https://doi.org/10.52889/1684-9280-2024-3-74-4-9
UDC 616-089.23; 616-001; 615.477.2; 616-089.28/.29; 615.47:617-089
IRSTI 76.29.41; 76.13.21

Original article

Mathematical Modeling of a Plate for Fixation of Periprosthetic Fractures of the Proximal Femur

Amanzhol Balgazarov [1], Arman Batpen [2], Serik Balgazarov [3], Boris Gorbunov [4], Zhanatai Ramazanov [5], Ruslan Abilov [6], Alexandr Krikliviy [7], Artyom Moroshan [8], Aliya Atepileva [9]

[1] *PhD student at the Karaganda Medical University, Karaganda, Kazakhstan. E-mail: balgazarov@inbox.ru*

[2] *Deputy Director for Research and Strategy, National Scientific Center of Traumatology and Orthopedics named after Academician N.D. Batpenov, Astana, Kazakhstan. E-mail: batpen_a@mail.ru*

[3] *Head of the Traumatology Department No.4, National Scientific Center of Traumatology and Orthopedics named after Academician N.D. Batpenov, Astana, Kazakhstan. E-mail: balgazarovss@gmail.com*

[4] *Assistant professor of the Kazakh Agrotechnical Research University named after S. Seifullin, Astana, Kazakhstan. E-mail: gdn_kz@mail.ru*

[5] *Orthopedic Traumatologist of the Traumatology Department No.4, National Scientific Center of Traumatology and Orthopedics named after academician N.D. Batpenov, Astana, Kazakhstan. E-mail: 66zhanatai@gmail.com*

[6] *Traumatologist of the Traumatology Department No.4, National Scientific Center of Traumatology and Orthopedics named after academician N.D. Batpenov, Astana, Kazakhstan. E-mail: abilovruslan79@gmail.com*

[7] *PhD student at the Karaganda Medical University, Karaganda, Kazakhstan. E-mail: kriklivyialexandr@gmail.com*

[8] *Traumatologist of the Traumatology Department No. 4, National Scientific Center of Traumatology and Orthopedics named after academician N.D. Batpenov, Astana, Kazakhstan. E-mail: moroshartem92@gmail.com*

[9] *PhD student at the Karaganda Medical University, Karaganda, Kazakhstan. E-mail: daringdiva@mail.ru*

Abstract

Periprosthetic fractures of the proximal femur pose a significant medico-social problem, as their treatment is complicated by the presence of a prosthetic stem in the medullary canal, which makes fragment fixation difficult and determines the stability of the prosthesis. According to the expert group of the World Health Organization, up to 1 million 500 thousand total hip replacements are performed annually in the world. According to various data, the prevalence of periprosthetic femoral fractures varies over a wide range - from 0.1 to 46.0%, which is a significant medical and social problem. he main problem in the treatment of periprosthetic fractures is the presence of a prosthetic leg in the bone marrow canal, which makes it difficult to fix fragments and determines the stability of the prosthesis leg.

***The purpose of this study** to conduct mathematical modeling of a domestically developed plate for use in fixing periprosthetic fractures of the proximal femur.*

***Materials and methods.** The examination of the plate for fixation of periprosthetic fractures of the proximal femur was carried out using the finite element method. For the computer implementation of the FEM, there were used COMPASS-3D, Autodesk Inventor PRO and SolidWorks programs. The physical and mechanical parameters of the system components taken from the references data were used for calculations.*

***Results.** The performed the stress-strain state calculations showed that the magnitude of stresses arising under the influence of a load does not exceed the strength limit of the plate material 900-1100 MPa, the greatest stresses in the periprosthetic plate occurring in the area of the holes of the locking screws and side paired holes, it also does not exceed the permissible strength values and is 56.48 MPa.*

***Conclusion.** According to the results of the conducted studies, it can be concluded that there is a sufficient margin of safety of the periprosthetic plate for fixing periprosthetic fractures of the proximal femur and of the system «femur – endoprosthesis – periprosthetic plate» as a whole.*

***Keywords**: plate, periprosthetic fracture, total hip arthroplasty.*

Corresponding author: Kriklivyy Alexandr, PhD student, Karaganda Medical University, Karaganda, Kazakhstan
Postal code: M01K7G6
Address: Kazakhstan, Karaganda, Gogol str. 40
Phone: +77023727034
E-mail: kriklivyialexandr@gmail.com

J Trauma Ortho Kaz 2024; 3 (74): 4-9
Recieved: 11-07-2024
Accepted: 19-08-2024

Introduction

According to the expert group of the World Health Organization, up to 1 million 500 thousand total hip replacements are performed annually in the world. The number of total hip arthroplasties (THA) has increased by 80% in Germany and the European Community over the past 5 years and amounts to 175 thousand per year (Germany) [1-3]. In Kazakhstan, this figure is more than 5,000 operations per year. The growing popularity and widespread use of THA naturally leads to an increase in the total number of complications both during surgery and in the postoperative period [4-6].

One of them is a per prosthetic fracture - bone destruction in the area of the endoprosthesis components, and the presence of an intramedullary implant can significantly complicate reposition and treatment. According to the references, the prevalence of per prosthetic femoral fractures (PFF) varies in a wide range - from 0.1 to 46.0%, which is a significant medical and social problem [7-9].

Despite the wide choice of treatment for such patients with various options of osteosynthesis or reendoprosthesis, the number of complications, such as the formation of a false joint, instability of the prosthesis, occur in 37% of cases [10, 11]. Currently, there is no single generally accepted treatment strategy for PFF. The main problem in the treatment of per prosthetic fractures is the presence of a prosthetic leg in the bone marrow canal (BMC), which makes it difficult to fix fragments and determines the stability of the prosthesis leg [12]. Per prosthetic fractures are always a more difficult problem than ordinary fractures for two main reasons. Firstly, it is more difficult to fix bone fragments, and secondly, it is necessary to restore the stability and function of the end prosthesis. To date, there are several methods of surgical treatment of this category of patients.

Treatment of PFF with an external fixation device has not been widely used [13]. The main advantage of this method is low injury, but the risk of infection increases, which is a formidable complication.

Intramedullary fixation is used with a long revision leg reaching the middle third of the thigh. In cases of instability of the endoprosthesis, this option is the method of choice. However, with a stable leg of the femoral component of the endoprosthesis, this technique is irrational due to the high traumatic nature of the surgery.

Extra medullary osteosynthesis with the use of a locking compression plate (LCP) plate with angular stability and monocortical fixation of screws has become the most widespread in the surgical treatment of PFF [14]. However, monocortical osteosynthesis is often ineffective, since for reliable screw integration, the modified cortical bone plate as a result of osteoporosis is not always suitable: it manages to accommodate a small number of turns, compared with traditional bone osteosynthesis. Angular stabilization of the screws does not solve this problem, but only exacerbates it by increasing the risk of diastasis during lysis of the ends of bone fragments.

The purpose of this study is to conduct mathematical modeling of a domestically developed plate for use in fixing periprosthetic fractures of the proximal femur.

Materials and methods

The examination of the plate for fixation of per prosthetic fractures of the proximal femur was carried out using the finite element method (FEM) [15,16]. The plate design is shown on Figure 1.

Figure 1 - Plate design for fixation of periprosthetic fractures of the proximal femur

For the computer implementation of the FEM, there were used COMPASS-3D APM FEM, Autodesk Inventor PRO and SolidWorks programs [17,18]. The physical and mechanical parameters of the system components taken from the references data were used for calculations [19-22].

As the main functional resultant load, the force applied in the center of the endoprosthesis head in a direction of 10° relative to the hip axis and having a value of F is equal to 1000 N [21].

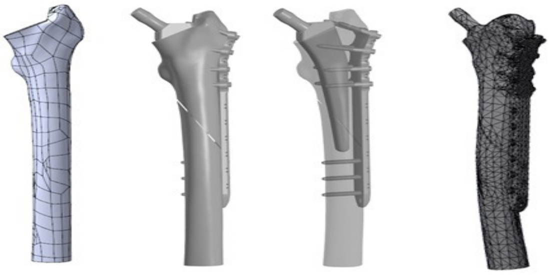

Figure 2 - Computer model and finite element grid of the investigated system "femur – endoprosthesis – periprosthetic plate"

Using the finite element method, mathematical computer modeling of the stress-strain state (SSS) was carried out and the interaction of elements of the biomechanical system "femur – endoprosthesis – periprosthetic plate" was studied [15-18].

Based on X-rays, anatomical atlases and references, mathematical 3D models of the femur, endoprosthesis and plate were developed and the system “femur – endoprosthesis – periprosthetic plate” was developed. The computational model of the femur with an installed endoprosthesis and a periprosthetic plate was presented from 57.873 elements – linear tetrahedra. The total number of nodes was 96.635. Three-dimensional 3D computer models and a finite element grid of the system are shown in Figure 2.

Results

Figure 3 shows the stress distribution over the entire surface of the periprosthetic plate from the outer and inner sides.

Based on the results of the conducted studies, it was concluded that there is a sufficient margin of safety of the periprosthetic plate and of the system “femur – endoprosthesis – periprosthetic plate” as a whole (Table 1).

Table 1 - Physical and mechanical parameters of the simulated systems

Material	Modulus of elasticity, MPa	Poisson’s ratio
The cortical bone	15.000	0.3
Spongy bone	1.000	0.3
Plate, prosthesis, screws, Titanium alloy	110.000	0.3

The performed SSS calculations (Figures 3-6) showed that the magnitude of stresses arising under the influence of a load does not exceed the strength limit of the plate material 900-1100 MPa, the greatest stresses in the periprosthetic plate occurring in the area of the holes of the locking screws and side paired holes, it also does not exceed the permissible strength values and is 56.48 MPa. The largest displacement occurs in the head of the endoprosthesis and is equal to 0.35 mm. The minimum safety factor for the plate is 4.88 (Table 2).

Table 2 - Comparative results of stress-strain state calculations

№	Indicators	The periprosthetic plate	The femur	Endoprosthesis
1	Maximum equivalent voltage according to Mises, MPa	56.48	258	111.8
2	Maximum linear displacement, mm	0.21	0.24	0.35
3	Minimum safety factor	4.88	0.80	2.46

It should be noted that, according to the obtained research results (Figure 3), we observe an asymmetric stress distribution in the central part of the periprosthetic plate, they are shifted to the left (if viewed from the outer side of the plate). This may be due to the nature of the fracture in question or the geometry of the plate (in the axial direction it does not provide anatomical contouring of the femur).

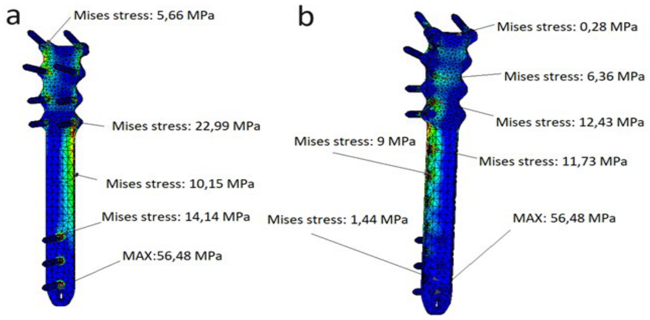

Figure 3 - Stress distribution of the periprosthetic plate from the a) inner and b) outer sides according to Mises

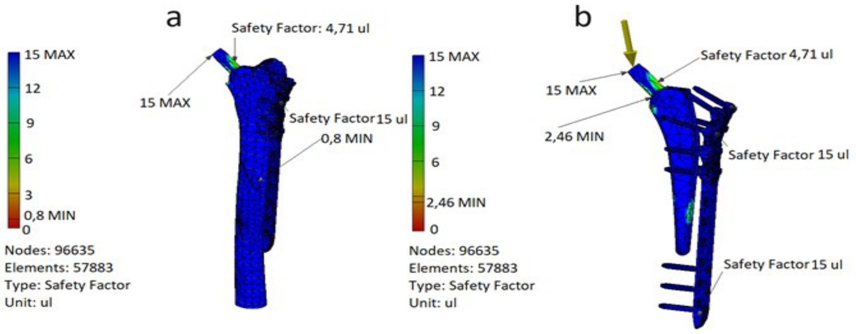

Figure 4 -The stress distribution pattern according to Mises in MPa for: a) the entire femur-endoprosthesis-plate system b) endoprosthesis and plate

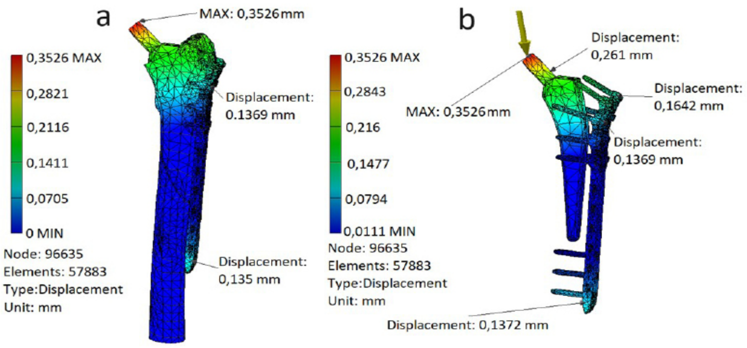

Figure 5 - Picture of the distribution of displacements of system elements in mm for: a) the entire system femur-endoprosthesis-plate b) endoprosthesis and plate

Discussion

This study investigated the biomechanical properties of a novel locking plate for fixation of periprosthetic fractures of the proximal femur (PFF) using finite element analysis. The results demonstrate that the plate design possesses sufficient safety margins, ensuring its suitability for PFF treatment.

Key findings. Stress distribution: The analysis revealed that stress levels within the plate do not exceed the material's yield strength, indicating a sufficient safety margin.

Maximum stress points: The areas of highest stress concentration were identified as the locking screw holes and the side paired holes, suggesting the need for careful screw placement and a robust design in these regions.

Overall system stability: The biomechanical model of the femur-endoprosthesis-plate system revealed sufficient safety margins, indicating that the proposed plate design can effectively stabilize the bone and prosthetic components in a PFF scenario.

Implications of the findings. The findings of this study have significant implications for the development and application of novel fixation devices for PFF treatment. The proposed plate design addresses the challenges associated with the presence of a prosthetic stem in the medullary canal, particularly the difficulty in achieving stable fixation. The computational analysis provides valuable insights into the stress distribution within the plate and the overall system, which can guide further refinements and optimization of the design.

Limitations and future research directions. Single design: The analysis focused on a single plate design, which warrants further investigation of variations in geometry and material properties for optimized performance.

Simplified model: The model employed simplified representations of bone and implant materials, requiring further validation with more detailed material properties and biomechanical testing.

Load scenarios: The study considered a single load scenario, requiring future investigations to analyze the plate's performance under different loading conditions and patient specific factors.

Clinical validation: The biomechanical study needs to be complemented by clinical trials to assess the plate's effectiveness in real-world scenarios.

Conclusion

The current study offers promising biomechanical evidence for the feasibility and safety of the proposed plate for PFF fixation. Future research should address the identified limitations and conduct clinical trials to validate the potential clinical benefits of this novel design.

Conflict of interests. The authors declare that there is no conflict of interest when writing this article.

Funding. This study is funded by the Committee of Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan "Development, study of safety and effectiveness of premium innovative domestic implants for surgical treatment of patients with injuries and diseases of the musculoskeletal system" (BR21881815).

The contribution of the authors. Conceptualization – S.B., A.B.; methodology – B.G; verification – A.B; formal analysis – Zh.R; data search and processing – R.A., A.A., A.M.; writing (original rough preparation) – A.B., A.K., A.A.; writing (review and editing) – A.B.

References

1. Soleimani M., Barkhordari S., Mardani F., Shaarbafchizadeh N., Naghavi-Al-Hosseini F. Rationing access to total hip and total knee replacement in the Islamic Republic of Iran to reduce unnecessary costs: policy brief. East Mediterr Health J. 2020; 26(11):1396–1402. [Crossref]

2. Szymski D., Walter N., Krull P., Melsheimer O., Schindler M., et al. Comparison of mortality rate and septic and aseptic revisions in total hip arthroplasties for osteoarthritis and femoral neck fracture: an analysis of the German Arthroplasty Registry. Journal of Orthopaedics and Traumatology, 2023; 24(1): 29. [Crossref]

3. Kumar P., Ksheersagar V., Aggarwal S., Jindal K., et al. Complications and mid to long term outcomes for hip resurfacing versus total hip replacement: a systematic review and meta-analysis. European Journal of Orthopaedic Surgery & Traumatology, 2023; 33(5): 1495-1504. [Crossref]

4. Bekarissov O., Batpen A., Belokobylov A., Baidalin T., et al. Safety and Efficacy of Latitud™ Hip Replacement in Total Hip Arthroplasty: An Observational Study in Kazakhstan, 2024. A preprint [Crossref]

5. Serikova-Esengeldina D. S., Goremykina M. V., Glushkova N. E. Epidemiological aspects of osteoarthritis and total arthroplasty. Nauka i zdravoohranenie, 2019; (5): 5-10. [Google Scholar]

6. Viderman D., Aubakirova M., Salamat A., Kaldybayev D., et al. The Impact of Gabapentinoids on Pain-Related Outcomes after Knee and Hip Surgery: A Systematic Review with Meta-Analysis of Randomized Controlled Trials. Journal of Clinical Medicine, 2024; 13(14): 4205. [Crossref]

7. Bissias C., Kaspiris A., Kalogeropoulos A., Papoutsis K., et al. Factors affecting the incidence of postoperative periprosthetic fractures following primary and revision hip arthroplasty: a systematic review and meta-analysis. Journal of Orthopaedic Surgery and Research, 2021; 16: 1-14. [Crossref]

8. Samdanis V., Manoharan G., Jordan R.W., Watts A.C., et al. Indications and outcome in total elbow arthroplasty: a systematic review. Shoulder & Elbow, 2020; 12(5): 353-361. [Crossref]

9. Ferguson R.J., Palmer A. J., Taylor A., Porter M.L., et al. Hip replacement. The Lancet, 2018; 392(10158): 1662-1671. [Crossref]

10. Raupov R.K., Vissarionov S.V., Babaeva G.A., Noyanova Y.G., et al. Enthesitis-related arthritis in children: A literature review of the clinical features and differential diagnosis. Pediatric Traumatology, Orthopaedics and Reconstructive Surgery, 2023; 11(1): 105-120. [Crossref]

11. Лоскутов А.Е., Олейник А.Е., Ковбаса Е.А. Клинико-статистический анализ выживаемости эндопротезов тазобедренного сустава // Ортопедия, травматология и протезирование. - 2014. - №2(595). - С. 11-15. [Google Scholar]

Loskutov A.E., Oleinik A.E., Kovbasa E.A. Kliniko-statisticheskii analiz vyzhivaemosti endoprotezov tazobedrennogo sustava (Clinical and statistical analysis of the survival rate of hip joint endoprostheses) [in Russian]. Ortopediia, travmatologiia i protezirovanie. 2014; 2(595): 11-15. [Google Scholar]

12. Челноков А.Н., Пивень И.М. Перипротезные переломы бедра с нестабильностью бесцементной ножки - возможность остеосинтеза без ревизии? (Случай из практики) // Гений Ортопедии. - 2015. - №4. - С. 85-89. [Crossref]

Chelnokov A.N., Piven I.M. Periproteznye perelomy bedra s nestabil'nost'iu bestsementnoi nozhki - vozmozhnost' osteosinteza bez revizii? (Sluchai iz praktiki) (Periprosthetic femoral fractures with instability of a cementless stem - the possibility of osteosynthesis without revision?) [in Russian]. Genii Ortopedii. 2015; 4: 85-89. [Crossref]

13. Schwartz J.T., Mayer J.G., Engh C.A. Femoral fracture during non-cemented total hip arthroplasty. J Bone Joint Surg Am. 1989; 71(8): 1135-42. [Google Scholar]

14. Patsiogiannis N., Kanakaris N.K., Giannoudis P. V. Periprosthetic hip fractures: an update into their management and clinical outcomes. EFORT Open Reviews, 2021; 6(1): 75-92. [Crossref]

15. Бате К., Вилсон Е. Численные методы анализа и метод конечных элементов / Монография. - 2012. - С. 445. [Google Scholar]

Bate K., Vilson E. Chislennye metody analiza i metod konechnykh elementov (Numerical methods of analysis and finite element method) [in Russian]. Monografiia. 2012; 445. [Google Scholar]

16. Старовойтов Э.И. Сопротивление материалов / Учебное пособие. - Москва: Физматлит. - 2010. - С. 384. [Google Scholar]

Starovoitov E.I. Soprotivlenie materialov (Strength of materials) [in Russian]. Uchebnoe posobie. - Moskva: Fizmatlit. 2010; 384. [Google Scholar]

17. Tickoo S. Autodesk Inventor Professional 2018 for Designers. CADCIM Technologies. 2017. [Google Scholar]

18. Большаков В.П., Бочков А.Л., Лячек Ю.Т. Твердотельное моделирование деталей в CAD-системах: AutoCAD, КОМПАС-3D, SolidWorks, Inventor, Creo. Изд.: Питер. - 2014. - С. 304. [Google Scholar]

Bol'shakov V.P., Bochkov A.L., Liachek Iu.T. Tverdotel'noe modelirovanie detalei v SAD-sistemakh: AutoCAD, KOMPAS-3D, SolidWorks, Inventor, Creo (Solid modeling of parts in CAD systems: AutoCAD, KOMPAS-3D, SolidWorks, Inventor, Creo) [in Russian]. Izd.: Piter. 2014; 304. [Google Scholar]

19. Батпенов Н.Д., Баймагамбетов Ш.А., Батпен А.Н. Эндопротезирование тазобедренного сустава КазНИИТО и его клиника - биомеханическое обоснование / Монография. - 2015. - С. 24. [Google Scholar]

Batpenov N.D., Baimagambetov Sh.A., Batpen A.N. Endoprotezirovanie tazobedrennogo sustava KazNIITO i ego klinika - biomekhanicheskoe obosnovanie (Hip replacement KazNIITO and its clinic – biomechanical justification) [in Russian]. Monografiia. 2015; 24. [Google Scholar]

20. Taylor S.J., Walker P.S., Perry J.S., Cannon S.R. et al. The forces in the distal femur and the knee during walking and other activities measured by telemetry. J Arthroplasty. 1998; 13(4): 428-37. [Crossref]

21. Rau D., Rußow G., Heyland M., Wulsten D. et al. A New System for Periprosthetic Fracture Stabilization-A Biomechanical Comparison. J Clin Med. 2022; 11(3): 892. [Crossref]

22. Währnert D., Müller M., Tiedemann H., Märdian S. et al. Periprosthetic fracture fixation in Vancouver B1 femoral shaft fractures: A biomechanical study comparing two plate systems. J Orthop Translat. 2020; 24: 150-154. [Crossref]

Жамбас сүйегінің перипротездік сынықтарын бекітуге арналған пластинаны математикалық модельдеу

Балгазаров А.С. [1], Бәтпен А.Н. [2], Балгазаров С.С. [3], Горбунов Б.Н. [4], Рамазанов Ж.К. [5],
Абилов Р.С. [6], Крикливый А.А. [7], Морошан А.В. [8], Атепилева А.М. [9]

[1] Қарағанды медицина университетінің PhD докторанты, Қарағанды, Қазақстан. E-mail: balgazarov@inbox.ru

[2] Директордың ғылыми жұмыстар және стратегия жөніндегі орынбасары, Академик Н.Д. Батпенов атындағы травматология және ортопедия ұлттық ғылыми орталығы, Астана, Қазақстан. E-mail: batpen_a@mail.ru

[3] №4 травматология бөлімшесінің меңгерушісі, Академик Н.Д. Батпенов атындағы травматология және ортопедия ұлттық ғылыми орталығы, Астана, Қазақстан. E-mail: balgazarovss@gmail.com

[4] С. Сейфуллин атындағы Қазақ ғылыми-зерттеу агротехникалық университетінің доценті, Астана, Қазақстан. E-mail: gdn_kz@mail.ru

[5] №4 травматология бөлімшесінің травматологы, Академик Н.Д. Батпенов атындағы травматология және ортопедия ұлттық ғылыми орталығы, Астана, Қазақстан. E-mail: 66zhanatai@gmail.com

[6] №4 травматология бөлімшесінің травматологы, Академик Н.Д. Батпенов атындағы травматология және ортопедия ұлттық ғылыми орталығы, Астана, Қазақстан. E-mail: abilovruslan79@gmail.com

[7] Қарағанды медицина университетінің PhD докторанты, Қарағанды, Қазақстан. E-mail: kriklivyialexandr@gmail.com

[8] №4 травматология бөлімшесінің травматологы, Академик Н.Д. Батпенов атындағы травматология және ортопедия ұлттық ғылыми орталығы, Астана, Қазақстан. E-mail: moroshartem92@gmail.com

[9] Қарағанды медицина университетінің PhD докторанты, Қарағанды, Қазақстан. E-mail: daringdiva@mail.ru

Түйіндеме

Проксимальды сан сүйегінің перипротездік сынықтар маңызды медициналық-әлеуметтік мәселе болып табылады. Өйткені оларды емдеу сүйек каналында протездік аяқтың болуымен қиындайды, бұл сынықтарды бекітуді қиындатады және протездің тұрақтылығын анықтайды. Дүниежүзілік денсаулық сақтау ұйымының сарапшы тобының мәліметі бойынша әлемде жыл сайын жамбас жамбастарын жалпы 1 миллион 500 мыңға дейін ауыстыру операциясы жасалады. Әртүрлі мәліметтерге сәйкес, жамбас сүйектерінің перипротездік сынықтарының таралуы 0,1-ден 46,0% -ға дейін ауытқиды, бұл маңызды медициналық және әлеуметтік мәселе болып табылады. Перипротездік сынықтарды емдеудегі негізгі мәселе фрагменттерді бекітуді қиындататын және протездік аяқтың тұрақтылығын анықтайтын медулярлық арнада протездік аяқтың болуы болып табылады.

Зерттеудің мақсаты: жамбас сүйегінің перипротездік сынықтарын бекітуде қолдануға арналған отандық пластинаның математикалық моделін орындау.

Әдістері. Аяқ сүйегінің проксимальды сүйектерінің перипротездік сынықтарын бекітуге арналған пластинаны зерттеу ақырлы элементтер әдісімен жүргізілді. Ақырғы элементтер әдісін компьютерде жүзеге асыру үшін COMPASS-3D, Autodesk Inventor PRO және SolidWorks бағдарламалары пайдаланылды. Есептеулер үшін анықтамалық деректерден алынған жүйе компоненттерінің физикалық және механикалық параметрлері пайдаланылды.

Нәтижесі. Кернеу - деформация күйін есептеулер жүктің әсерінен пайда болатын кернеулердің шамасы пластина материалының созылу беріктігінен 900-1100 МПа аспайтынын көрсетті. Перипротездік пластинадағы ең жоғары кернеулер саңылаулар, бекіткіш бұрандалар және бүйірлік жұпталған тесіктер аймағында пайда болады, сонымен қатар рұқсат етілген беріктік мәндерінен аспайды және 56,48 МПа құрайды.

Қорытынды. Зерттеу нәтижелеріне сүйене отырып, сан сүйегінің проксимальды перипротездік сынықтарын және тұтастай алғанда «сан сүйегі - эндопротездеу - перипротездік пластинка» жүйесін бекіту үшін перипротездік пластинаның жеткілікті қауіпсіздік шегі бар деп қорытынды жасауға болады.

Түйін сөздер: пластина, перипротездік сынық, жамбастың жалпы артропластикасы.

Математическое моделирование пластины для фиксации перипротезных переломов проксимального отдела бедренной кости

Балгазаров А.С. [1], Бәтпен А.Н. [2], Балгазаров С.С. [3], Горбунов Б.Н. [4], Рамазанов Ж.К. [5],
Абилов Р.С. [6], Крикливый А.А. [7], Морошан А.В. [8], Атепилева А.М. [9]

Резюме

Перипротезные переломы проксимального отдела бедренной кости являются значимой медико-социальной проблемой, так как их лечение затруднено наличием протезной ножки в костномозговом канале, что усложняет фиксацию отломков и определяет стабильность протеза. По данным экспертной группы Всемирной организации здравоохранения, ежегодно в мире проводится до 1 миллиона 500 тысяч тотальных эндопротезирований тазобедренного сустава. По разным данным, распространенность перипротезных переломов бедра колеблется в пределах - от 0,1 до 46,0%, что является значимой медико-социальной проблемой. Основной проблемой лечения перипротезных переломов является наличие протезной ножки в костномозговом канале, что затрудняет фиксацию отломков и определяет стабильность ножки протеза.

Цель исследования: провести математическе моделирование пластины отечественной разработки для применения при фиксации перипротезных переломов проксимального отдела бедренной кости.

Материалы и методы. Исследование пластины для фиксации перипротезных переломов проксимального отдела бедренной кости проводили методом конечных элементов. Для компьютерной реализации метода конечных элементов использовались программы COMPASS-3D, Autodesk Inventor PRO и SolidWorks. Для расчетов использовались физико-механические параметры компонентов системы, взятые из справочных данных.

Результаты. Проведенные расчеты напряженно-деформированного состояния показали, что величина напряжений, возникающих под действием нагрузки, не превышает предела прочности материала пластины 900-1100 МПа. Наибольшие напряжения в околопротезной пластинке возникают в районе отверстий, стопорных винтов и боковых парных отверстий и также не превышает допустимых значений прочности и составляет 56,48 МПа.

Выводы. По результатам проведенных исследований можно сделать вывод о наличии достаточного запаса прочности перипротезной пластинки для фиксации перипротезных переломов проксимального отдела бедренной кости и системы «бедренная кость – эндопротез – перипротезная пластинка» в целом.

Ключевые слова: пластина, перипротезный перелом, тотальное эндопротезирование тазобедренного сустава.