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Results of Surgical Correction of Fixed Flexion Deformity during Total Knee Arthroplasty in Patient of Knee Osteoarthritis: A Comprehensive Review

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Abstract

Background: Fixed flexion deformity (FFD) is a common manifestation of knee osteoarthritis (OA) that significantly impacts patients' functional abilities and quality of life. Surgical correction of FFD during total knee arthroplasty (TKA) aims to restore joint alignment and improve range of motion. However, a comprehensive understanding of the outcomes and factors influencing the success of this procedure is essential. Objectives: This review article aims to provide a comprehensive overview of the results of surgical correction of FFD during TKA in patients with knee OA. It examines the surgical techniques used, evaluates functional outcomes, pain relief, and range of motion improvements, and assesses the reported rates of complications. Additionally, the durability of the correction and its impact on patient satisfaction and quality of life are explored. Factors influencing long-term success or failure of the procedure are identified. Conclusions: Surgical correction of FFD during TKA has shown promising results in terms of functional improvements, pain relief, and range of motion. Patients experience enhanced functional abilities and improved quality of life following surgery. While complications can occur, meticulous surgical techniques, proper patient selection, and adherence to best practices can help minimize their occurrence. Factors such as surgical technique, patient compliance with rehabilitation, implant selection, and patient-specific characteristics influence the long-term success of the procedure.

Keywords: Fixed Flexion Deformity; Knee Osteoarthritis; Surgical Correction; Functional Outcomes; Pain Relief; Range of Motion; Complications; Durability.

1. Introduction

Knee osteoarthritis (OA) is a prevalent degenerative joint disease characterized by the progressive deterioration of the articular cartilage in the knee joint. It is a leading cause of chronic pain and disability, particularly among older adults. Knee OA can significantly impact a person's quality of life, limiting their mobility, causing pain, and affecting their ability to perform daily activities [1].

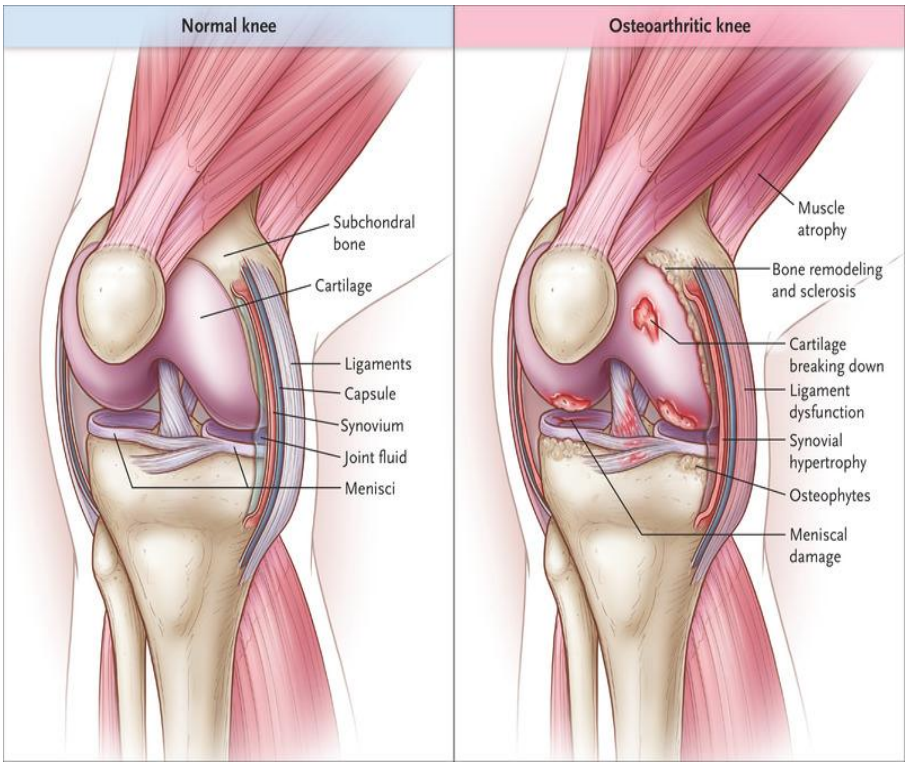

Fig. (1) Osteoarthritis of the Knee [2].

Within the knee OA, fixed flexion deformity (FFD) represents a significant clinical challenge. FFD refers to a fixed and persistent flexion contracture of the knee joint, whereby the knee is unable to achieve full extension. This deformity is often accompanied by soft tissue contractures, ligament tightness, and structural changes in the joint [3].

The significance of FFD in knee OA lies in its detrimental effects on functional outcomes, joint stability, and implant positioning during total knee arthroplasty (TKA). Patients with FFD experience difficulties in walking, climbing stairs, and performing basic movements, leading to a considerable impairment in their quality of life. Moreover, FFD can complicate the surgical procedure and affect the accuracy of component alignment and ligament balancing, potentially influencing the long-term success of TKA [4].

The purpose of this review article is to explore the results and outcomes of surgical correction of FFD during TKA in patients with knee osteoarthritis. By examining the existing literature, we aim to provide a comprehensive analysis of the various surgical techniques employed, the preoperative assessment and patient selection criteria, the surgical outcomes, and the long-term follow-up data. Through this review, we seek to assess the effectiveness and impact of surgical correction of FFD on functional outcomes, pain relief, range of motion improvements, and patient satisfaction [5].

Fixed flexion deformity (FFD) in knee osteoarthritis (OA) has multifactorial etiology and pathophysiology. The development of FFD is often a result of progressive degeneration and structural changes in the knee joint associated with OA. The underlying causes can include articular cartilage loss, osteophyte formation, synovial inflammation, ligamentous laxity, and muscular imbalance [6].

In knee OA, the articular cartilage that cushions the joint surfaces gradually breaks down, leading to joint space narrowing and increased friction between the bones. As a protective mechanism, the body responds by producing osteophytes, which are bony outgrowths, in an attempt to stabilize the joint. These structural changes contribute to the development of FFD by altering the joint mechanics and placing abnormal stresses on the surrounding soft tissues [7].

The clinical implications of FFD in knee OA are significant. Patients with FFD experience functional limitations that impact their daily activities and overall quality of life. The fixed flexion contracture of the knee makes it challenging to achieve full extension, leading to difficulties in walking, stair climbing, and standing from a seated position. The reduced range of motion and gait abnormalities can result in compensatory movements and muscle imbalances, further exacerbating the functional limitations [8].

In addition to the functional limitations, FFD poses challenges during total knee arthroplasty (TKA), which is a surgical intervention commonly performed to alleviate pain and improve function in patients with knee OA. During TKA, the surgical correction of FFD becomes crucial for optimizing outcomes. The presence of FFD can affect the accuracy of component positioning, ligament balancing, and overall joint stability during the procedure. Failure to address FFD adequately may result in residual deformity, compromised implant alignment, altered joint mechanics, and potential postoperative complications [9].

Surgical correction of FFD during TKA aims to restore the alignment and functionality of the knee joint. By releasing contractures, addressing ligamentous tightness, and utilizing various surgical techniques, the goal is to achieve full extension and correct the flexion deformity. Surgical correction not only helps improve functional outcomes but also facilitates the proper alignment and positioning of the implant components, allowing for optimal joint mechanics and long-term implant survivorship [10].

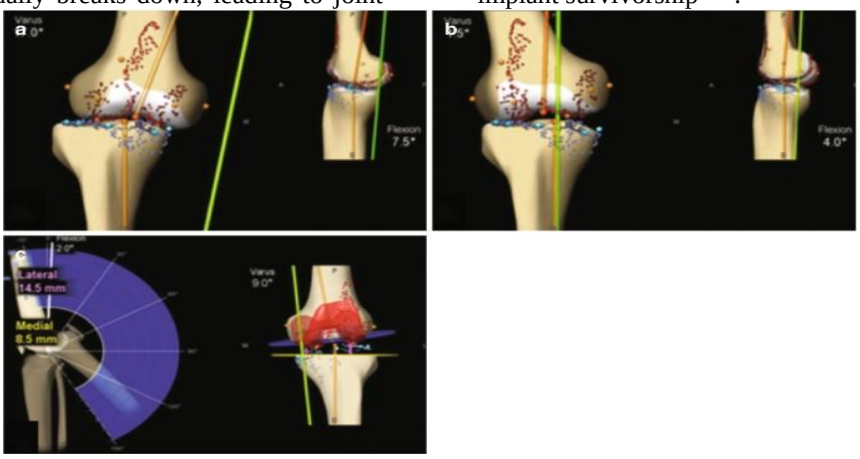

Fig. (2) The three principal clinical features of varus arthritic deformity which needs to be noted during TKA (shown here using computer navigation screen shot images). Maximum varus deformity (using a varus stress at the knee joint in maximum extension) and maximum knee deformity in the sagittal plane (flexion) (a). Maximum correctability of varus deformity (using a valgus stress at the knee joint in maximum extension) (b). Maximum lateral soft-tissue laxity (using a varus stress at the knee joint in maximum extension) (c) [11].

Considering the clinical implications, functional limitations, and the impact on surgical outcomes, the importance of surgical correction of FFD during TKA cannot be overstated. Successful correction of FFD enables patients to regain a more natural gait, improved range of motion, and enhanced functional capabilities. By restoring proper knee alignment and mechanics, surgical correction of FFD during TKA contributes to better postoperative outcomes and patient satisfaction [12].

2. Surgical Techniques for Correcting FFD:

Surgical Techniques for Correcting Fixed Flexion Deformity (FFD) during Total Knee Arthroplasty (TKA):

Several surgical techniques are employed for correcting FFD during TKA, including soft tissue releases, and navigation-assisted procedures. Each technique has its own rationale and reported outcomes [13].

Surgical Technique	Rationale	Reported Outcomes	Advantages	Disadvantages
Soft Tissue Releases	Release or lengthen contracted/tight soft tissues	Improved knee extension, reduced flexion contracture	Relatively simple, less invasive approach	Excessive release can lead to instability or weakening of soft tissues
Navigation-Assisted Procedures	Use of computer navigation systems for enhanced precision	Improved alignment, optimal component positioning	Improved accuracy, indirect correction of FFD	Longer operative times, specialized equipment, increased costs
Additional bone from distal femur removal	Enlarges the narrowed extension gap, improves knee alignment	Improved knee alignment, correction of flexion deformity	Addresses soft tissue contractures, improves knee alignment	Excessive distal femoral resection may result in joint line elevation, compromise knee stability, posterior tension band effect, compromise Varus valgus stability due to longer collateral ligaments

A. Soft Tissue Releases:

Soft tissue releases involve the release or lengthening of contracted or tight structures around the knee joint. The common soft tissue releases performed for FFD correction include quadriceps tendon release, hamstring release, and posterior capsular release [14].

The rationale behind soft tissue releases is to relieve the tension in the contracted soft tissues, allowing for improved knee extension. Quadriceps tendon release involves the release of the tight quadriceps tendon or patellar tendon, which can limit full knee extension. Hamstring release addresses the tightness of the hamstring muscles, which can contribute to flexion contracture. Posterior capsular release targets the tight posterior capsule, enabling better extension [15].

Soft tissue releases have shown promising outcomes in terms of improving knee extension and reducing flexion contracture. However, excessive release can lead to instability or weakening of the soft tissues, requiring careful consideration and surgical planning [16].

B. Navigation-Assisted Procedures:

Navigation-assisted procedures involve the use of computer navigation systems to enhance the precision and accuracy of TKA. These systems provide real-time feedback on limb alignment, implant positioning, and soft tissue balance [17].

Fig. (3) Computer assisted navigation in total knee and hip gives improved surgical outcomes [18].

The rationale behind navigation-assisted procedures is to achieve optimal component alignment and balance the soft tissues, which can indirectly correct FFD. By accurately assessing the joint mechanics and making necessary adjustments intraoperatively, navigation systems help in achieving better postoperative outcomes [19].

Navigation-assisted procedures have shown potential in improving overall alignment and reducing deformities, including FFD. However, the use of navigation systems may increase operative time, require specialized equipment, and have a steeper learning curve for surgeons [20].

C. Additional bone from the distal femur removal:

Another technique employed for correcting flexion deformity during total knee arthroplasty (TKA) involves the removal of additional bone from the distal femur [21]. This approach aims to enlarge the narrowed extension gap and improve knee alignment. It is typically utilized following posterior capsule release and posterior osteophyte excision, as these steps help address soft tissue contractures that contribute to the flexion deformity. The removal of additional distal femur to correct flexion deformity is generally performed after addressing the soft tissue constraints and considering the overall alignment of the knee [22]. Excessive distal femoral resection may result in joint line elevation, which can have implications for overall knee function and stability. Additionally, when employing this technique, it is essential to strike a balance between achieving extension and preserving proper Varus valgus stability. Excessive distal femoral resection can lead to a posterior tension band effect, which may result in slight flexion of the knee joint. This can compromise the knee's ability to maintain optimal Varus valgus stability, as the collateral ligaments may become relatively longer compared to the posterior soft tissue restraints [23].

Advantages and Disadvantages:

Soft tissue releases offer a relatively simple and less invasive approach for correcting FFD. They can be performed using standard surgical techniques without requiring additional equipment. However, excessive release can lead to instability or weakening of the soft tissues, requiring careful surgical planning [24].

Navigation-assisted procedures offer improved accuracy in achieving proper alignment and soft tissue balance. They can help correct FFD indirectly by optimizing joint mechanics. However, they require specialized equipment, longer operative times, and increased costs [25].

The selection of the surgical technique depends on various factors, including the severity of FFD, patient-specific characteristics, surgeon expertise, and available resources. The decision should be based on a comprehensive evaluation of the patient and careful consideration of the potential benefits and risks associated with each technique [26].

3. Preoperative Assessment and Patient Selection for Surgical Correction of Fixed Flexion Deformity (FFD):

The preoperative assessment plays a crucial role in identifying patients with fixed flexion deformity (FFD) who would benefit from surgical correction during total knee arthroplasty (TKA). It helps determine the severity of FFD, evaluate its impact on functional outcomes, and identify any specific considerations for patient selection. Let's delve into the importance of preoperative evaluation, the parameters used to assess FFD severity, and the considerations in patient selection [5]:

a) Importance of Preoperative Evaluation:

Preoperative evaluation is essential for several reasons [27]:

- Identification of FFD: Preoperative assessment allows for the identification of patients with FFD, confirming the presence and severity of the deformity. This helps in determining the need for surgical correction during TKA.
- Functional Impact Assessment: Evaluation of the functional limitations caused by FFD provides insights into the patient's quality of life and the potential benefits of surgical correction. It helps set realistic expectations and guides treatment planning.
- Optimal Surgical Planning: Preoperative assessment helps the surgeon choose the most appropriate surgical technique, considering the severity of FFD and any associated factors that may affect the surgical approach.
- Patient Counseling: The preoperative evaluation provides an opportunity for the surgeon to educate the patient about FFD, discuss the potential benefits and risks of surgical correction, and address any concerns or questions.

b) Clinical and Radiographic Parameters for FFD Severity Assessment:

The assessment of FFD severity involves both clinical and radiographic parameters. The following parameters are commonly used [28]:

Goniometric Measurement:

Clinical evaluation includes goniometric measurement of knee flexion contracture, which quantifies the degree of FFD. It provides a baseline measurement and helps track the progress postoperatively [29].

Range of Motion:

Evaluating the patient's range of motion helps assess the functional impact of FFD. It includes measuring the ability to achieve full extension, as well as the limitations in flexion [30].

Radiographic Analysis:

Radiographic evaluation, such as X-rays and/or computed tomography (CT) scans, aids in assessing the bony deformities associated with FFD. It helps determine the presence of osteophytes, joint space narrowing, and any alignment abnormalities [31].

Additional Assessments:

Additional assessments, such as evaluating the presence of ligamentous laxity, joint stability, and the overall condition of the knee joint, may be performed to guide treatment planning and determine the need for adjunctive procedures [32].

Considerations in Patient Selection:

Patient selection for surgical correction of FFD requires careful consideration of several factors: The severity of FFD and its impact on the patient's daily activities and quality of life are important considerations. Surgical correction may be more beneficial for patients with significant functional limitations. Assessing joint stability is crucial. Patients with significant ligamentous laxity or instability may require additional procedures, such as collateral ligament reconstruction or augmentation, in addition to FFD correction. Evaluating the overall condition of the knee joint, including the presence of significant bone loss, malalignment, or previous surgeries, helps determine the feasibility of FFD correction during TKA. Understanding the patient's expectations, goals, and ability to adhere to postoperative rehabilitation is essential. Patient compliance with postoperative rehabilitation plays a crucial role in achieving optimal outcomes [5].

4. Surgical Outcomes and Complications of Fixed Flexion Deformity (FFD) Correction during Total Knee Arthroplasty (TKA):

Numerous studies have investigated the surgical correction of FFD during TKA, aiming to assess functional outcomes, pain relief, range of motion improvements, and the rates of complications associated with the procedure [9].

Functional Outcomes and Pain Relief:

Studies evaluating functional outcomes following surgical correction of FFD during TKA have reported significant improvements in various parameters [4]:

Improved Range of Motion:

Surgical correction of FFD has consistently shown improvements in achieving full extension and increasing knee flexion. Studies have reported increases in range of motion, allowing patients to perform activities with greater ease [33].

Enhanced Functional Abilities:

Surgical correction has been associated with improved functional outcomes, such as walking ability, stair climbing, and activities of daily living. Patients experience reduced functional limitations, increased independence, and improved quality of life [34].

Pain Relief:

Surgical correction of FFD during TKA has demonstrated substantial pain relief. Patients experience a significant reduction in knee pain, allowing them to engage in daily activities and physical exercise with less discomfort [12].

Range of Motion Improvements:

Surgical correction of FFD has consistently shown improvements in range of motion, including achieving full extension and increasing knee flexion. Studies have reported postoperative increases in the range of motion, allowing patients to achieve near-normal or even better than normal joint motion [9].

Complications:

While surgical correction of FFD during TKA has generally shown favorable outcomes, it is important to consider the reported rates of complications associated with the procedure [35].

a. Wound Problems:

Incidence of wound complications, such as infection, wound dehiscence, or delayed wound healing, can occur following surgery. However, with proper surgical techniques, meticulous wound closure, and adherence to infection prevention protocols, the rates of wound complications can be minimized [36].

b. Instability:

Postoperative knee instability can be a concern after FFD correction. Factors such as inadequate soft tissue balancing, ligamentous laxity, or implant-related issues may contribute to instability. However, careful intraoperative assessment and appropriate surgical techniques can help optimize stability and reduce the risk of instability-related complications [37].

c. Implant-related Issues:

Complications related to the implant, such as component malalignment, dislocation, or loosening, may occur. Proper surgical technique, accurate implant positioning, and meticulous attention to detail can help mitigate the risk of these complications [13].

5. Long-term Follow-up of Surgical Correction of Fixed Flexion Deformity (FFD) during Total Knee Arthroplasty (TKA):

Long-term follow-up studies are essential to assess the durability of surgical correction of FFD during TKA and evaluate the impact on patient satisfaction and quality of life [9].

Durability of Correction:

Long-term studies have shown favorable outcomes regarding the durability of FFD correction after TKA. These studies indicate that surgical correction of FFD can lead to sustained improvement in range of motion and alignment over extended periods. Patients often maintain the corrected alignment and enjoy long-term functional benefits, including improved mobility and reduced pain [12].

Patient Satisfaction and Quality of Life:

Long-term studies consistently report high levels of patient satisfaction following surgical correction of FFD during TKA. Patients typically experience significant improvements in pain relief, functional abilities, and quality of life. They report increased participation in daily activities, sports, and recreational pursuits, leading to enhanced overall satisfaction with the surgical outcome [38].

Factors Influencing Long-term Success:

Several factors may influence the long-term success or failure of the procedure:

The use of proper surgical techniques, including precise soft tissue balancing, optimal implant positioning, and meticulous alignment, plays a crucial role in achieving long-term success. Accurate

component alignment and balancing contribute to the durability of the correction and overall joint stability. Postoperative rehabilitation is vital for long-term success. Patients must actively participate in rehabilitation programs, including exercises aimed at restoring range of motion and strengthening the surrounding muscles. Compliance with rehabilitation protocols greatly influences the functional outcomes and long-term success of the procedure. The choice of implant and its design characteristics can impact the long-term success of FFD correction during TKA. Implants with proven long-term survivorship and stability are preferred to minimize the risk of implant-related complications such as loosening or wear. Individual patient factors, such as age, body mass index (BMI), comorbidities, and bone quality, can influence the long-term success of FFD correction. Patient characteristics should be carefully considered in the preoperative evaluation and surgical planning process [39].

5.Conclusion

Surgical correction of FFD during TKA has shown promising results in terms of functional improvements, pain relief, and range of motion. Patients experience enhanced functional abilities and improved quality of life following surgery. While complications can occur, meticulous surgical techniques, proper patient selection, and adherence to best practices can help minimize their occurrence. Factors such as surgical technique, patient compliance with rehabilitation, implant selection, and patient-specific characteristics influence the long-term success of the procedure. Long-term follow-up studies are necessary to further understand the longevity and potential late complications associated with FFD correction during TKA.

References

[1] 1. T. Zhao, S. Wang, W. Liu, J. Shen, Y. Dai, M. Shi, et al. Clinical efficacy of Yiqi Yangxue formula on knee osteoarthritis and unraveling therapeutic mechanism through plasma metabolites in rats. Front Genet;14:1096616. 2023

[2] 2. L. Sharma. Osteoarthritis of the knee. New England Journal of Medicine;384:51-9. 2021

[3] 3. K. Khatri, D. Bansal, K. Rajpal. Management of Flexion Contracture in Total Knee Arthroplasty. Knee Surgery-Reconstruction and Replacement: IntechOpen; 2020.

[4] 4. P.P. Purudappa, O.P. Sharma, J. Chandrasekharan, P.J. Sudevan, V. Mounasamy, S.N. Sambandam. Clinical outcome, functional outcome and patient satisfaction after cruciate retaining total knee arthroplasty for stiff arthritic knee - A short term outcome study. J Orthop;20:6-11. 2020

[5] 5. K.M. Kc, D.R. Rc, S.B. Marahatta, B.R. Pangeni. Total Knee Arthroplasty in Moderate to Severe Fixed Flexion Deformity in a Tertiary Care Center: A Descriptive Cross-sectional Study. JNMA J Nepal Med Assoc;59:1234-8. 2021

[6] 6. A.I. Zayda. Outcome of severe fixed-flexion deformity of the knee managed by ring fixator. The Egyptian Orthopaedic Journal;56:140-7. 2021

[7] 7. T. Fan, S. Chen, M. Zeng, J. Li, X. Wang, G. Ruan, et al. Osteophytes mediate the associations between cartilage morphology and changes in knee symptoms in patients with knee osteoarthritis. Arthritis Res Ther;24:217. 2022

[8] 8. J.Y. Chen, B. Loh, Y.L. Woo, S.-L. Chia, N.N. Lo, S.J. Yeo. Fixed flexion deformity after unicompartmental knee arthroplasty: how much is too much. The Journal of Arthroplasty;31:1313-6. 2016

[9] 9. C. Quah, G. Swamy, J. Lewis, J. Kendrew, N. Badhe. Fixed flexion deformity following total knee arthroplasty. A prospective study of the natural history. Knee;19:519-21. 2012

[10] 10. E.P. Su. Fixed flexion deformity and total knee arthroplasty. J Bone Joint Surg Br;94:112-5. 2012

[11] 11. A. Mullaji, T. Panjwani. Deformity correction in total knee arthroplasty. Basics in Primary Knee Arthroplasty: Springer; 2022. p. 521-36.

[12] 12. K. Cheng, D. Ridley, J. Bird, G. McLeod. Patients with fixed flexion deformity after total knee arthroplasty do just as well as those without: ten-year prospective data. Int Orthop;34:663-7. 2010

[13] 13. A. Salam, M.A. Islam, M.Z.H. Khan, M.S.B. Sharif, M.H.R. Milon, M.A.H. Khan, et al. Total knee arthroplasty in patients with fixed flexion deformity. KYAMC Journal;8:2-7. 2018

[14] 14. B.B. Hinckel, C.A. Baumann, E.A. Arendt, R.G. Gobbi, A.J. Garrone, E. Voss, et al. Quadriceps Tendon Lengthening for Obligatory (Habitual) Patellar Dislocation in Flexion. Arthrosc Tech;11:e1589-e95. 2022

[15] 15. G.R. Waryasz, A.Y. McDermott. Patellofemoral pain syndrome (PFPS): a systematic review of anatomy and potential risk factors. Dyn Med;7:9. 2008

[16] 16. E. Martinez-Lozano, I. Beeram, D. Yeritsyan, M.W. Grinstaff, B.D. Snyder, A. Nazarian, et al. Management of arthrofibrosis in neuromuscular disorders: a review. BMC Musculoskelet Disord;23:725. 2022

[17] 17. Y. Pan, B. Jiang, Y. Li, Y. Yu, Y. Chen. Alignment analysis of Brainlab knee 3 navigation-guided total knee arthroplasty using the adjusted mechanical method. Front Surg;9:1040025. 2022

[18] 18. S. Chauhan, R. Scott, W. Breidahl, R. Beaver. Computer-assisted knee arthroplasty versus a conventional jig-based technique: a

randomised, prospective trial. The Journal of bone and joint surgery British volume;86:372-7. 2004

[19] 19. J. Moya-Angeler, V.J. León-Muñoz, C. Jimenez-Soto, K. Huber, B. Christen, T. Calliess. Fixed Flexion Contracture Can Successfully Be Addressed with Exact Preservation of the Femoral Joint Line and Only Minimal Increase of Tibia Resection in the Concept of Kinematically Aligned Total Knee Arthroplasty. Journal of Personalized Medicine;13:868. 2023

[20] 20. S.J. Song, D.K. Bae. Computer-Assisted Navigation in High Tibial Osteotomy. Clin Orthop Surg;8:349-57. 2016

[21] 21. W.R. Hardy, D.C. Landy, B.P. Chalmers, F.M. Sabatini, S.T. Duncan. Additional Distal Femoral Resection Minimally Improves Terminal Knee Extension: A Systematic Review and Meta-Regression Challenging the Dogma. Arthroplast Today;19:101083. 2023

[22] 22. C. Batailler, J. Swan, E. Sappey Marinier, E. Servien, S. Lustig. New Technologies in Knee Arthroplasty: Current Concepts. J Clin Med;10. 2020

[23] 23. G. Matziolis, M. Loos, S. Böhle, C. Schwerdt, E. Roehner, M. Heinecke. Effect of additional distal femoral resection on flexion deformity in posterior-stabilized total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc;28:2924-9. 2020

[24] 24. A. Attard. 4D CT based analysis of knee kinematics. 2020

[25] 25. R.E. Rosenberger, C. Hoser, S. Quirbach, R. Attal, A. Hennerbichler, C. Fink. Improved accuracy of component alignment with the implementation of image-free navigation in total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc;16:249-57. 2008

[26] 26. C. Gunaratnam, M. Bernstein. Factors Affecting Surgical Decision-making-A Qualitative Study. Rambam Maimonides Med J;9. 2018

[27] 27. J.S. Palmer, L.D. Jones, A.P. Monk, M. Nevitt, J. Lynch, D.J. Beard, et al. Varus alignment of the proximal tibia is associated with structural progression in early to moderate varus osteoarthritis of the knee. Knee Surg Sports Traumatol Arthrosc;28:3279-86. 2020

[28] 28. L. Becker, F. Schömig, L.M. Cordes, G.N. Duda, M. Pumberger, H. Schmidt. Finger-Floor Distance Is Not a Valid Parameter for the Assessment of Lumbar Mobility. Diagnostics (Basel);13. 2023

[29] 29. S. Spencer, A. Deakin, J. Clarke, editors. Measurement and identification of fixed flexion deformities of the knee using non-invasive tracking. Orthopaedic Proceedings; 2012: The British Editorial Society of Bone & Joint Surgery.

[30] 30. B.L. Hansberger, R. Loutsch, C. Hancock, R. Bonser, A. Zeigel, R.T. Baker. Evaluating the relationship between clinical assessments of apparent hamstring tightness: a correlational analysis. Int J Sports Phys Ther;14:253-63. 2019

[31] 31. K. Alexiou, H. Stamatakis, K. Tsiklakis. Evaluation of the severity of temporomandibular joint osteoarthritic changes related to age using cone beam computed tomography. Dentomaxillofac Radiol;38:141-7. 2009

[32] 32. M. Ciba, E.M. Winkelmeyer, J. Schock, P. Schad, N. Kotowski, T. Nolte, et al. Comprehensive Assessment of Medial Knee Joint Instability by Valgus Stress MRI. Diagnostics (Basel);11. 2021

[33] 33. G.A. Hosny, M. Fadel. Managing flexion knee deformity using a circular frame. Clinical orthopaedics and related research;466:2995-3002. 2008

[34] 34. D.R. Aglawe, B.M. Agarwal, B.D. Sawant. Physical Function in Critically Ill Patients during the Duration of ICU and Hospital Admission. Indian J Crit Care Med;26:314-8. 2022

[35] 35. S. Zainul-Abidin, B. Lim, H.R. Bin-Abd-Razak, C. Gatot, J.C. Allen, J. Koh, et al. Periprosthetic Fractures after Total Knee Arthroplasty: the Influence of Pre-Operative Mechanical Factors versus Intraoperative Factors. Malays Orthop J;13:28-34. 2019

[36] 36. A.H. Goldman, K. Tetsworth. AAOS Clinical Practice Guideline Summary: Prevention of Surgical Site Infection After Major Extremity Trauma. Journal of the American Academy of Orthopaedic Surgeons;31:e1-e8. 2023

[37] 37. T. Al-Jabri, A. Brivio, N. Maffulli, D. Barrett. Management of instability after primary total knee arthroplasty: an evidence-based review. J Orthop Surg Res;16:729. 2021

[38] 38. Y.J. Choi, H.J. Ra. Patient Satisfaction after Total Knee Arthroplasty. Knee Surg Relat Res;28:1-15. 2016

[39] 39. A. Siddiqi, T. Horan, R.M. Molloy, M.R. Bloomfield, P.D. Patel, N.S. Piuzzi. A clinical review of robotic navigation in total knee arthroplasty: historical systems to modern design. EFORT Open Rev;6:252-69. 2021