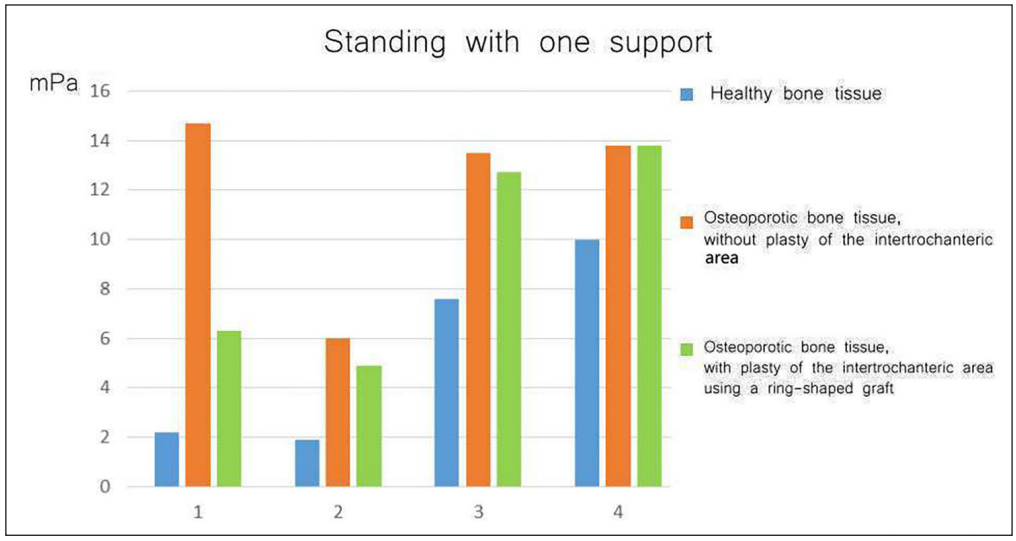

Fig. 4. Mises stress values - frontal section of the femur (control points 1, 2, 3, 4).

RESULTS

We did not observe complications related to reconstruction of the proximal part of the femur and implantation of endoprostheses, as well as infectious complications. Restoration of movements in the hip joint and full loading of the operated limb was allowed, depending on the physical condition of the patient, the day after the operation. The duration of stay in the hospital varied from 6 to 11 days (8.3 ± 1.8 days on average). On the day of discharge, all patients could move with the help of a walker or crutches without limiting the load on the operated limb.

Clinical and radiological examination was performed 3, 6 and 12 months after the day of surgery. A total of 39 patients were studied after arthroplasty for 31-A1 (4), 31-A2 (28) and 31-A3 (7) fractures. Among them, 11 patients were examined between 18 and 33 months. There were no cases of hip dislocations after hemi- and total arthroplasty. The level of mobility depended on the comorbid condition, but all patients noted the capability to apply full load on the operated limb during walking. There were found no signs of instability of the femoral component and destruction of bone tissue around the implants on control radiographs within the observation period. In 4 patients, moderate proximal displacement of fragments of the apex of the greater trochanter was noted, which did not affect the function of support and gait.

In the case of primary arthroplasty for type 31-A2 fractures, we supplement the reconstruction of the trochanteric zone with bone plasty with an annular autograft to restore the medial cortical wall (Adams' arch) and form the upper opening of the bone marrow canal. The graft is taken from the basal part of the proximal fragment that is being removed. It contains 2 to 3 cm of cortical medial wall (Adams' arch). Its size is determined by the X-ray of the contralateral hip joint during surgery planning. The transplant is placed on the edges of the fragments of the trochanteric zone previously fixed with a wire. In this way, we unsure an

established optimal level of immersion of the stem in the bone marrow channel, restoration of the offset and stabilizing function around the joint muscles.

Analysis of the strained-deformed state (SDS) of the model with an unstable osteoporotic fracture of the trochanteric zone and an implanted femoral component of the endoprosthesis shows that the most strained element of the model is the femur. The influence of the mineral density of bone tissue on the nature of the distribution and value of strains on the outer surface of the femur and on the inner surface of the bone-marrow canal around the leg of the implant was established. In the presence of osteoporosis, the strain value on the outer surface of the bone decreases (Fig. 3), but significantly increases on the inner surface around the implant (Fig. 4). Especially in the area of the destroyed proximal metaphysis. The reconstruction of the trochanteric zone, in comparison with the model without reconstruction, does not affect the nature of the SDS in the area of the diaphyseal part of the bone marrow canal. The main result of the reconstruction is a significant decrease in the strained state in the bone tissue of the restored proximal metaphysis, namely in the area of the restored medial and posterior wall of the bone marrow canal (Table I).

In the area of the entrance to the medullary canal along the medial surface, it decreased to 6.3 MPa (compared to 14.7 MPa for the model without reconstruction). On the lateral surface, the stress level decreased by 18.4% and amounted to 4.9 MPa (compared to 6 MPa for the model without reconstruction) (Fig. 4).

DISCUSSION

In the case of fractures at the level of the small trochanter, and in the absence of an osteopenic state, endoprostheses with diaphyseal fixation stems are offered, which significantly reduces the level of stress in the proximal metaphysis of the femur.

In case of unstable osteoporotic pertrochanteric fractures, ensuring the stability of the femoral component is provided by using cement fixation of the leg and reconstruction of the destroyed acetabular area. The argument in favor of hemiarthroplasty with cement fixation is the relatively low traumatic nature of the surgery and a much lower level of complications in the medium-term observation period [14, 15]. The presence of a collar (collared versions) prevents stem subsidence due to being supported by the medial-posterior cortical wall (calcar) [16].

Due to the lack or insufficient fixation of fragments in pertrochanteric fractures, there is a threat of displacement and non-union of fragments, bursitis, pain on the outer surface of the thigh, weakness of the abductors and associated lameness, and the possibility of dislocations are observed [17]. Repositioning and "rigid fixation" of fragments of the trochanteric zone during primary arthroplasty contributes to the restoration of the function of the muscles attached to them and the anatomical and physiological features of this area, since the total strain these muscles put on the trochanteric zone during regular walking is doubled, and when going up the stairs - up to 4 times more than the body weight [9, 18].

Techniques for fixing fragments of the trochanteric zone vary. Trochanteric Buttress Plates are used, which fixate the apex of the greater trochanter and are fixed with screws on the outer surface of the trochanteric zone [19]. However, the most common is fixation with a wire or steel cable, including small and large trochanters [9, 20, 21].

Computer tomography with 3D modeling provides the most accurate assessment of the nature of the destruction of the trochanteric zone and the justified choice of surgical tactics [22, 23].

Viewing the data of Li M. et al., according to the results of CT studies of unstable fractures, when the posterior-medial surface of the proximal metaphysis is destroyed, in 32.2% of cases a single fragment of the intertrochanteric ridge with a small trochanter is formed, in 42.37% they are represented by two separate fragments, and in 25.42% the separated small trochanter was presented as 3 or more fragments [24, 25].

From the standpoint of these studies, we consider fixation of fragments with a cerclage wire in the form of tightening wire loops depending on the type of fracture to be the most reasonable. In our patients with type 31-A2 fractures, we form a tension wire loop in such a way that the apex of the greater trochanter is fixed, the crossing of the wire over the interacetabular ridge and two parallel wraps above and below the lesser trochanter are created, which ensures fixation of the most destroyed posterior-medial wall of the trochanteric zone.

Unstable fractures of type 31-A3 (reverse fractures) are mainly due to destruction of the medial wall of the proximal metaphysis. This is illustrated by the requirements to ensure positive contact of the proximal and distal fragments in the area of Adam's arch - Positive medial cortex support (PVCS) when applying osteosynthesis [26]. In arthroplasty for reverse fractures, we form a tightening wire loop in such a way as to create compression tension between the fragments along the entire fracture surface.

In case of 31-A2 fractures, before the implantation of the endoprosthesis stem, various options are offered for replacing the defect of the Adams' arch and the area of the

calcar. The authors suggest filling the defect of the posterior-medial wall by impaction of bone fragments with or without wire fixation [27]. Compact autografts from the lower part of the removed head and neck are used [28], or a semicircular graft from the removed capitus [29].

Thus, the results of the calculations and gathered data confirm the biomechanical effectiveness of the reconstruction of the trochanteric zone in unstable osteoporotic trans-acetabular fractures by fixing the fragments with a tightening wire loop and plasty of the proximal opening of the entrance to the bone-medullary canal with a ring-shaped autograft with the restoration of the Adams arch and Calcar zone.

CONCLUSIONS

Despite the limited number of operated patients, the obtained clinical results, as well as the results of biomechanical calculations, confirm the possibility and feasibility of using primary arthroplasty in unstable osteoporotic fractures of the trochanteric zone with the aim of early restoration of the support function of the damaged limb in individuals with limited physical capabilities. Reconstruction of the intertrochanteric area with a ring-shaped autograft contributes to the achievement of primary stability of the femoral component, restoration of the total femoral offset and stabilizing function of muscles around the joints.

REFERENCES

1. Liu P, Jin D, Zhang C, Gao Y. Revision surgery due to failed internal fixation of intertrochanteric femoral fracture: current state-of-the-art. BMC Musculoskelet Disord. 2020;21(1):573. doi:10.1186/s12891-020-03593-8.
2. Özdemir E, Okkaoglu MC, Evren AT et al. The Cost and Consequences of Failed Osteosynthesis of Intertrochanteric Femur Fractures: A Matched Cohort Study. Indian J Orthop. 2021;55(3):629-635. doi:10.1007/s43465-020-00322-0.
3. Marks R. Hip fracture epidemiological trends, outcomes, and risk factors, 1970-2009. Int J Gen Med. 2010;3:1-17.
4. Huang G, Zhang M, Qu Z et al. Fixation options for reconstruction of the greater trochanter in unstable intertrochanteric fracture with arthroplasty. Medicine (Baltimore). 2021;100(26):e26395. doi:10.1097/MD.0000000000026395.
5. Ouyang X, Ding Yu, Yu L, Xin F et al. Comparison of the curative effects of PFNA and DHS fixation in treating intertrochanteric fractures in elderly patients. Biomed Research-tokyo. 2017;28(6);2717-2723.
6. Martinho T, Stoffel K. Treatment of Intertrochanteric Femur Fractures with Hip Arthroplasty in Older Patients: A Narrative Review of Indications and Outcomes. Medicina (Kaunas). 2021;57(8):763. doi:10.3390/medicina57080763.
7. Müller F, Galler M, Zellner M et al. Total hip arthroplasty after failed osteosynthesis of proximal femoral fractures: Revision and mortality of 80 patients. J Orthop Surg (Hong Kong). 2017;25(2):2309499017717869. doi:10.1177/2309499017717869.
8. Fahad Ul Islam M, Ahmed Qureshi O. Consequences of treatment of extracapsular fractures of hip with cemented bipolar hemiarthroplasty and dynamic hip screw fixation: A clinical study International Journal of Orthopaedics Sciences 2020;6(2):701-706. doi: 10.22271/ortho.2020.v6.i2k.2123.
9. Huang G, Zhang M, Qu Z et al. Fixation options for reconstruction of the greater trochanter in unstable intertrochanteric fracture with arthroplasty. Medicine (Baltimore). 2021;100(26):e26395. doi:10.1097/MD.0000000000026395.
10. Fichman SG, Mäkinen TJ, Safir O et al. Arthroplasty for unstable pertrochanteric hip fractures may offer a lower re-operation rate as compared to cephalomedullary nailing. Int Orthop. 2016;40(1):15-20. doi:10.1007/s00264-015-2794-7.
11. Paul M. Kurowski Engineering Analysis with SolidWorks Simulation 2012. 2012, p.475
12. Crowninshield RD, Brand RA. A physiologically based criterion of muscle force prediction in locomotion. J Biomechanics. 1981;14(11):793-801. doi: 10.1016/0021-9290(81)90035-x.
13. Vyrva OE, Golovina YaA, Karpinsky MYu et al. The study of the stress-strain state in the "implant-bone" system on the model of the allocomposite endoprosthesis of the proximal femur. Travma. 2020; 21(1). doi:10.22141/1608-1706.1.21.2020.197797.
14. Kelly M, Chen AF, Ryan SP et al. Cemented Femoral Fixation in Total Hip Arthroplasty Reduces the Risk of Periprosthetic Femur Fracture in Patients 65 Years and Older: An Analysis From the American Joint Replacement Registry. J Arthroplasty. 2023;38(7/2):S351-S354. doi:10.1016/j.arth.2023.04.039.
15. Rassir R, Schuiling M, Sierevelt IN et al. What Are the Frequency, Related Mortality, and Factors Associated with Bone Cement Implantation Syndrome in Arthroplasty Surgery?. Clin Orthop Relat Res. 2021;479(4):755-763. doi:10.1097/CORR.0000000000001541.
16. Demey G, Fary C, Lustig S et al. Does a collar improve the immediate stability of uncemented femoral hip stems in total hip arthroplasty? A bilateral comparative cadaver study. J Arthroplasty. 2011;26(8):1549-1555. doi:10.1016/j.arth.2011.03.030.
17. Frankel A, Booth RE Jr, Balderston RA et al. Complications of trochanteric osteotomy. Long-term implications. Clin Orthop Relat Res. 1993;(288):209-213.
18. Pachore JA, Shah VI, Upadhyay S, Patel SB. Primary Arthroplasty for Unstable and Failed Intertrochanteric Fractures: Role of Multi-Planar Trochanteric Wiring Technique. Hip Pelvis. 2023;35(2):108-121. doi:10.5371/hp.2023.35.2.108.
19. Ganjale SB, Gadegone W, Kothadia P. Trochanteric Buttress Plate Combined with Proximal Femoral Nail for Unstable Intertrochanteric Fractures. [Innovative Technique]. Open Journal of Orthopedics. 2018. doi: 10.4236/ojo.2018.86027.

20. Huang C, Wu X. Surgical Selection of Unstable Intertrochanteric Fractures: PFNA Combined with or without Cerclage Cable. Biomed Res Int. 2021;2021:8875370. doi:10.1155/2021/8875370.
21. Wu HF, Chang CH, Wang GJ et al. Biomechanical investigation of dynamic hip screw and wire fixation on an unstable intertrochanteric fracture. Biomed Eng Online. 2019;18(1):49. doi:10.1186/s12938-019-0663-0.
22. Kalia RB, Arora SS, Sarkar B et al. A comprehensive 3D CT based classification of intertrochanteric fracture. J Clin Orthop Trauma. 2022;30:101912. doi:10.1016/j.jcot.2022.101912.
23. Zhang Y, Sun Y, Liao S, Chang S. Three-Dimensional Mapping of Medial Wall in Unstable Pertrochanteric Fractures. Biomed Res Int. 2020;2020:8428407. doi:10.1155/2020/8428407.
24. Li M, Li ZR, Li JT et al. Three-dimensional mapping of intertrochanteric fracture lines. Chin Med J (Engl). 2019;132(21):2524-2533. doi:10.1097/CM9.0000000000000446.
25. Mei J, Pang L, Jiang Z. Strategies for managing the destruction of calcar femorale. BMC Musculoskelet Disord. 2021;22(1):460. doi:10.1186/s12891-021-04324-3.
26. Kozono N, Ikemura S, Yamashita A et al. Direct reduction may need to be considered to avoid postoperative subtype P in patients with an unstable trochanteric fracture: a retrospective study using a multivariate analysis. Arch Orthop Trauma Surg. 2014;134(12):1649-1654. doi:10.1007/s00402-014-2089-2.
27. Sinno K, Sakr M, Girard J, Khatib H. The effectiveness of primary bipolar arthroplasty in treatment of unstable intertrochanteric fractures in elderly patients. N Am J Med Sci. 2010;2(12):561-568. doi:10.4297/najms.2010.2561.
28. Vital PR, Rao S, Rao NRP. Primary cemented bipolar hemiarthroplasty with trochanteric and calcar reconstruction in unstable intertrochanteric fractures in elderly: a prospective study. J Evid Based Med Healthc. 2015;2(40):6586-6586. doi: 10. 18410 /je bmh /2015/ 898.
29. Kadam R, Gupta A, Chhallani A. Calcar reconstruction in bipolar hemiarthroplasty in elderly patients. Journal of Evolution of Medical and Dental Sciences. 2016;5(77):5701-5704. doi: 10.14260/jemds/2016/1286.

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