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EFFECT OF POSTOPERATIVE EDEMA ON PROPRIOCEPTION IN THE EARLY PERIOD AFTER TOTAL KNEE ARTHROPLASTY

TOTAL DİZ ARTROPLASTİSİ SONRASI ERKEN DÖNEMDE POSTOPERATİF ÖDEMİN PROPRİYOSEPSİYON ÜZERİNE ETKİSİ

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ABSTRACT

Aim: Total knee arthroplasty (TKA) further increases edema and proprioception losses. We aimed to investigate the effect of postoperative edema after TKA on the loss of proprioception, which adversely affects the quality of life and levels of independence.

Material and Method: Demographic information of 35 volunteer participants with an average age of 65.54±6.37 years who were in the first month after TKA was recorded. Pain, postoperative edema, and proprioception measurements were assessed. Circumference measurements were converted to volumetric form using the Frustum formula. An Angle-Reproduction test was used to measure proprioception at 40° and 60° knee flexion.

Results: The participants' postoperative edema and proprioception loss were statistically determined (p≤0.05). Volumes above the patella and total volume both affected knee proprioception at 40° knee flexion (p≤0.05). Nevertheless, postoperative edema did not affect 60° knee flexion proprioception (p>0.05).

Conclusion: This study reveals that postoperative edema affects proprioception in the early period after TKA. Reducing postoperative edema is of primary importance in the physiotherapy programs planned after TKA.

Keywords: Pain, Physiotherapy and Rehabilitation, Postoperative Edema, Proprioception, Total Knee Arthroplasty.

ÖZET

Amaç: Ödem ve propriyosepsiyon kayıpları TDA nedeniyle daha da artar. Bu çalışmada yaşam kalitesi ile bağımsızlık düzeyini olumsuz etkileyen propriyosepsiyon kayıpları üzerinde, TDA sonrası postoperative ödemin etkisini araştırmayı amaçladık.

Materyal ve Metot: TDA sonrası 1. ayında ve yaş ortalaması 65,54±6,37 yıl olan 35 gönüllü katılımcının demografik bilgileri kaydedildi. Ağrı, postoperative ödem ve propriyosepsiyon değerlendirmeleri yapıldı. Çevre ölçümleri Frustum formülü kullanılarak hacimsel forma dönüştürüldü. Propriyosepsiyon ölçümü için 40° ve 60° diz fleksiyonu açılarında Angle-Reproduction testi kullanıldı.

Bulgular: Çalışmaya dâhil edilen katılımcılarda postoperatif ödem ve propriyosepsiyon kaybı istatistiksel olarak tespit edildi (p≤0.05). Patella üstü hacim ve toplam hacmin 40° diz fleksiyonu propriyosepsiyonunu etkilediği tespit edildi (p≤0.05), fakat 60° diz fleksiyonu üzerinde ödemin etkisi tespit edilmedi (p>0.05).

Sonuç ve Öneriler: Bu çalışma, TDA sonrası erken dönemde postoperatif ödemin propriyosepsiyonu etkilediğini ortaya koymaktadır. TDA sonrası planlanan erken fizyoterapi programlarında postoperatif ödemin azaltılması birincil öneme sahiptir.

Anahtar Kelimeler: Ağrı, Fizyoterapi ve Rehabilitasyon, Postoperatif Ödem, Propriyosepsiyon, Total Diz Artroplastisi.

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INTRODUCTION

Osteoarthritis, the most common joint disease, is a degenerative disease that predominantly affects the elderly population and causes great loss of function. It is clinically characterized by pain, postoperative edema, joint stiffness, decreased range of motion (ROM), weakened muscle strength, shorter walking distance, and slower walking speed (Petersson & Jacobsson, 2002; Sharma et al., 2003).

In patients with moderate to severe arthritis, total knee arthroplasty (TKA) is a reliable method to reduce post-operative pain by 90%, improve extremity alignment, achieve functional independence, and improve the quality of life (Rankin et al., 2004; Xue et al., 2022). However, it is seen that TKA does not remove all obstacles when compared to those who have undergone surgery and their peers (Fallah Yakhdani et al., 2010)

Proprioception is further reduced by aging and degenerative arthritis. With progressive arthritis, changes occur in the joint space and periarticular tissues, including ligaments, tendons, and muscles (Brandt et al., 2008). During TKA, many structures of the knee joint, such as the anterior cruciate ligament, meniscus, and articular cartilage, are resected, which provide most of the proprioception input. TKA, on the other hand, has no negative effects and even leads to improvements in proprioception, kinesthesia, and balance by reducing pain and inflammation (Buz Swanik et al., 2004). However, the effects of TKA on proprioception are debatable; some authors observed an improvement in knee proprioception after TKA, while others reported further loss (Buz Swanik et al., 2004; Fuchs et al., 2005; Xue et al., 2022).

In rehabilitation after TKA, primarily ROM and walking with or without an assistive device are prioritized, but muscle strength, postoperative edema, balance, and proprioception are put in the rear. The authors emphasize the importance of proprioceptive training, but they cannot fully predict the factor that most affects proprioception after TKA (Eymir, 2016).

Having looked through the literature, it was noticed that the studies investigating postoperative knee proprioception mostly pay insufficient attention to the early period, and the reason for the loss of proprioception in the early period was not focused on. In looking at these data, the aim of this study was to examine the effects of postoperative edema on proprioception in the first month after TKA.

MATERIAL AND METHOD

Participants

Volunteer participants who had undergone TKA surgery were included in the study. This study was conducted by the principles of the Helsinki Declaration. Permission for the study was obtained from the Bolu Abant Izzet Baysal University Clinical Research Ethics Committee with decision number 2018/122. The current study was conducted from April 2018 to August 2018 at the Department of Orthopaedics and Traumatology of the Bolu Abant Izzet Baysal University. Participants were included in the study by signing an informed consent form.

The sample size was calculated by using G*power 3.0 Software (Faul et al., 2007). In this study, a model was established on two dependent variables (40° and 60° knee flexion) and three independent variables (above and below the patella and, total volume). In line with the information we have obtained (Chan et al., 2018), and our expectations, the power analysis was performed by assuming that the effect size of the independent variables that may affect knee proprioception could be at a large level ($f2=0.35$), this study needed a sample size of 32 participants to provide 80% power and 95% confidence level. (Cohen, 2013; Polit & Beck, 2017). For the effect size level ($R2=0.197$; $f2=0.25$) obtained from the regression analysis applied to the values we obtained from these 35 participants, it was calculated that our study reached 70% power at the 95% confidence level.

Inclusion criteria for participants in the study include volunteering, being over 50 years old, undergoing TKA due to primary OA, and being in the first month after unilateral TKA surgery. Exclusion criteria were as follows: previous surgery in both knees; the presence of cardiovascular or neurological diseases; systemic diseases such as diabetes, hypertension, cancer, etc.; loss of vision and hearing; loss of extension in the knee; and inability to reach at least a 90º knee flexion angle.

Patients diagnosed in the XXX Hospital Orthopedics and Traumatology Outpatient Clinic and underwent TKA surgery were reached in the hospital ward. Patients who met the inclusion criteria were invited for evaluation in the first month of surgery (days 28–35). Evaluations were given to the participants within the scope of their permission: demographic information, pain assessment, knee ROM measurement, circumference measurement, and proprioception assessment. Both knees of the participants were assessed. The operated knees of the participants constituted the study group, and the non-operated knees constituted the control group.

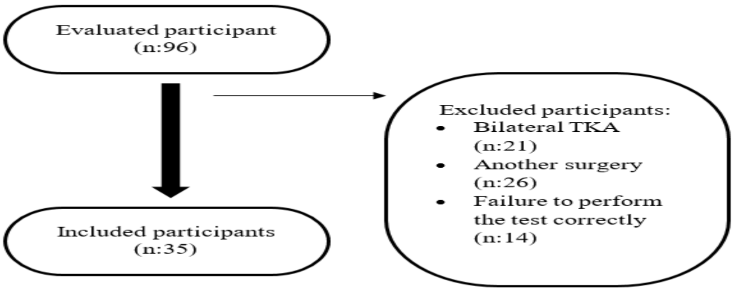

Figure 1. Flow diagram

Evaluation Methods

Demographic Information

The gender, age, height, and weight of the participants were recorded. The body mass index (BMI) was calculated based on height and weight data. The waist circumference was measured with a tape measure at the end of expiration from the area where it is thinnest between just below the ribs and between the crista iliaca, and the hip circumference was measured with a tape measure from the thickest area over the trochanter major; the waist/hip ratio was calculated by dividing waist circumference by hip circumference (Schult et al., 2018). The sides of the knees where the participants underwent surgery were recorded.

Pain Measurement

Pain was assessed using the Visual Analogue Scale. The far left was determined as "0-(No Pain)" and the far right was determined as "10-(Severe Pain)" of a 10 cm straight horizontal line. The participant was asked to mark the most appropriate point on this line for their pain. The point marked by the participant was measured with the help of a ruler and recorded in cm (Yaray et al., 2011).

Postoperative Edema Measurement

The circumference was measured around both knees for postoperative edema. The patella circumference was measured 20 cm above and below the patella with the help of a tape measure at 5 cm intervals, and the values were recorded in cm (Yau et al., 2022). The measurements taken were converted into volumetric form using the Frustum Formula and recorded in dm^3 (Kaulesar Sukul et al., 1993). According to this formula, the circumference measurement values are given as follows; “C” value for the circumference measurement of the highest point of the selected region; “c” value for the circumference measurement of the lowest point of the selected region; and “h” value for the height between the lowest and the highest regions of the selected region.

Formula: $V = \frac{h \times (C^2 + C \times c + c^2)}{12\pi}$ (π=3.14)

Example;

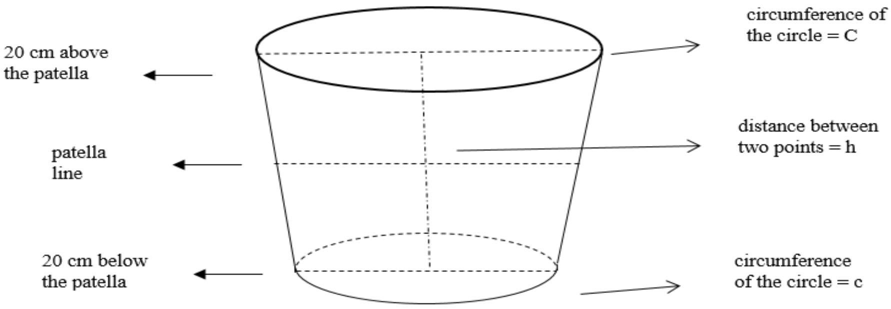

Figure 2: Illustration of Frustum formula

Proprioception Measurement

Proprioception was evaluated with the Angle-Reproduction Test (Pohl et al., 2015). The participant started in the sitting position with the knees in 90º flexion. Target angles were 40º and 60º knee flexion angles. The pivot point of the goniometer was placed at the lateral condyle. While the participant's eyes were closed, the knee was brought to the target angle and held at this angle for 4 seconds. Then, the participant was asked to actively repeat this angle while their eyes were closed. The angle-deviation range was recorded by goniometric measurement. Evaluations were repeated three times and recorded by averaging.

Statistical Analysis

Data were analyzed with the SPSS 24.0 (IBM SPSS Statistics 24 software (Armonk, NY: IBM Corp.)) package program. Continuous variables were expressed as mean (±) standard deviation and categorical variables were expressed as numbers and percentages. The conformity of the data to the normal distribution was examined by the "Shapiro-Wilk test". “t-test on independent groups” for comparison of independent group differences when parametric test assumptions were provided; when parametric assumptions were not met, the "Mann-Whitney U test" was used to compare independent group differences. “Linear regression analysis” was used to examine the relationships between numerical variables. In this study, a model was established on two dependent variables (knee 40° and 60° knee flexion) and three independent variables (above and below the patella, and total volume). To perform linear regression analysis, "scatter plot" analysis was performed. In significant data, the extreme values of the data set were analyzed by drawing a "casewise diagnostic" table, and the relationship between residual values and independent variables was examined with the "Durbin-Watson" test. $p \leq 0.05$ was considered statistically significant in all studies. “Cohen's d” for calculating effect size when parametric test assumptions were provided; when parametric assumptions were not met, the "r" was used to calculate effect size. Cohen’s guidelines for d are that a large effect is 0.8, a medium effect is 0.5, and a small effect is 0.2; for r are that a large effect is 0.5, a medium effect is 0.3, and a small effect is 0.1 (Fritz et al., 2012).

RESULTS

Among the 96 participants screened for in the study, 61 were excluded, of whom 21 had bilateral TKA, 26 had previous knee surgery, and 4 could not perform the test correctly. The data of 35 participants who met the inclusion criteria was evaluated.

The participants included in the study were elderly according to their average age and obese according to their average BMI and waist/hip ratios. The demographic data of the participants included in the study is shown in Table 1.

Table 1. Age, height, weight, BMI, waist/hip ratio data of participants (n=35)

Data	**Mean±SD**
Age (year)	65.54±6.37
Height (cm)	162.43±7.78
Weight (kg)	85.09±14.61
BMI (kg/m²)	32.94±5.90
Waist/Hip Ratio	0.90±0.04

SD: standard deviation, cm: centimeter, kg: kilogram, n: sample size

Overall, 24 participants (68.4%) were female and 11 participants (31.4%) were male; 20 participants (57.1%) on the right knee and 15 participants (42.9%) on the left knee had surgery. According to VAS scores, the mean value was measured as 1.57±2.26 (min: 0 - max 7.6) cm.

The circumference measurement data of the operative knees were found to be significantly higher than that of their nonoperative knees ($p<0.05$). The data are shown in Table 2.

Table 2. Comparison of circumference measurement data of the operative and nonoperative sides of the participants (n=35)

	Operative Knees (Median±IQR)	Nonoperative Knees (Median±IQR)	p value	r value
20 cm above (cm)	50.00±10.00	46.00±7.00	**0.0001*** (z:-4.944)	**0.84**
15 cm above (cm)	50.00±9.00	46.00±7.00	**0.0001*** (z:-5.096)	**0.86**
10 cm above (cm)	49.00±9.00	45.00±8.00	**0.0001*** (z:-5.027)	**0.85**
5 cm above (cm)	47.00±9.00	43.00±7.00	**0.0001*** (z:-4.905)	**0.83**
Patella line (cm)	46.00±7.00	40.00±5.00	**0.0001*** (z:-5.128)	**0.87**
5 cm below (cm)	40.00±7.00	38.00±6.00	**0.0001*** (z:-4.312)	**0.73**
10 cm below (cm)	39.00±8.00	37.00±5.00	**0.0001*** (z:-3.989)	**0.67**
15 cm below (cm)	37.00±7.00	36.00±6.00	**0.002*** (z:-3.033)	**0.51**
20 cm below (cm)	36.11±5.57	34.66±4.60	**0.003*** (t:3.227) [a]	**0.28**[b]

*: p≤0.05 statistically significant difference, IQR: interquartile range, p: significance value, t: t test in independent groups, z: Mann Whitney U test, cm: centimeter, n: sample size, r: effect size, [a]: since the data in two groups were distributed in accordance with normal distribution, the mean and standard deviation were shown, [b]: since the data in two groups were distributed in accordance with normal distribution, the Cohen's d effect were shown.

The postoperative edema volumes of the operative knees were significantly higher than that of their nonoperative knees (p<0.05). The data are shown in Table 3.

Table 3. Comparison of postoperative volumes of the operative and nonoperative knees of the participants included in the study (n=35)

	Operative Knees (Median±IQR)	Nonoperative Knees (Median±IQR)	p value	r value
Above Patella (dm^3)	3.67±1.26	3.02±0.92	**0.0001*** (z:-5.159)	**0.87**
Below Patella (dm^3)	2.57±0.90	2.24±0.62	**0.0001*** (z:-4,750)	**0.80**
Total (dm^3)	6.06±2.35	5.00±1.58	**0.0001*** (z:-5.143)	**0.87**

*: p≤0.05 statistically significant difference, IQR: interquartile range, p: significance value, z: Mann Whitney U test, dm^3: cubic decimeter, n: sample size, r: effect size.

The angle-deviation at 40º knee flexion and 60º knee flexion proprioception of the operative knees were shown to be significantly higher than their nonoperative knees (p<0.05). The data are shown in Table 4.

Table 4. Comparison of angle-deviation value of knee proprioception data on the operative and nonoperative knees of the participants included in the study (n=35)

	Operative Knees (Median±IQR)	Nonoperative Knees (Median±IQR)	p value	r value
40º Knee Flexion (º)	2.00±4.00	1.00±3.00	**0.007*** (z:-2.700)	**0.46**
60º Knee Flexion (º)	3.00±4.00	3.00±3.00	**0.046*** (z:2.702)	**0.46**

*: p≤0,05 statistically significant difference, IQR: interquartile range, p: significance value, z: Mann Whitney U test, º: angle value n: sample size, r: effect size.

It was determined that the above-patella volume and total volume data of the participants included in the study affected the 40º knee flexion proprioception deviation value and did not affect the 60º knee flexion proprioception deviation value. The data are shown in Table 5.

Table 5. The effect of postoperative edema data of the participants included in the study on 40º and 60º knee flexion proprioception (n=35)

		SC	t	p	95% CIFB	
		Beta			**LB**	**UB**
40º Knee Flexion	**Above Patella**	0.409	2.571	**0.015***	0.000	0.002
	Below Patella	0.306	1.848	0.074	0.000	0.003
	Total	0.384	2.389	**0.023***	0.000	0.001
R^2: 0.197; Durbin-Watson: 1,554						
60º Knee Flexion	**Above Patella**	0.028	0.163	0.871	0.001	0.001
	Below Patella	0.106	0.612	0.545	0.001	0.002
	Total	0.069	0.396	0.695	0.000	0.001
R^2: 0.028; Durbin-Watson: 2.**697**						

* p≤0,05 statistically significant difference, SC: standardized beta coefficient, t: linear regression analysis test value, CIFB: 95% confidence interval for beta, LB: lower limit, UB: upper limit, p: significance value, n: sample size, R^2: coefficient of determination.

DISCUSSION

In this study, it was determined that there was postoperative edema and loss of proprioception in the operated knees compared to their non-operated knees in 35 volunteer participants who were in the first month after TKA. We found that postoperative edema in the knee area and above the patella affects 40° knee flexion proprioception, while postoperative edema below the patella does not. We also found that postoperative edema did not affect 60° knee flexion proprioception.

There are improvements in proprioception as pain and inflammation decrease, but proprioception may not recover since the muscles, tendons, joint capsule ligaments, menisci, and skin receptors that provide the basic input of proprioception in the knee joint have been cut, removed, or damaged (Liebs et al., 2012; Moutzouri et al., 2017). While this current study reveals a factor affecting proprioception one month after TKA surgery, it may also reveal the factors that will optimize the proprioception that has not yet been restored.

TKA has a 90% success rate for reducing osteoarthritis pain (Rankin et al., 2004). However, while high-level pain is expected due to surgery in the early period, postoperative analgesic use is observed. In the meta-analysis and systematic review performed by Elmallah et al. (2018), the mean VAS scores in the early period after TKA were 2-4.5 cm. Our results were similarly 1.57±2.26 cm. The relatively low mean VAS scores can be explained by the use of analgesia in the pharmacological routine of the participants in the first month of surgery. In addition, the participants experienced high levels of preoperative pain due to chronic osteoarthritis pain and felt a low level of pain after the surgery (Davis & MacKay, 2013). Additionally, in the post-TKA period, rest and physiotherapy practices may have reduced pain. Many physiotherapy methods, such as exercises, cryotherapy, taping, and electrotherapy, play an effective role in reducing pain (Henderson et al., 2018). We did not perform any physiotherapy interventions in this study.

It is known that postoperative edema develops around the knee after TKA surgery (Adie et al., 2012; Kadı et al., 2019). Depending on the surgical techniques, the presence of postoperative edema is expected, and with the existing inflammation process, postoperative edema becomes inevitable. In the literature review and interpretation made by Liu et al. and Meier et al. (2020; 2008), it has been claimed that it affects the tissue in many ways, not only as postoperative edema. It is said that autogenic inhibition occurs in the muscles due to both surgical and postoperative edema, and therefore there are decreases in both muscle strength and ROM. The presence of postoperative edema in the participants included in the study is the factor explaining the decrease in ROM.

All findings, including loss of proprioception and postoperative edema, that occur after surgery will likely improve over time. But researchers argue that they may not be as successful as healthy individuals (Buz Swanik et al., 2004; Fallah Yakhdani et al., 2010). In this study, it was revealed that postoperative edema at 1 month after TKA surgery affects proprioception.

Loss of proprioception is observed due to aging and osteoarthritis. Many reasons, such as pain caused by osteoarthritis, loss of muscle strength, and walking problems, can also affect knee proprioception (Brandt et al., 2008). Additionally, during surgery, many structures are resected such as ligaments, menisci, and joint capsules, and many muscles are also damaged (Buz Swanik et al., 2004). Since the time between the patients' hospitalization and surgery was very short, an appropriate time interval for evaluation could not be found. For this reason, preoperative evaluation was not performed in this study. This is one of the limitations of this study.

Moreover, it is known that edema due to knee osteoarthritis reduces muscle strength and causes proprioception losses (Kim et al., 2018). The presence of edema triggers the spinal inhibitory mechanism of quadriceps motor neurons and reduces muscle activity. Thus, it leads to losses in proprioception (Cho et al., 2011; Xue et al., 2022). In this current study, it was concluded that the presence of postoperative edema may affect 40º knee flexion proprioception. Given that proprioception is processed with information from the bone periosteum, skin, and muscle fibers, it is expected that it will be affected by postoperative edema. Existing postoperative edema creates pressure on the skin, muscle fibers, and bone tissue and may impede or impair data transmission (Carmichael et al., 2022; Kim et al., 2018).

In the data we obtained, we determined that postoperative edema in the knee area and above the patella may affect 40º knee flexion proprioception, whereas postoperative edema below the patella may not have an effect. We think that this data reveals muscle activation due to proprioception loss. The control of the knee joint is mostly provided by the muscles located above the knee joint (quadriceps muscle, hamstring muscle group, sartorius, adductors, etc.) (Neumann, 2002). Since the presence of postoperative edema will affect the muscle contraction mechanism (Cho et al., 2011; Kim et al., 2018), it is understood why postoperative edema above the patella affects the proprioception of 40º knee flexion while postoperative edema below the patella does not. We did not perform muscle strength measurements because the participants were in the early post surgery period. However, based on literature information (Jerosch Prymka et al., 1996; Lee et al., 2009; Proske, 2006), we think that muscle strength and arthrogenic muscle inhibition are effective in proprioception loss.

In this study, while determining the may have an effect of postoperative edema on 40º knee flexion proprioception, no effect on 60º knee flexion was found. As mentioned above, muscle tissue has an important role in the process of proprioception. The golgi tendon organ and muscle spindle carry proprioception and kinesthesia information to the central nervous system. During knee flexion and extension, proprioception is perceived differently at each angle. Because muscle spindles work differently at the beginning, inside, and end of the movement (Angoules et al., 2011; Lee et al., 2009; Proske, 2006). Although the current study did not focus on the evaluation of muscle strength, the reason we could not determine the measures of postoperative edema on 60º knee flexion proprioception is based on the knowledge that different muscle activations may occur at every angle. The power of balance between quadriceps and hamstring muscle groups may be changing proprioception. There is proprioception loss at 60º knee flexion, but the reason for this has not been determined. In the literature, it is reported that the maximum knee angle of 60º knee flexion is rarely reached in the walking cycle (Neumann, 2002). The reason for the proprioception disorder in the 60° knee flexion angle, which is not normally used much, is not very important for the mobility of the patient.

In summary, studies in the literature have reported many complications in the hospital period after TKA, such as pain, decrease in ROM, postoperative edema, loss of muscle strength, balance and gait disturbances, and psychosocial problems. In fact, it has been observed that these complications continued even if there were improvements in the late period, such as the 3rd month, 6th month, and 1st year. In addition to these complications, although there are conflicting statements about loss of proprioception, the general opinion is that TKA surgery causes loss of proprioception due to dissection of tissues. There is not enough research on the factors contributing to the loss of proprioception that may affect the daily lives of TKA patients. This is an important study in which the presence of postoperative edema and the symptomatic cause of proprioception loss are revealed at 1 month after TKA. In the ongoing rehabilitation after TKA, important treatment options have been revealed in terms of reducing proprioception loss.

Limitations

This study has multiple limitations: Due to the economic problems experienced in the country at the time of the study, more participants could not be included in the study, and the evaluations were interrupted. Moreover, since the time between the patients' hospitalization and surgery was very short, an appropriate time interval for evaluation could not be found. For this reason, preoperative evaluation was not performed in this study.

CONCLUSION

This study demonstrated that proprioception impairments are brought on by early postoperative edema following TKA. In order to be successful in rehabilitation and to accelerate the process in the early period after TKA surgery, to reduce the incidence of falls after TKA surgery, which mostly elderly individuals undergo, to reach higher quality levels in ADL, and to reduce proprioception losses, first of all, postoperative edema should be reduced.

This study reveals that patients undergoing TKA experience a variety of complications, including pain, decreased ROM, postoperative edema, and loss of proprioception. We suggest that this study be expanded and that long-term follow-ups be repeated. We believe that these evaluations should be repeated preoperatively and in the early and late postoperative periods. In addition, we think that our recommendations to reduce postoperative edema, which we have found to have a partial effect on proprioception in the early postoperative period, are beneficial to use in rehabilitation and to reveal the results.

Conflict of interest

No potential conflict of interest was reported by the authors.

Author Contributions

Plan and desing: MB, ANN; Data collection: MB; Analysis and comments: MB, ANN; Review and check: ANN; Writing: MB, ANN.

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REFERENCES

Adie, S., Kwan, A., Naylor, J. M., Harris, I. A., & Mittal, R. (2012). Cryotherapy following total knee replacement. *Cochrane Database of Systematic Reviews*. https://doi.org/10.1002/14651858.cd007911.pub2

Angoules, A., Mavrogenis, A., Dimitriou, R., Karzis, K., Drakoulakis, E., & Michos, J. (2011). Knee proprioception following ACL reconsturction; a prospective trial comparing hamstrings with bone-patellar tendon-bone autograft. *Knee*.

Brandt, K. D., Dieppe, P., & Radin, E. L. (2008). Etiopathogenesis of Osteoarthritis. In *Rheumatic Disease Clinics of North America* (Vol. 34, Issue 3, pp. 531–559). https://doi.org/10.1016/j.rdc.2008.05.011

Buz Swanik, C., Lephart, S. M., & Rubash, H. E. (2004). Proprioception, Kinesthesia, and Balance After Total Knee Arthroplasty with Cruciate-Retaining and Posterior Stabilized Prostheses. In *THE JOURNAL OF BONE AND JOINT SURGERY*.

Carmichael, J., Dennis, D., Jennings, J., Stevens-Lapsley, J., & Bade, M. (2022). Feasibility and initial efficacy of a multimodal swelling intervention after total knee arthroplasty: A prospective pilot study with historical controls. *Knee*, *35*, 25–33. https://doi.org/10.1016/j.knee.2022.01.008

Chan, A. C. M., Jehu, D. A., & Pang, M. Y. C. (2018). *Falls After Total Knee Arthroplasty: Frequency, Circumstances, and Associated Factors-A Prospective Cohort Study Background. Individuals with total knee arthroplasty (TKA) often experience pain and* (Vol. 98). https://academic.oup.com/ptj

Cho, Y., Hang, B., Lim, S., Kim, H., Ko, Y., & Im, S. (2011). Effects of joint effusion on proprioception in patients with knee osteoarthritis: A single-blind, randomized controlled clinical trial. *Osteoartht Cartil*.

Cohen, J. (2013). *Statistical Power Analysis for the Behavioral Sciences*. Routledge. https://doi.org/10.4324/9780203771587

Davis, A., & MacKay, C. (2013). Osteoarthritis year in review: Outcome of rehabilitation. *Osteoarthritis and Cartilage*.

Elmallah, R. K., Chughtai, M., Khlopas, A., Newman, J. M., Stearns, K. L., Roche, M., Kelly, M. A., Harwin, S. F., & Mont, M. A. (2018). Pain Control in Total Knee Arthroplasty. *Journal of Knee Surgery*, *31*(6), 504–513. https://doi.org/10.1055/s-0037-1604152

Eymir, M. (2016). *Total Diz Protezli Hastalarda Hastane İçi Dönemde Neopren Dizlik'in Proprioseptif Duyu Üzerine Etkisinin Araştırılması*. Dokuz Eylül Üniversitesi Sağlık Bilimleri Enstitüsü.

Fallah Yakhdani, H., Bafghi, H., Meijer, O., Bruijn, S., Dikkenberg, N. van den, & Stibbe, A. (2010). Stability and variability of knee kinematics during gait in knee osteoarthritis before and after replacement surgery. *Clin Biomech*.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/bf03193146

Fritz, C. O., Morris, P. E., & Richler, J. J. (2012). Effect size estimates: Current use, calculations, and interpretation. *Journal of Experimental Psychology: General*, *141*(1), 2–18. https://doi.org/10.1037/a0024338

Fuchs, S., Tibesku, C. O., Frisse, D., Genkinger, M., Laaß, H., & Rosenbaum, D. (2005). Clinical and functional comparison of uni- and bicondylar sledge prostheses. *Knee Surgery, Sports Traumatology, Arthroscopy*, *13*(3), 197–202. https://doi.org/10.1007/s00167-004-0580-y

Henderson, K. G., Wallis, J. A., & Snowdon, D. A. (2018). Active physiotherapy interventions following total knee arthroplasty in the hospital and inpatient rehabilitation settings: a systematic review and meta-analysis. *Physiotherapy*, *104*(1), 25–35. https://doi.org/10.1016/j.physio.2017.01.002

Jerosch Prymka, J. M., Jerosch, J. N., & Prymka, M. (1996). Proprioception and joint stability. In *Knee Surg, Sports Traumatol* (Vol. 4). Springer-Verlag.

Kadı, M. R., Hepgüler, S., Atamaz, F. C., Dede, E., Aydoğdu, S., Aktuglu, K., Ozkayın, N., & Ozturk, C. (2019). Is interferential current effective in the management of pain, range of motion, and edema following total knee arthroplasty surgery? A randomized double-blind controlled trial. *Clinical Rehabilitation*, *33*(6), 1027–1034. https://doi.org/10.1177/0269215519829856

Kaulesar Sukul, D. M. K. S., den Hoed, P. T., Johannes, E. J., van Dolder, R., & Benda, E. (1993). Direct and indirect methods for the quantification of leg volume: comparison between water displacement volumetry, the disk model method and the frustum sign model method, using the correlation coefficient and the limits of agreement. *Journal of Biomedical Engineering*, *15*(6), 477–480. https://doi.org/10.1016/0141-5425(93)90062-4

Kim, D., Park, G., Kuo, L. T., & Park, W. (2018). The effects of pain on quadriceps strength, joint proprioception and dynamic balance among women aged 65 to 75 years with knee osteoarthritis 11 Medical and Health Sciences 1103 Clinical Sciences. *BMC Geriatrics*, *18*(1). https://doi.org/10.1186/s12877-018-0932-y

Lee, H., Cheng, C., & Liau, J. (2009). Correlation between proprioceptive, muscle strength, knee laxity, and dynamic standing balance in patients with chronic anterior cruciate ligament deficiency. *Knee*.

Liebs, T. R., Herzberg, W., Rther, W., Haasters, J., Russlies, M., & Hassenpflug, J. (2012). Multicenter randomized controlled trial comparing early versus late aquatic therapy after total hip or knee arthroplasty. *Archives of Physical Medicine and Rehabilitation*, *93*(2), 192–199. https://doi.org/10.1016/j.apmr.2011.09.011

Liu, P., Mu, X., Zhang, Q., Liu, Z., Wang, W., & Guo, W. (2020). Should compression bandage be performed after total knee arthroplasty? A meta-analysis of randomized controlled trials. *Journal of Orthopaedic Surgery and Research*, *15*(1). https://doi.org/10.1186/s13018-019-1527-9

Meier, W., Mizner, R., Marcus, R., Dibble, L., Peters, C., & Lastayo, P. C. (2008). Total knee arthroplasty: Muscle impairments, functional limitations, and recommended rehabilitation approaches. In *Journal of Orthopaedic and Sports Physical Therapy* (Vol. 38, Issue 5, pp. 246–256). Movement Science Media. https://doi.org/10.2519/jospt.2008.2715

Moutzouri, M., Gleeson, N., Billis, E., Tsepis, E., Panoutsopoulou, I., & Gliatis, J. (2017). The effect of total knee arthroplasty on patients' balance and incidence of falls: a systematic review. In *Knee Surgery, Sports Traumatology, Arthroscopy* (Vol. 25, Issue 11, pp. 3439–3451). Springer Verlag. https://doi.org/10.1007/s00167-016-4355-z

Neumann, D. (2002). *Knee. İçinde: Kinesiology of the Musculoskeletal System Foundations for Physical Rehabilitation*. Mosby.

Petersson, I. F., & Jacobsson, L. T. H. (2002). Osteoarthritis of the peripheral joints. *Best Practice and Research: Clinical Rheumatology*, *16*(5), 741–760. https://doi.org/10.1053/berh.2002.0266

Pohl, T., Brauner, T., Wearing, S., Stamer, K., & Horstmann, T. (2015). Effects of sensorimotor training volume on recovery of sensorimotor function in patients following lower limb arthroplasty. *BMC Musculoskeletal Disorders*, *16*(1). https://doi.org/10.1186/s12891-015-0644-9

Polit, D., & Beck, C. (2017). *Nursing research: generating and assesing evidence for nursing practice (10th ed.)* (D. Polit & C. Beck, Eds.; 10th ed.). Lippincott Williams & Wilkins.

Proske, U. (2006). Kinesthesia: The role of muscle receptors. In *Muscle and Nerve* (Vol. 34, Issue 5, pp. 545–558). https://doi.org/10.1002/mus.20627

Rankin, E., Alarcon, G., Chang, R., Cooney, L., Costley, L., & Delitto, A. (2004). *NIH Consensus Statements Total Knee Replacement Replacement December 8-10, 2003*. http://consensus.nih.gov

Schult, A., Mehlig, K., Björkelund, C., Wallerstedt, S., & Kaczynski, J. (2018). Waist-to-hip ratio but not body mass index predicts liver cirrhosis in women. *Scandinavian Journal of Gastroenterology*, *53*(2), 212–217. https://doi.org/10.1080/00365521.2017.1420219

Sharma, L., Cahue, S., Song, J., Hayes, K., Pai, Y. C., & Dunlop, D. (2003). Physical Functioning over Three Years in Knee Osteoarthritis: Role of Psychosocial, Local Mechanical, and Neuromuscular Factors. *Arthritis and Rheumatism*, *48*(12), 3359–3370. https://doi.org/10.1002/art.11420

Xue, Y. Y., Shi, J. N., Zhang, K., Zhang, H. H., & Yan, S. H. (2022). The effects of total knee arthroplasty on knee proprioception of patients with knee osteoarthritis: a meta-analysis. In *Journal of Orthopaedic Surgery and Research* (Vol. 17, Issue 1). BioMed Central Ltd. https://doi.org/10.1186/s13018-022-03142-0

Yaray, O., Akesen, B., Ocaklioğlu, G., & Aydinli, U. (2011). Validation of the Turkish version of the visual analog scale spine score in patients with spinal fractures. *Acta Orthopaedica et Traumatologica Turcica*, *45*(5), 353–358. https://doi.org/10.3944/AOTT.2011.2528

Yau, L. K., Henry, F., Man Hong, C., Amy, C., Wai Kwan Vincent, C., Ping Keung, C., & Kwong Yuen, C. (2022). Swelling assessment after total knee arthroplasty. *Journal of Orthopaedic Surgery*, *30*(3), 102255362211276. https://doi.org/10.1177/10225536221127668