SHORT REPORTS AND NOTES FROM PRACTIC

УДК 616.718.5-089.853:617.58-7](045)

DOI: http://dx.doi.org/10.15674/0030-59872025190-95

Use of individual instrument for high tibial algus osteotomy in varus gonarthrosis

M. L. Golovakha [1], S. A. Bondarenko [2], R. Hart [3], W. Orljanski [4]

[1] Zaporizhzhia State Medical and Pharmaceutical University. Ukraine
[2] Clinic «Motor Sich». Ukraine
[3] MHA Wiener Gesundheitsverbund Klinik Ottakring. Austria
[4] «Wiener Privat klinik». Austria

The work purpose was to present a new method of preoperative planning of high valgus tibial osteotomy with an individual instrument. Methods. Computed tomography (CT) of the lower extremities of a patient with stage II varus gonarthrosis was used. Bone segmentation from surrounding tissues, modeling of the lower extremities, correction of the tibia axis, and construction of individual blocks for resection were performed. The individual instrument is a block for performing osteotomy with depth indication and a hole for the upper middle screw of the T-shaped plate and two individual wedges for opening the osteotomy to the marks applied to them. The surgical intervention was performed with fluoroscopy control after knee arthroscopy. Partial removal of the medial meniscus and microfracture of the cartilage defect of the medial femoral condyle were performed simultaneously. Results. The planned correction of the tibia was accurately reproduced, which was confirmed by CT after surgery. In the postoperative period, there were no complications with wound healing, loading of the limb was started after 3 weeks, walking with a cane after 6, and without additional support after 10. X-rays were performed after 6, 12 weeks and 6, 12 months after the operation. A year later, the full range of motion and symmetrical walking were restored. The individual instrument allowed for quick and accurate placement of the plate, and wedges for opening the osteotomy helped to correctly reproduce the correction and hold it during osteosynthesis. Conclusion. The use of the proposed individual instrument for high valgus tibial osteotomy was convenient, simplified some stages of the surgical intervention, and ensured accurate planned correction of the angular deformity.

Мета. Навести нову методику передопераційного планування високої вальгізуючої остеотомії великогомілкової кістки з виготовленням індивідуального інструмента. Методи. Використано комп'ютерну томографію (КТ) нижніх кінцівок пацієнта з варусним гонартрозом II стадії. Було здійснено сегментування кістки від навколишніх тканин, моделювання нижніх кінцівок, корекція осі великогомілкової кістки та побудова індивідуальних блоків для резекції. Індивідуальний інструмент — це блок для виконання остеотомії із вказанням глибини й отвором під верхній середній гвинт Т-подібної пластинки та два індивідуальні клини для розкриття остеотомії до нанесених на них міток. Оперативне втручання проведено з рентгеноскопічним контролем після артроскопії колінного суглоба. Одночасно здійснено парціальне видалення медіального меніска та мікрофрактиризацію дефекту хряща медіального виростка стегнової кістки. Результати. Заплановану корекцію великогомілкової кістки точно відтворено, що підтвердило КТ після втручання. У післяопераційному періоді не було ускладнень із загоєнням рани, навантаження кінцівки розпочато через 3 тижні, ходьба з тростиною — через 6, а без додаткової опори — через 10. Рентгенографію проводили через 6, 12 тижнів та 6, 12 міс. після операції. Через рік відновлено повний обсяг рухів та симетричну ходьбу, Індивідуальний інструмент дозволив швидко та точно встановити пластинку, а клини для розкриття остеотомії допомогли правильно відтворити корекцію й утримувати її під час остеосинтезу. Висновок. Використання запропонованого індивідуального інструмента для високої вальгізуючої остеотомії великогомілкової кістки було зручним, спростило деякі етапи проведення оперативного втручання та забезпечило точну заплановану корекцію кутової деформації. Ключові слова. Остеотомія, індивідуальний інструмент, гонартроз.

Key words. Osteotomy, individual instrument, gonarthrosis

Introduction

Corrective osteotomy of the tibia is one of the widely used surgical methods that allow preserving the knee joint for a long period of time [1, 8, 9]. It is combined with arthroscopy, as well as various chondroplasty techniques. Using corrective osteotomy, we can restore the function of the knee joint against the background of various deformities for a period of at least 8 years [3, 8, 11]. The problematic issues lie simultaneously in several planes:

– at what stage should the patient be offered osteotomy;

– how best to replace the cartilage defect;

– within what limits should the axis of the knee joint be corrected;

– how to ensure the accuracy of the planned correction of the deformity?

Purpose: to present a new method of preoperative planning of high valgus osteotomy of the tibia with the manufacture of an individual instrument.

Material and methods

The study was approved by the ethics committee of the Zaporizhzhia State Medical and Pharmaceutical University (protocol No. 8 dated 26.12.2022), the patient's informed consent was obtained.

This study presents the result of the treatment of a 53-year-old patient L. with secondary osteoarthritis of the knee joint and varus deformity (Fig. 1), who underwent corrective osteotomy using an individual instrument. Body mass index — 32 kg/m^2, varus deformity with a peak in the proximal tibia, without significant damage to the lateral knee joint, stage II by Kellgren-Lawrence classification.

The study used computed tomography (CT) of the patient's lower limbs with a slice thickness of 0.8 mm. The design was carried out in two stages: 1) segmentation of the bone from the surrounding tissues was performed in the Materialise Mimics 26.0 software; 2) modeling of the lower limbs, correction of the tibia axis and construction of individual blocks for resection were performed in the Geomagic FreeForm Plus software (Fig. 2).

The basis for planning an osteotomy in the knee joint area is the femur. Therefore, the sagittal and frontal planes of the model were installed on it and the slope of the "knee joint line" was assessed, which in three-dimensional modeling does not look like a line, but a plane. This is determined by the structure of the femur — in this case, the slope of the knee joint plane was normal. The software restored the correct mechanical axis of the limb by means of a virtual high valgus opening osteotomy (Fig. 3). After compensating for the deformity, we measured the correction angle and planned the osteotomy level, the position of its plane and the position of the plate for osteosynthesis (Fig. 4). Finally, we designed an individual instrument consisting of a cutting block with holes for guide wires along the osteotomy plane and a channel for the upper middle screw of the Tomofix plate [2], as well as two individual wedges for opening the osteotomy with marks of their insertion depth (Fig. 5). The patient data, the depth of the osteotomy and the drilling of the channel for the upper middle screw of the plate were applied to the cutting block. After approval, the tibial model, cutting block and wedges were printed from the medical photopolymer resin Dental SG Resin (Fig. 6).

After surgery, a CT scan of the knee joint was performed and the accuracy of the instrument was assessed by comparing the radiographic parameters of the osteotomy planning and the data after the intervention. The operation was performed according to a known technique with fluoroscopy control after knee arthroscopy [5, 8, 9]. Partial removal of the medial meniscus and microfracture of the cartilage defect of the medial femoral condyle were performed simultaneously. During the surgical intervention, after the proximal tibia was isolated, we applied the individual cutting block to the model and to the bone alternately, trying to achieve maximum compliance of the block position. The stages of the surgical intervention of the double high valgus osteotomy of the tibia are shown in Fig. 7.

Results

To verify the accuracy of the application of the individual instrument for corrective osteotomy, we performed a virtual installation of individual cutting guides and wedges in a three-dimensional model, which was built using a CT scan of the patient after surgery. Thus, Fig. 8 shows a model of the lower limb after surgery, an open osteotomy, virtually "inserted" wedges and an applied individual template for cutting.

Fig. 1. X-ray of the knee joint of a 53-year-old patient L. before surgery

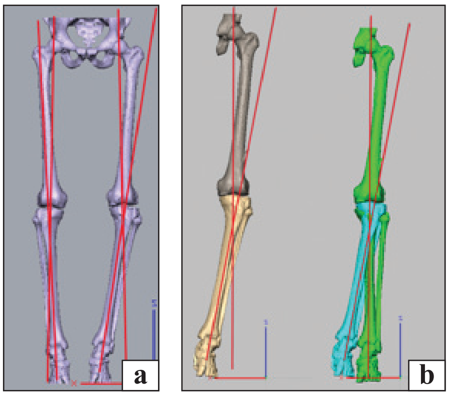

Fig. 2. Limb model for planning osteotomy, determining deformation and assessing the limb axis (a); measuring the required correction angle (b)

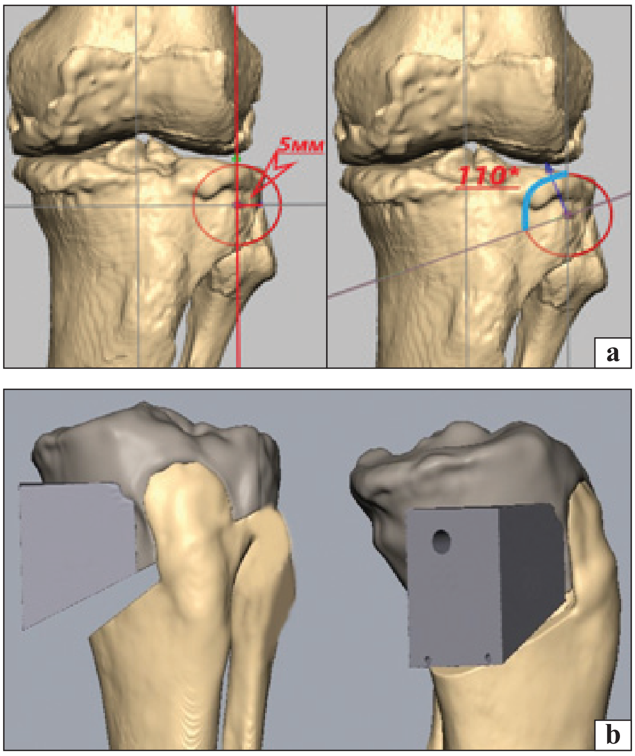

Fig. 3. Osteotomy planning: a) the upper point of the osteotomy at the level of the fibular head, which is 5 mm from the cortical layer; b) double osteotomy design

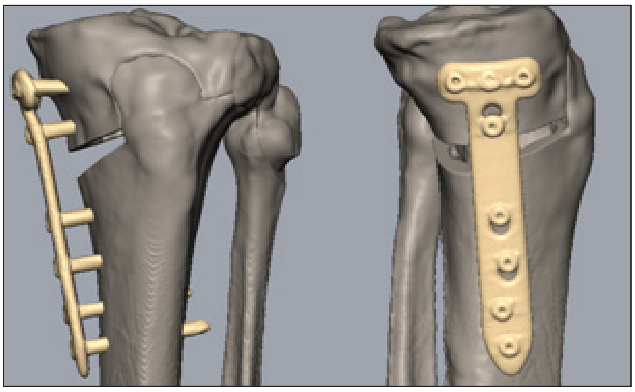

Fig. 4. Modeling the plate position

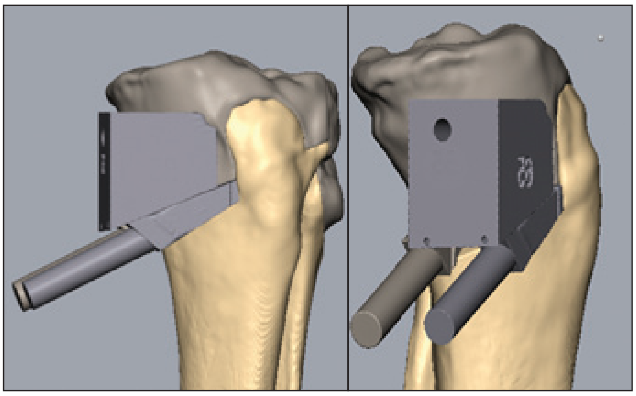

Fig. 5. Designing individual wedges to hold the osteotomy opening and the hole for the upper middle screw of the plate

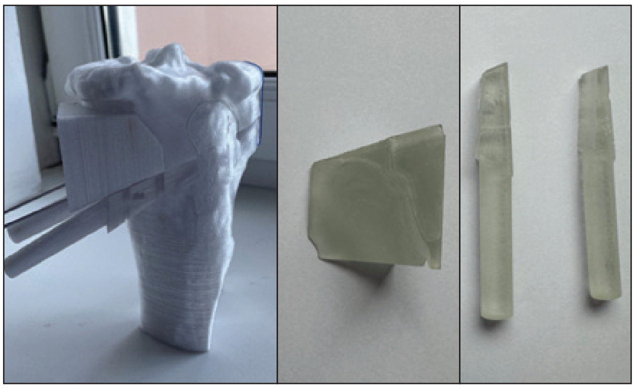

Fig. 6. Tibia model, individual block and wedges for osteotomy opening

In (Fig. 8, b, c) it is clearly seen that the wedges absolutely “laid” in the open osteotomy, and the template for cutting — on the surface of the tibia.

A comparative analysis of the primary radiographic indicators used for osteotomy planning and correction was conducted based on post-operative results. CT was used before and after surgical intervention (Fig. 9, Table).

As a result of the analysis, no significant deviations from the plan presented on the radiographs were identified (Fig. 10).

In the postoperative period, there were no complications with wound healing, the patient began to load the limb 3 weeks after the operation according to the protocol after microfracture of the knee cartilage defect. Walking with a cane was allowed after 6 weeks, and without additional support after 10. Radiography was performed 6 and 12 weeks and 6, 12 months after the operation. One year post-intervention, the patient exhibited full range of motion and symmetrical gait. The Knee Society Score (KSS) was 173 points, the Hospital for Special Surgery (HSS) score was 92, and the Lequesne index was 3.

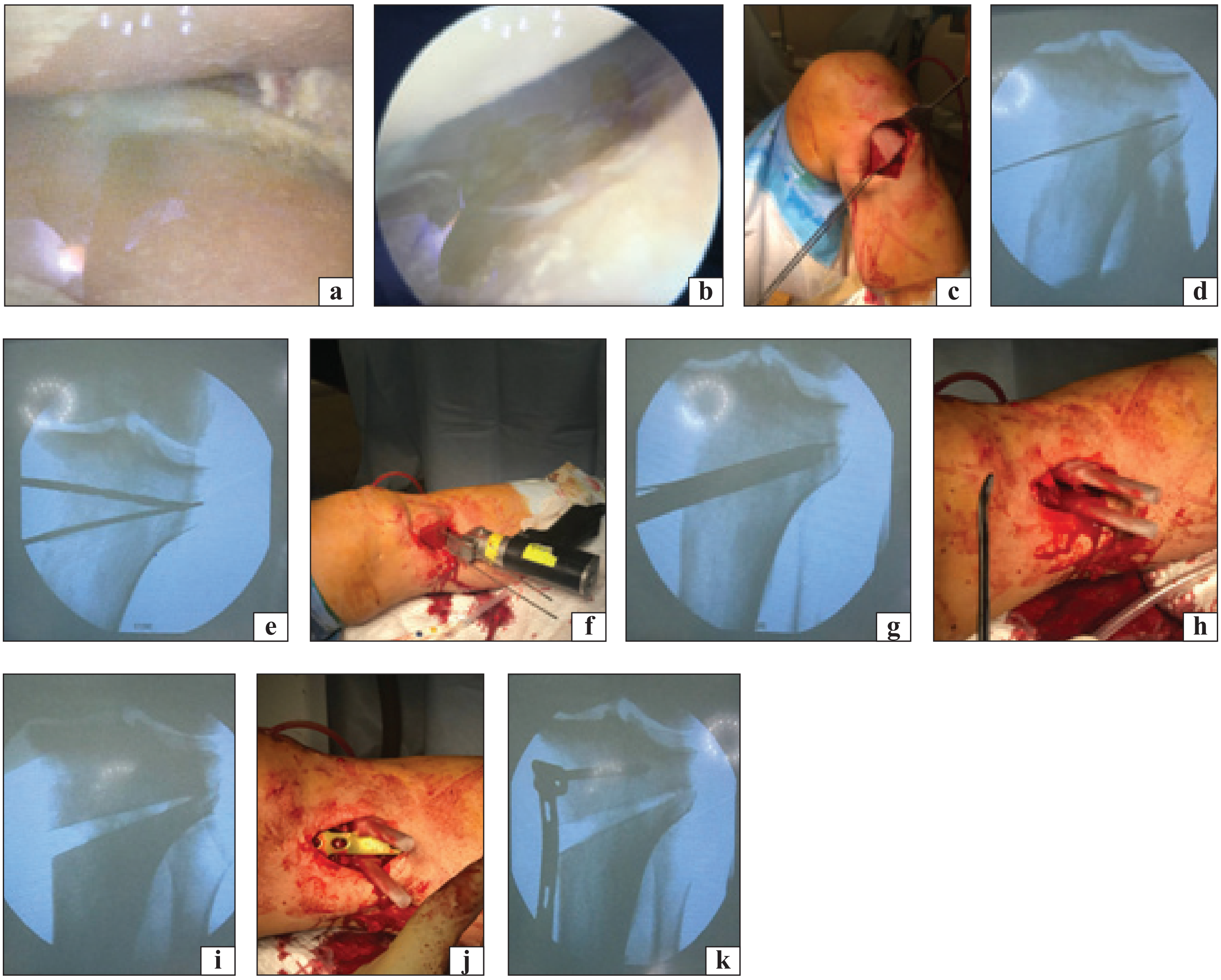

Fig. 7. Stages of surgical intervention with an individual instrument for high valgus osteotomy of the tibia: medial (a) and lateral (b) parts of the knee joint; c) installation of an individual conductor and insertion of guide wires; d) fluoroscopy check; e) drilling of a hole for the middle proximal screw; f) osteotomy along the lower edge of the individual block; g) fluoroscopy control of the depth of the osteotomy; h) after opening the osteotomy, individual wedges are installed; i) X-ray control - plastic wedges do not cover the bone; j) installation of the plate through the middle proximal hole on a pre-drilled channel and insertion of the screw; k) X-ray of plate installation

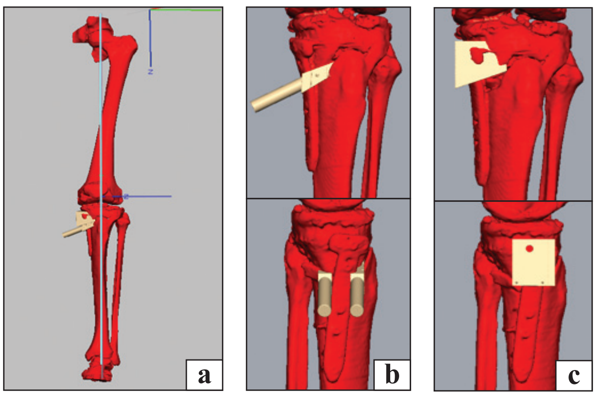

Fig. 8. Three-dimensional model of the limb after osteotomy with installation of models of individual wedges for opening and individual conductor for cutting: a) the mechanical axis of the lower limb is determined; comparison of the results of the installation of wedges (b) and conductor (c)

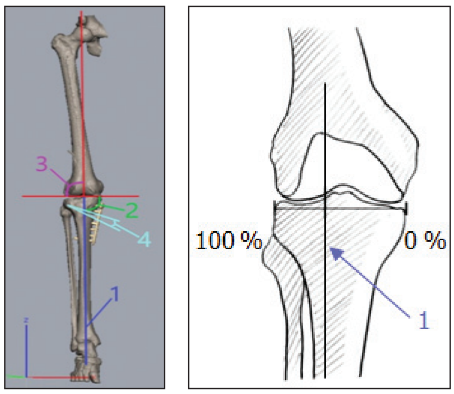

Fig. 9. Scheme of comparison of the results: 1) the point of the mechanical axis of the limb on the tibial plateau (in percent); 2) the value of the mechanical proximal medial tibial angle; 3) data of the mechanical distal lateral femoral angle; 4) the angle of opening of the osteotomy

Table

Radiographic parameters planned and obtained as a result of surgical intervention

Patient	Osteotomy opening angle		Limb axis position, %		Medial tibial angle, °		Lateral femoral angle, °	
	plan	after intervention	plan	after intervention	plan	after intervention	plan	after intervention
1	11.0	11.0	58.0	58.1	87.0	87.1	87.0	87.2

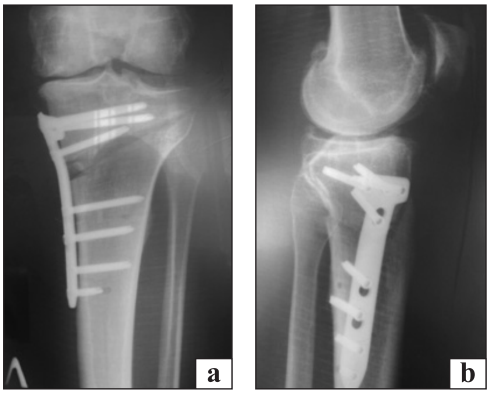

Fig. 10. Radiography after surgery: a) frontal and b) lateral projections

Fig. 11. Radiography 4 years after surgery

The metal structure was subsequently removed. The observation lasted for 4 years (Fig. 11) and showed a satisfactory functional result, the patient did not notice any deterioration in his condition, although the radiography corresponds to stage III gonarthrosis.

Discussion

As a result of the surgical intervention, the individual instrument allowed to quickly find the osteotomy plane, did not require an increase in the length of the skin incision, and did not interfere with fluoroscopy control. The planned hole for the upper middle screw allowed for a quick and accurate installation of the plate. Individual wedges for opening the osteotomy helped to correctly reproduce the correction and maintain it during osteosynthesis, regardless of the fluoroscopy data.

Our study has a number of shortcomings. To obtain more accurate and generalized conclusions, further comparative studies are required, which should include a larger number of patients and consider long-term results. In addition, it is important to anticipate the individual characteristics of each case and the optimal choice of treatment method taking into account clinical and anatomical factors. Particular attention should be paid to the comparative analysis of the effectiveness of the operation with an individual instrument and convection technique, as well as the study of long-term results and patient satisfaction.

In general, published articles in recent years confirm the prospects and effectiveness of using individual instruments for tibial osteotomy in varus gonarthrosis [4, 6, 7, 10]. Further studies will allow us to clarify and supplement the obtained data, which will contribute to improving the results of surgical treatment of this pathological condition [10, 11].

Individual three-dimensional osteotomy planning has a significant advantage as it enables the detection of limb deformation, rotation, and the position of the knee joint plane. It also allows for accurate determination of both the level and height of the osteotomy opening. An individual conductor and wedge-spacers that are non-contrast for fluoroscopy facilitate the work during the operation, and a predetermined position of the plate for osteosynthesis simplifies and speeds up the operation.

Conclusion

The use of the proposed individual instrument for high valgus osteotomy of the tibia was convenient, simplified the main stages of the surgical intervention and ensured accurate planned correction of angular deformation.

Conflict of interest. The authors declare the absence of a conflict of interest.

Prospects for further research. Conducting an analysis of the results of using an individual instrument for high valgus osteotomy of the tibia to determine the accuracy of the instrument's operation, ease of use and studying the analysis of the immediate and long-term results of its use.

Information on financing. The study was financed from our own funds.

Authors' contribution. Golovakha M. L. — planning the work, setting goals and objectives, developing instrument models, performing surgical interventions; Bondarenko S. A. — construction of three-dimensional models and their 3D printing, statistical analysis; Hart R. — reviewing the work and preparing the manuscript; Orlyansky V. — planning of surgical interventions and analysis of results.

References

1. Coventry, M. B. (2001). Osteotomy of the upper portion of the tibia for degenerative arthritis of the knee. *The journal of bone and joint surgery-american volume, 83*(9), 1426. https://doi.org/10.2106/00004623-200109000-00021
2. DePuySynthes (2016) TomoFix Medial High Tibial Plate (MHT) surgical technique. DSEM/TRM/0115/0288(0112)
3. Lau, L. C., Fan, J. C., Chung, K., Cheung, K., Man, G. C., Hung, Y., Kwok, C. K., Ho, K. K., Chiu, K., & Yung, P. S. (2021). Satisfactory long-term survival, functional and radiological outcomes of open-wedge high tibial osteotomy for managing knee osteoarthritis: Minimum 10-year follow-up study. *Journal of orthopaedic translation, 26*, 60–6. https://doi.org/10.1007/s00590-019-02389-410.1016/j.jot.2020.03.003
4. Fucentese, S. F., Meier, P., Jud, L., Köchli, G., Aichmair, A., Vlachopoulos, L., & Fürnstahl, P. (2020). Accuracy of 3D-planned patient specific instrumentation in high tibial open wedge valgisation osteotomy. *Journal of experimental orthopaedics, 7*(1). https://doi.org/10.1186/s40634-020-00224-y
5. Fujisawa, Y., Masuhara, K., & Shiomi, S. (1979). The effect of high tibial osteotomy on osteoarthritis of the knee. *Orthopedic Clinics of North America, 10*(3), 585–608. https://doi.org/10.1016/s0030-5898(20)30753-7
6. Hinterwimmer, S., Feucht, M. J., Paul, J., Kirchhoff, C., Sauerschnig, M., Imhoff, A. B., & Beitzel, K. (2016). Analysis of the effects of high tibial osteotomy on tibial rotation. *International orthopaedics, 40*(9), 1849–1854. https://doi.org/10.1007/ s00264-015-3100-4 PMID: 26753845
7. Kim, H. J., Yoon, J., Choi, G. W., & Yang, J. (2016). Imageless navigation versus conventional open wedge high tibial osteotomy: A meta-analysis of comparative studies. *Knee surgery & related research, 28*(1), 16–26. https://doi.org/10.5792/ksrr.2016.28.1.16
8. Lobenhoffer, P. (2017). The rationale of osteotomy around the knee. *The Journal of knee surgery, 30*(05), 386–392. https://doi.org/10.1055/s-0037-1603755
9. Pang, R., Jiang, Z., Xu, C., Shi, W., Zhang, X., Wan, X., Bahat, D., Li, H., Senatov, F., Bulygina, I., Wang, H., Zhang, H., & Li, Z. (2022). Is patient-specific instrumentation accurate and necessary for open-wedge high tibial osteotomy? A meta-analysis. *Orthopaedic surgery, 15*(2), 413–422. https://doi.org/10.1111/os.13483
10. Sprenger, T. R., & Doerzbacher, J. F. (2003). Tibial osteotomy for the treatment of Varus gonarthrosis. *The journal of bone and joint surgery-american volume, 85*(3), 469–474. https://doi.org/10.2106/00004623-200303000-00011.

The article has been sent to the editors	Received after review	Accepted for printing
02.01.2025	17.02.2025	18.02.2025

USE OF INDIVIDUAL INSTRUMENT FOR HIGH TIBIAL ALGUS OSTEOTOMY IN VARUS GONARTHROSIS

M. L. Golovakha [1], S. A. Bondarenko [2], R. Hart [3], W. Orljanski [4]

[1] Zaporizhzhia State Medical and Pharmaceutical University. Ukraine
[2] Clinic «Motor Sich». Ukraine
[3] MHA Wiener Gesundheitsverbund Klinik Ottakring. Austria
[4] «Wiener Privat klinik». Austria

✉ Maxim Golovakha, MD, Prof. in Traumatology and Orthopaedics: golovahaml@gmail.com; https://orcid.org/0000-0003-2835-9333
✉ Stanislav Bondarenko, MD: trauma.bon.s@gmail.com; https://orcid.org/0000-0002-6192-1466
✉ Radek Hart, MD, Prof.: radekhart23@gmail
✉ Weniamin Orljanski, MD, Prof. in Traumatology and Orthopaedics: orljanski@hotmail.com