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Original Article *Özgün Araştırma*

WHY IS LEFT TOTAL KNEE ARTHROPLASTY SURGERY HARDER FOR RIGHT-HANDED ORTHOPEDIC SURGEONS? SIDE ANALYSIS IN TOTAL KNEE ARTHROPLASTY

Sol Total Diz Artroplastisi Sağ El Dominant Cerrah İçin Neden Daha Zordur? Total Diz Artroplastisinde Taraf Analizi

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ABSTRACT

Objective: We hypothesize that right-handed surgeons can achieve equally successful results in both right and left sides of patients, although they are exposed to more occupational damage when performing knee arthroplasty on the left side.

Material and Methods: A total of 246 (113 right and 133 left) total knee prosthesis operations performed by two right-handed orthopaedic surgeons in our institution were included. Patients were divided into right and left knee arthroplasty groups for comparison. The demographic data of the patients, the knee range of motion (ROM), hip-knee-ankle angle (HKAA), lateral distal femoral angle (LDFA), medial proximal tibial angle (MPTA), and Knee Society Score (KSS) values were evaluated for all groups. Moreover, electromyographic measurements of specific muscle groups, which were used while performing the right and left total knee arthroplasty procedures, were taken for the two surgeons to compare the differences in efficacy of surgeries performed on different sides.

Results: There was no statistically significant difference between the two groups when the postoperative bleeding volumes and flexion, extension levels, and pain and function scores at 3 months and 1 year were compared There was no significant difference between groups in term of postoperative ROM, HKAA, LDFA, MPTA, and KSS values. It was observed that the right latissimus dorsi muscles of the surgeons exhibited about five times more activation, the left latissimus dorsi muscles exhibited three times more activation, and the left gluteus medius muscles exhibited two times more activation during left knee surgery than right knee surgery.

Conclusion: Right-handed surgeons can provide equally good results when operating left knees as right ones, although they exert more effort when performing left-sided arthroplasty. However, we conclude that left knee surgeries cause more occupational damage for surgeons.

***Keywords**: Arthroplasty, laterality, surgeon, surgery, total knee arthroplasty*

ÖZ

Amaç: Bizim hipotezimiz, sağ elini kullanan cerrahların sol tarafta diz artroplastisi yaparken daha fazla mesleki hasara maruz kalmalarına rağmen, her iki tarafa artroplastilerde eşit başarılı sonuçlar elde edebilmesidir.

Gereç ve Yöntemler: Kurumumuzda çalışan 2 sağ el dominant Ortopedi cerrahı tarafından gerçekleştirilen toplam 246 (113 sağ ve 133 sol) total diz protezi operasyonu çalışmaya dahil edildi. Karşılaştırma için hastalar sağ ve sol diz artroplastisi gruplarına ayrıldı. Hastaların demografik verileri, eklem hareket açıklığı (EHA), kalça-diz-ayak bileği açısı (KDAA), lateral-distal-femoral açı (LDFA), medial-proksimal-tibial açı (MPTA) ölçümleri ve Diz Derneği Skorları (KSS) değerlendirildi. Ayrıca sağ ve sol total diz artroplastisi işlemleri yapılırken kullanılan spesifik kas gruplarının elektromiyografik ölçümü, farklı taraflara yapılan ameliyatların etkinlik farklarını karşılaştırmak amacıyla 2 cerrah için ayrı ayrı yapıldı.

Bulgular: Postoperatif kanama hacimleri ile 3. ay ve 1. yıldaki fleksiyon, ekstansiyon açıları, ağrı ve fonksiyon skorları karşılaştırıldığında 2 grup arasında istatistiksel olarak anlamlı fark yoktu. Postoperatif EHA, KDAA, LDFA, MPTA ve KSS değerleri açısından gruplar arasında anlamlı farklılık yoktu. Sol diz cerrahisinde sağ diz cerrahisine göre cerrahların sağ latissimus dorsi kasının yaklaşık 5 kat, sol latissimus dorsi kasının 3 kat, sol gluteus medius kasının 2 kat daha fazla aktivasyon sergilediği görüldü.

Sonuç: Sağ elini kullanan cerrahlar, sol tarafa diz artroplastisi yaparken daha fazla çaba sarf etseler de sağ tarafa uygulanan cerrahiler kadar iyi sonuçlar sağlayabilmektedirler. Ancak sol diz ameliyatlarının sağ elini dominant olarak kullanan cerrahlar için daha fazla mesleki zarara neden olduğunu düşünüyoruz.

***Anahtar Kelimeler**: Artroplasti, taraf, cerrah, cerrahi, total diz artroplastisi*

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INTRODUCTION

Although there are many therapeutic modalities in advanced-stage arthrosis, the most effective method to date is total knee arthroplasty (TKA). The result of TKA varies according to the characteristics of the patient, the postoperative setting, the hospital, and the surgical expertise involved in the operation (1,2). From the perspective of the orthopaedic surgeon, there are variable and invariable factors involved in achieving better results in TKA applications. Some of the variable factors include keeping up to date on the current literature on arthroplasty, training or participation in courses, novel methods and follow-up of implant technology, and the personal development of the surgeon himself or herself, which is paramount for achieving better patient outcomes. However, an orthopaedic surgeon cannot change the dominant hand during operations. The dominant hands of surgeons used in routine work and operations are one of the most studied forms of human asymmetry. Laterality has been examined frequently in medicine, especially in the surgical branches (3). Mehta et al. assessed TKAs performed by right-handed surgeons and reported the results of TKAs performed on the left knee to be worse at the 1-year follow-up (4).

While there are a large number of studies in the literature comparing the side of operation with regards to the patient, the ergonomic problems of the surgeon have often been ignored. Specifically, the disruption of body balance during operations may be the cause of occupational diseases of surgeons. In this study, whether the hand used by the orthopaedic surgeon made a difference in the results of TKAs was evaluated, and, more importantly, the differences that occurred for the surgeons during the procedure were evaluated. The hypothesis thus formed in terms of patient outcomes was that the two sides would be similar, but in terms of the surgeon outcomes, the right and left knee applications would reveal differing results.

MATERIALS AND METHODS

A total of 246 total knee prostheses were applied by two right-handed orthopaedic surgeons in our institution between January 2016 and February 2017. All 246 patients were included in the study, which was approved by the institution's ethics committee (Ankara Numune Hospital, Ethics Committe of Clinical Research, date: 14.02.2018; number: E-17-1718). Both of the surgeons had an annual number of cases exceeding 100 and at least 15 years of specialization experience preceding the cases in this study. All of the surgeries were performed in 3 different rooms, under the same operating room conditions. No changes were made in the surgical techniques or implant selections within the duration of the study.

Of the patients, 94.4% had primary osteoarthritis and 5.6% had rheumatoid arthritis, posttraumatic arthritis, or other diagnoses. A tourniquet was applied to all patients. A medial parapatellar incision was performed routinely. At 6 h postoperatively, all of the patients, provided that there were no contraindications, were started on low-molecular-weight heparin, which was administered at 0.6 IU/mL for deep vein thrombosis prophylaxis. This was continued for 6 weeks. A Hemovac drain was used for all of the patients and mobilization with full weight-bearing was commenced at 1 day postoperatively. A continuous passive motion device was commenced at 6 h postoperatively, reaching 120° at 3 days postoperatively. As for the preoperative evaluation, the age, gender, information on handedness of surgeon, body mass index (BMI), and other demographic information about the patients were recorded. Hip-knee-ankle angle (HKAA), lateral distal femoral angle (LDFA), and medial proximal tibial angle (MPTA) measurements were all done radiologically by an orthopaedic specialist who was not involved in the preoperative and postoperative treatments. The joint range of motion, Knee Society pain and functional scores were all recorded preoperatively and then again at 3 months and 1 year

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postoperatively for clinical assessment (5). The amount of bleeding from the drains of the patients was recorded to assess the American Society of Anesthesiologists (ASA) scores, as well as operation times.

Unlike past literature studies, a measurement of specific muscle groups was performed, which were taken while right and left TKA procedures were being performed by the two separate surgeons. Written informed consent was obtained from all the patients and surgeons. A wireless surface electromyography (EMG) system (Noraxon Telemyo DTS System, Scottsdale, AZ, USA) was used to measure the surgeons' muscle activation. During surgery, repetitive muscle measurements were performed at the same sequence of femoral or tibial osteotomy for all of the measurements and noted. Specific muscle assessments were recorded in the same sequence during the operations of different patients. The right and left posterior deltoid, middle trapezius, latissimus dorsi, and gluteus medius muscles were measured via EMG activity and recorded. Prior to electrode placement, the electrode sites of the body were prepared by shaving any hair on the skin, abrading the skin with fine sandpaper, and cleaning the skin with 70% isopropyl alcohol to minimize skin impedance. Surface EMG for non-invasive assessment of muscles (SENIAM) guidelines were used for the electrode placement on the muscles (6).

For the posterior deltoid, the electrodes were placed about two finger breadths behind the angle of the acromion. Placement of the electrodes for the middle trapezius was in the middle of the medial side of the scapula and the 3rd thoracic vertebra. For the latissimus dorsi, the electrodes were placed over the muscle belly at the T12 level along a line connecting the most superior point of the posterior axillary fold and the S2 spinous process. The electrodes were placed at 50% of the distance between the iliac crest and the greater trochanter of the femur for the gluteus medius.

Maximum voluntary isometric contraction (MVIC) tests were also performed for each muscle prior to the muscle activation measurements during the surgeons' tasks. For the posterior deltoid MVIC, the arm was abducted to 90° and held in neutral rotation with resistance applied just proximal to the elbow in an anterior direction (7). MVIC for the middle trapezius was tested in prone position and resistance was applied over the elbow level while the arm was in 90° horizontal abduction in external glenohumeral rotation (8). For the latissimus dorsi MVIC, the subjects were prone, and they were instructed to extend and internally rotate the arm against manual resistance applied to the wrist (9). For the gluteus medius MVIC, the subject was positioned lying on the non-dominant side.

The tested leg was extended to neutral and supported by a small step stool at approximately 5° of hip abduction. A belt was wrapped under the table and over the upper surface of the tested leg just proximal to the lateral malleolus. The subject performed the MVIC test by raising his or her leg against the belt (10).

All of the MVIC measurements were performed by the same researcher. For each MVIC, the subjects performed one practice trial and then performed three repetitions of a 5-s MVIC test. There was a 1-min rest period between the repetitions. After the MVIC measurements, a 5-min rest was given and then the surgeons began surgery.

Statistical Analysis: Statistical evaluation of the data obtained was performed using SPSS 11.5 for Windows (SPSS Inc., Chicago, IL, USA). The normality of the test of quantitative variables was evaluated using the Kolmogorov-Smirnov test. The Student t-test was performed for quantitative comparisons of the side-by-side variables, and the chi-square test was used for the qualitative data. In each group, two-way ANOVA was used for dependent variables to evaluate both the group and time effects together with the time-dependent change of the quantitative variables using the paired t-test. In addition, the paired t-test was applied for

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comparison of the quantitative variables in two-tailed testing. Statistical significance was accepted as $p<0.05$.

RESULTS

A total of 246 patients were operated on, 113 on the right knee and 133 on the left. Both groups comprised 85% female patients. There was no significant difference between the two groups in terms of age, BMI, or gender. In the comparison of flexion, extension, pain scores, and function scores pre- and postoperatively, there was no significant difference between the groups except for the extension values preoperatively. The difference in extension was seen to be the result of minimal standard deviation and it did not cause a clinical effect (Table 1). There was no statistically significant difference between the two groups upon comparing the postoperative bleeding volumes and the flexion, extension levels, and pain and function scores at 3 months and 1 year postoperatively. The operating time for left-sided surgery was slightly longer (Table 2). The ASA scores were similar for both groups. Complications such as infection, wound site problems, pulmonary embolism, and early prosthetic failure were observed in three patients for the right knee and seven patients for the left knee. No significant difference was found between the two groups ($p=0.350$).

Table 1: Demographic and clinical characteristics of the cases

Parameters	Right Knee (Standard Deviation)	Left Knee (Standard Deviation)	P-value
Age	66.4 (7,8)	65.7 (7.7)	0.516
BMI	33.8 (5.4)	32.7 (5.1)	0.093
Gender (Male/Female)	96/17 (-)	113/20 (-)	0.999
Pre-operative Flexion	111.6° (16.5°)	111.2° (18.2°)	0.857
Pre-operative Extension	-1.5° (-3.2°)	-2.8° (-4.8°)	0.015
Pre-operative Pain Scoring	38.7 (12.7)	38 (13.6)	0.672
Pre-operative Functionality Scoring	45.9 (11)	46.5 (11.1)	0.698

Table 2: Post-operative parameters of the cases

Parameters	Right Knee	Left Knee	P-value
3 Month Post-operative Flexion	99.6° (9.5°)	99.5° (9.9°)	0.942
1 Year Post-operative Flexion	103.8° (9.5°)	103.8° (11.1°)	0.951
3 Months Post-operative Extension	-0.3° (1.6°)	-0.08° (1.5°)	0.495
1 Year Post-operative Extension	-0.08° (0.6°)	-0.15° (0.85°)	0.533
3 Month Post-operative Pain Scoring	86.7 (5.5)	85.8 (6.9)	0.275
1 Year Post-operative Pain Scoring	89.8	89.5	0.672
3 Months Post-operative Functionality Scoring	66.2	66.3	0.939
1 Year Post-operative Functionality Scoring	75.3	77.3	0.215
Drain (ml)	546	573.3	0.149
Surgery Duration(mins)	92.3	96.9	0.042

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For angular parameters, the HKAA, LDFA, and MPTA measurements were evaluated both pre- and postoperatively. Statistically, in the preoperative LDFA measurement, significant differences were found between the right- and left-side HKAA values and the postoperative MPTA measurements. The TKA process caused a change in each of the parameters for both right and left knee groups. However, there was no statistically significant difference between the two sides in terms of flexion, pain scores, and function scores (p=0.978; 0.603, and 0.513, respectively).

The EMG activations of the right-handed surgeons' posterior deltoid, middle trapezius, latissimus dorsi, and gluteus medius muscles during the right and left knee surgeries were compared. The bilateral latissimus dorsi muscle exhibited more activation during left knee surgery than right knee surgery. It was observed that the right latissimus dorsi muscle exhibited about five times more activation and the left latissimus dorsi muscle exhibited three times more activation during left knee surgery than during right knee surgery. Similarly, during left knee surgery, the left gluteus medius muscle exhibited two times more activation than during right knee surgery. An interesting observation was that the posterior deltoid muscle was more active bilaterally during left knee surgery, although this difference was not significant. The activity was seen to be more prominent on the operating side of the middle trapezoidal muscle (Table 3).

Table 3: Intraoperative EMG values for orthopedic surgeons performing right and left knee surgery

Muscle groups	**Right Knee Surgery %MVC***	**Left Knee Surgery %MVC***
Right Posterior Deltoid Muscle	1.23	2.33
Right Middle Trapezius Muscle	26.5	16.3
Right Latissimus Dorsi Muscle	6.6	32.5
Right Gluteus Medius Muscle	9.07	9.79
Left Posterior Deltoid Muscle	1.87	2.82
Left Middle Trapezius Muscle	2.81	9.76
Left Latissimus Dorsi Muscle	4.59	16.6
Left Gluteus Medius Muscle	16	33.2

*MVC: Maximum Voluntary Contraction

DISCUSSION

This study aimed to compare the results of right and left knee arthroplasty applications in terms of the radiological angular parameters and clinical scores and to investigate the effects on the surgeon's body. As a result of the study, it was observed that there was no difference in the angular parameters and clinical scores of the patients. The surgeons' right latissimus dorsi, left latissimus dorsi, and left gluteus medius muscles were more active during the arthroplasty procedure applied to the right sides of patients than the left sides. depending on the operated side of the patient in surgeries like left-sided knee arthroplasty, the left-sided acetabular component of hip arthroplasty, the right-sided femoral component, left-sided shoulder arthroscopy, and left-sided hip fractures (11,12). It is

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debated in the literature whether this difficulty affects clinical outcomes (11-13). In a study by Mehta et al. of TKAs performed by right-handed orthopaedists, the results were reported to be worse in patients who underwent left-sided knee surgery (12). Another study looked at the failure of dynamic hip screws, and it was shown that right-handed surgeons had worse outcomes in left hip fracture surgeries (13). In the current study, there was no significant difference between the two sides of the knee in terms of functional and pain results, flexion degrees, and radiological outcomes. This situation may be related to the surgeons' experience and large operation volume. Surgeons with an interest in knee surgery who had more than 100 patients per year and over 15 years of expertise were shown to achieve better clinical outcomes for their patients (14).

Surgeons position themselves spatially during procedures. While right-handed orthopaedists are performing right and left arthroplasties, they tend to use their dominant hands instead of using different hands according to the side on which they are operating. Compared to right knee applications, spatial positioning of the surgeon should change when operating on the left knee, but while staying in the mid-line, the surgeon uses his or her right hand. In the current study, to assess the difference between the two sides, changes in muscle contractions during the procedures were examined via EMG recordings taken from the surgeons. Depending on the position of the patient in knee arthroplasty surgery, the surgeon exerts much more effort to bring his or her hand to the mid-line on the left side. The latissimus dorsi muscle does this job as the most important adductor of the arm. In the current study, up to five times more contractions were observed in the latissimus dorsi muscle during left knee surgery than during right knee surgery. Similarly, this situation was mirrored by the gluteus medius and middle trapezius muscles. The increased activity in the gluteus medius muscle may be considered as one of the important causes of low back pain, iliotibial band syndrome, and trochanteric pain syndrome, which appear in surgeons over the long term (15,16). The results of this study show that right-handed surgeons may be exposed to more occupational damage without causing any change in the results for the patient while executing TKA on the left side when compared to the right side. Best of our knowledge, there was not any similar study in the literature.

Longer operating times and improper posture in the operating room may pose a health risk to the surgeon by creating physical pivot points, which are harmful from an ergonomic health standpoint. Failure to detect this situation in the early stages leads the surgeon to have a shorter professional life (17). A large proportion of surgeons must take time off at various periods due to pain or illness directly related to their work. Usually, these problems occur at an early age. In a study conducted at the Mayo Clinic, 16 of 17 surgeons were found to show problems of deterioration with surgery starting at an early age. The most important of these problems were predominantly in the neck, shoulders, and back with pain around the head.

Ensuring that surgeons do their jobs safely is the duty of occupational health and safety units. There are no training or regulatory activities for occupational damage, except for limited local programs around the world. A study by Matern et al. found that 97% of surgeons stated that they needed surgical training units in the operating room and have made ergonomic arrangements, taking the issue of ergonomics more seriously (18). It is necessary to take measures to enhance the ergonomic function of the operating room environment so as to reap the benefits of long and healthy occupational careers for surgeons. The current study suggests that the most favourable and accurate way for healthcare providers to ensure the least occupational damage to professionals is by playing a more proactive role in the employee growth process.

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There were some limitations of the current study. First, the results obtained were from TKAs performed by two right-handed surgeons; therefore, the results may only be generalized to this group. Additionally, variations of the materials used and the local conditions of the operating room were ignored. In the future, it is suggested to perform studies in which left-handed surgeons are included so that the effect of the hand used on the results of the patients can be evaluated more strongly. Finally, a wider catchment of data needs to be achieved regarding occupational injury and energy consumption per operation. This will perhaps result in changes to the classical approaches in orthopaedic practice. On the other hand, the implants and patient groups in this study were found to be homogeneous in terms of angular, functional, and demographic data. This consistency allowed the evaluation of the surgeons to be performed.

Occupational competence, patient experience, and personal experience of the surgeon can all affect patient outcomes. The dominant hand of the surgeon does not result in different patient outcomes. However, right-handed surgeons are subjected to more occupational damage while performing left-sided TKAs when compared to the right side.

In our opinion, these findings should be noted and reflected in daily practice as another variable that surgeons should consider when planning their surgical lists. Simple measures such as reducing the number of left sided TKAs in the same day could ensure that orthopaedic surgeons can continue performing surgeries for many years with decreased occupational damage to their careers.

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