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Professional article
Stručni članak
UDK 617.583-06:616.833-001
https://doi.org/10.2298/MPNS2302035R

SAPHENOUS NERVE INJURY AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

POVREDA SAFENUS NERVA TOKOM REKONSTRUKCIJE PREDNJEG UKRŠTENOG LIGAMENTA

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Summary

Introduction. Iatrogenic injury to the infrapatellar branch of the saphenous nerve is the most common complication after anterior cruciate ligament reconstruction. The aim of the study is to present the incidence, analyze risk factors, and possibilities of prevention. **Material and Methods**. One year after bone-patellar tendon-bone surgery, we surveyed 787 patients, 78.3% males, with mean age 27.7 years (14 - 59), mean height 180.6 cm (154 - 207), and mean weight 81.8 kg (46 - 145). We monitored the incidence of anterolateral skin numbness below the operated knee joint. **Results and Discussion**. Of the total number of examinees, 71.8% had a feeling of numbness, while 27.3% reported constant numbness. In the group of patients with a higher body mass, the feeling of numbness occurred significantly less often compared to the group with lower body mass, as was the case in the tallest patients, who reported numbness significantly less often compared to the shortest ($p < 0.001$). The incidence of anterolateral skin numbness was lowest among basketball players (64.5%) and highest among skiers (84.8%). Numbness was not significantly affected by age, laterality, and body mass index, level of sports activity, competition ranking or time until surgery. The horizontal surgical incision, intraoperative identification of the nerve, minimally invasive surgery, and the choice of bone graft harvesting sites, can reduce the complication rate. **Conclusion**. One year after the anterior cruciate ligament reconstruction, every fourth patient felt constant anterolateral skin numbness of the operated knee. Although this did not significantly affect the quality of life, it can be prevented by the surgeon who is obliged to warn every candidate for surgery about the possibility of complications, especially short and slim persons.

Key words: Anterior Cruciate Ligament Reconstruction; Peripheral Nerve Injuries; Intraoperative Complications; Iatrogenic Disease; Risk Factors; Hypesthesia; Accident Prevention

Sažetak

Uvod. Jatrogena povreda podčašične grane predstavlja najčešću komplikaciju rekonstrukcije prednjeg ukrštenog ligamenta, pa cilj studije predstavlja prikaz njene učestalosti, analizu faktora rizika i mogućnosti prevencije. **Materijal i metode.** Godinu dana nakon operacije kost-čašična veza-kost tehnikom, anketirali smo 787 pacijenata, 78,3% muškog pola, prosečne: starosti 27,7 godina (14−59), visine 180,6 cm (154−207) i telesne mase 81,8 kg (46−145). Pratili smo učestalost utrnulosti kože sa spoljašnje strane ispod operisanog kolenog zgloba. **Rezultati i diskusija.** Osećaj utrnulosti imalo je 71,8% ispitanika, konstantnu 27,3%. U grupi pacijenata sa većom telesnom masom osećaj utrnulosti se značajno ređe javljao u poređenju sa grupama mršavijih pacijenata, kao što je bio slučaj i kod najviših pacijenata koji su ga značajno ređe imali u poređenju sa najnižim ($p < 0,001$). Komplikacija se najređe javljala među košarkašima (u 64,5% slučajeva), a najčešće među skijašima (84,8%). Na utrnulost nisu značajno uticali: starost, lateralnost, indeks telesne mase, nivo sportske aktivnosti, rang takmičenja i vreme proteklo do operacije. Horizontalni položaj hirurškog reza, intraoperativna identifikacija živca, minimalno invazivna hirurgija i izbor mesta uzimanja kalema, mogu je smanjiti. **Zaključak.** Godinu dana nakon rekonstrukcije prednjeg ukrštenog ligamenta konstantnu utrnulost oseća svaki četvrti pacijent. Iako komplikacija ne ostavlja značajne posledice na kvalitet života, hirurg može da prevenira njenu učestalost i dužan je da svakog kandidata za operaciju upozori, posebno niže i mršavije osobe.

Ključne reči: rekonstrukcija prednjeg ukrštenog ligamenta; povrede perifernih nerava; intraoperativne komplikacije; jatrogene povrede; faktori rizika; hipoestezija; prevencija povreda

Introduction

Saphenous nerve divides into two subcutaneous branches above the hamstring tendon junction on the tibial pes anserinus. One of them passes over the patellar ligament [1, 2]. This infrapatellar branch is purely sensory, without a motor component and innervates the antero-lateral region below the knee [2]. Anatomical position is important due to its vulnerability during surgical approaches to the knee, especially graft harvesting for anterior cruciate ligament (ACL) reconstruction [1, 3]. There is no absolutely safe incision that would avoid it, due to numerous variations in the path of its propagation

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Abbreviations

ACL – anterior cruciate ligament
BMI – body mass index
BPTB – bone-patellar tendon-bone
HT – hamstring tendon

[2]. The recovery prognosis is also uncertain, so spontaneous regeneration may take a few months, but irreversible damage may also be done [1].

Until the last twenty years, surgeons considered saphenous nerve injury inevitable and unimportant [2, 3]. The preventive measures to avoid injury started mainly with studies that identified this injury as a complication of knee surgery, including ultrasonography, blunt nerve isolation, grafting procedure with the knee in 90 degrees of flexion, and localization of safer surgical incision sites [4–24].

Iatrogenic injury to the infrapatellar branch of the saphenous nerve is the most common complication after anterior cruciate ligament reconstruction, but a completely safe operative technique to avoid it has not yet been found [4–24]. The aim of the study is to present the incidence, analyze risk factors, and possibilities of prevention.

Material and Methods

The research was carried out at the Clinic of Orthopedic Surgery and Traumatology of the Clinical Center of Vojvodina, with the prior approval of the Ethics Committee. This retrospective study included 787 respondents who filled out the survey: Response to quality of life [25].

All patients underwent the same operative bone-patellar tendon-bone (BPTB) technique [21] and were monitored for at least 12 months after ACL reconstruction. The following data were recorded and analyzed: gender, age, height, weight, cause of injury, level of sports activity, competition ranking, side of the injured limb, time from injury to diagnosis, time from injury to surgery, feeling of skin numbness below the knee and potential dissatisfactions with the surgery due to this complication.

The survey included 616 males (78.27%) and 171 females (21.73%). The average age was 27.71 years (28.32 years in males and 25.49 years in females). The youngest respondent was 14 years old, the oldest 59. They were divided into seven groups according to age. There were 134 patients under the age of 20 (17.03%); 205 between 20 and 25 years (26.05%); 171 from 25 - 30 years (21.73%); 102 from 30 - 35 years (12.96%); 91 from 35 - 40 years (11.56%); 46 from 40 - 45 years (5.84%), and 38 over the age of 45 years (4.83%). Thus, young athletes (20 - 25 years) made up the largest part of the sample, and the fewest respondents were in the group over the age of 45 years.

The average height was 180.65 cm. The shortest respondent was 154 cm and the highest 207 cm high. The largest part of the sample was between 180 and 190 cm high, and the least respondents were shorter than 160 cm **(Table 1)**.

The average body weight was 81.82 kg; the lowest weight was 46 kg and the highest 145 kg. The sample was divided into six groups: 50 respondents weighed up to 60 kg (6.35%), 99 60 - 70 kg (12.58%), 178 70 - 80 kg (22.62%), 217 80 - 90 kg (27.57%), 163 90 - 100 kg (20.71%), and 80 of them weighed over 100 kg (10.17%). The largest group weighed between 80 and 90 kg, and the smallest weighed less than 60 kg.

In the total sample, 409 had ACL reconstruction of the right knee, 355 of the left, while 23 had an injury of both knees.

According to sports activity, the respondents were divided into: 282 professional athletes (22.19%), 463 recreational athletes (58.06%) and 42 inactive in sports (4.7%). Among the active athletes, 82 compete at an international level, 140 at national, and 176 at regional level.

During the first month after the injury, the diagnosis of ACL rupture was made in 461 cases (58.58%), in the second month in 72 cases, in the third in 42, in the fourth in 27, in the fifth in 15, in the sixth month in 38, and more than half a year after injury the correct diagnosis was made in 132 respondents (16.77%). Seven subjects waited up to 15 days for surgery (0.89%), 18 waited 15 - 30 days, 79 30 - 45 days, 20 45 - 60 days, and 663 waited for over 60 days (84.24%).

The descriptive statistics included the mean value, standard deviation, minimum and maximum, analysis of variance and F-test. In comparative statistics, T-test was used for independent samples, with statistical significance set at $p < 0.001$. The results were compared, analyzed and presented in a table and graphs.

The study excluded 312 subjects who did not want to fill out the form voluntarily or filled it incompletely, as well as those who had other surgeries on the same knee joint, polyneuropathy or spinal nerve root damage.

Results

In the whole sample, 71.8% of the respondents (565) felt skin numbness on the anterolateral side of the operated knee. Numbness did not occur in 28.2% of cases (222), and it was always present in 27.3% (215). Persistent numbness was reported in 13.6% (107), occasional in 16.7% (131), rare in 14.2% i.e. 112 respondents.

Laterality did not significantly affect the sensation of numbness, which never occurred in 116 subjects with an injury of the right knee (28.3%), 100 with an injury of the left (28.2%) and 6 with an injury of both knees (26.1%). It was always present in 109 subjects with right knee injury (26.7%), 98 with left knee injury (27.6%) and 8 with both knee injuries (34.8%). Persistent numbness was the least reported, in 53 with an injury of the right knee (13%) and 56 with an injury of the left knee (15.8%). The subgroup with bilateral knee injuries included the fewest respondents who sometimes experienced numbness.

Table. 1. Incidence of numbness in groups classified according to height
Tabela 1. *Učestalost utrnutosti u grupama telesne visine*

Hight/*Visina*	No./*Br.*	Always/*Uvek*	Never/*Nikad*
< 160 cm	6	50%	16.7%
160 - 169 cm	73	38.4%	21.9%
170 - 179 cm	255	28.2%	20%
180 - 189 cm	321	25.6%	29.3%
190 - 199 cm	124	23.4%	38.7%
> 200 cm	8	12.5%	62.5%

In the youngest group (up to 20 years) including 134 respondents, 43 (32.1%) felt numbness all the time, and 42 (31.3%) never felt numbness. In the oldest group (over 45 years) out of 38 respondents, 8 (21.1%) always felt numbness and 9 (23.7%) never. The feeling of numbness never appeared in 69 out of 205 subjects (33.7%) aged between 20 and 25 years, but in the same age group there were most of those who always felt numbness (51 cases). Between the ages of 25 and 30, numbness rarely occurred in 31 respondents, often in 25, and the same age group had the largest number of those who sometimes experienced it, so there was no significant correlation (p = 0.05).

According to the gender distribution, 30 females (17.5%) and 192 males (31.2%) never felt numbness, while 69 females (40.4%) and 146 males (23.7%) always felt it. In 18 female respondents, numbness occurred sometimes (10.5%), while in 76 males it occurred least often (12.3%).

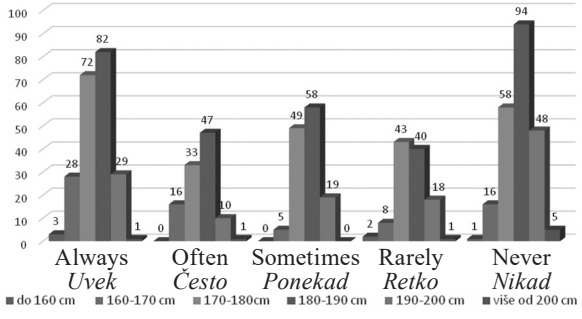
Shorter respondents reported this complication significantly more often than taller ones **(Table 1)**. Among the six subjects up to 160 cm high, there were three cases of permanent numbness (50%), compared to eight subjects over two-meters tall, where only one always felt numbness (12.5%). We can conclude that the increase in body height is associated with lower incidence of the feeling of numbness, so in the tallest respondents it occurred least often, while in the shortest, it occurred most often, especially in 83.3% of the respondents in the shortest group. There is a statistically significant difference (p < 0.001) in the correlation between this complication and the height of the examinees **(Graph 1)**.

In the slimmest group of 50 subjects weighing up to 60 kg, 19 (38%) always felt numbness and 9 (18%) never. In the group with the highest body weight over 100 kg, among 80 subjects, 16 (20%) always had this complication and 29 (36.2%) never **(Graph 2)**. We found that subjects with a higher body mass least often had the feeling of numbness (never), while those with a lower body mass often had this complication (always) (p = 0.001).

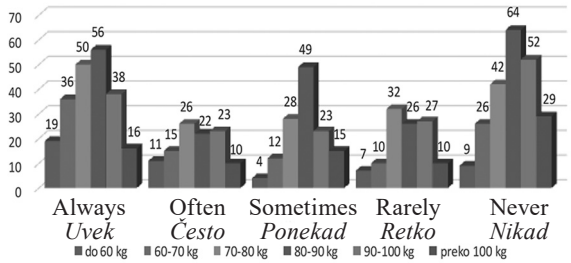
Analyzing the relationship between the body mass index (BMI) and the feeling of numbness, we may conclude that in subjects with higher BMI, the feeling of numbness "never" occurred, while in those with lower BMI it occurred "always", but the BMI does not statistically significantly correlate with this complication (p = 0.102).

In regard to sports activity, numbness was never reported in 126 subjects who were recreational athletes, i.e. in 89 subjects who were professional athletes and 7 non-athletes. However, numbness always occurred in 116 recreational athletes (25.1%), 87 professional athletes (30.9%) and 12 non-athletes (28.6%). The complication occurred least often in recreational and professional athletes and sometimes in non-athletes. There is no statistically significant correlation (p = 0.167) between numbness and the level of sports activities.

The feeling of numbness never appeared in 44 competitors at the national level, 52 at the regional level and in 94 recreational athletes, 26 respondents



Graph. 1. Sensation of numbness among groups classified according to height (always, often, sometimes, rarely, never)
Grafikon 1*. Osećaj stepena utrnutosti među grupama po visini (uvek, često, ponekad, retko, nikad)*



Graph 2. Sensation of numbness among groups classified according to body weight (always, often, sometimes, rarely, never)
Grafikon 2*. Osećaj stepena utrnutosti među grupama po telesnoj masi (uvek, često, ponekad, retko, nikad)*

at the international level and 6 non-athletes. It rarely occurred in 8 non-athletes, 60 recreational athletes, and 13 respondents at the national level, 19 at the regional level and 12 at the international level of competition. There is no statistically significant correlation ($p = 0.134$) between the feeling of numbness and the rank of competition.

The statistical analysis showed that there is no statistically significant difference ($p = 0.529$) in the occurrence of the feeling of numbness in relation to the time that passed from the moment of the injury to surgery.

Returning to sports activities one year after surgery was reported by 575 respondents (73.1%). Among the other 212 (26.9%) who did not return to sports, not a single respondent reported numbness of the antero-lateral side below the knee as the cause of dissatisfaction with the surgery outcome.

Discussion

Although it is the most common postoperative complication of ACL reconstruction [1, 4, 5, 26], certainly the most common neurological complication, studies have intensively monitored only the iatrogenic injury of the infrapatellar branch of the saphenous nerve in the last 20 years. This was contributed to unclear causes of anterior knee pain after numerous surgical procedures [22, 24, 27], such as prosthetic knee replacement, osteosynthesis of the proximal part of the tibia, reconstruction of the patellar ligament [28] and especially after harvesting a graft for ACL reconstruction, both BPTB [4, 13–17] and hamstring tendons (HT) [5–12, 26]. This complication can also occur during the incision of the antero-medial portal for arthroscopy, as well as by drilling a tunnel in the tibia [6, 7]. Injury to this sensory branch may have consequences in the form of symptoms of saphenous neuralgia, which, especially immediately postoperatively, can manifest as intense burning pain, increased local sensitivity during palpation, and later as a feeling of numbness below the antero-lateral side of the knee [1, 3]. In such cases, application of local therapy is suggested: 1.5 ml of anesthetic (0.5% bupivacaine), with or without depo corticosteroids [3]. At the end of the surgery, patients also receive a local anesthetic. More serious symptoms due to painful neuroma and sympathetic algodystrophy have also been described [5], resulting in anterior knee pain and discomfort during kneeling, sometimes with a negative impact on the patient's quality of life and satisfaction with surgery [5].

There are no clear guidelines for the diagnosis of this complication. Certain studies claim that ultrasonography provides the best information about nerve projections [29]. If an injury to the infrapatellar branch is suspected, the following methods are available: clinical examination, inspection of the scar site, type of pain, loss of sensitivity, positive Tinel sign, and electrodiagnostic procedures [3, 12]. Palpation and percussion are limited by the differential diagnosis of this region, and the complication may be misdiagnosed by the pathology associated with other nerves and anatomical structures (e.g. medial collateral ligament injury) [29]. Electrodiagnostic tests are technically challenging and usually useless in routine practice. Nevertheless, a group of Chilean authors, managed to detect 68% of these cases using an electrophysiological method, out of 77% of patients with numbness [12].

The incidence of saphenous nerve injury during classic HT harvesting ranges from 21 to even 88% [5–12, 26]. In an American study, 70% of patients felt numbness 6 weeks after surgery. Six months later, only 17% had a spontaneous recovery, 73% noticed an improvement after a year, and 14% had no complaints [10]. There are studies that prove that spontaneous recovery until returning to sports occurs only in every fourth patient, and every twentieth regretted having the surgery at all [13]. When we add that a Norwegian received insurance compensation of €605,100 due to permanent saphenous nerve deficit after ACL reconstruction [30], as well as that every fourth of our operated patients has a permanent feeling of numbness after one year, everything points to the importance of the problem and its prevention.

A group of Iranian authors significantly reduced the incidence of this iatrogenic injury ($p < 0.001$) when harvesting HT through a horizontal and oblique incisions, parallel to the extension of the nerve branch ($p < 0.001$) [5]. On cadavers, the oblique incision at a 45 degree angle proved to be the best, because the vertical one caused 65%, the horizontal 50%, and the oblique only 28% of injuries [9]. A group of Greek authors also reduced the incidence of complication just by changing the position of the incision from 40% in vertical to only 15% in horizontal [11]. Successful techniques for harvesting HT using two smaller incisions have also been described [31]. However, there are also studies that show that the incidence of complications is not affected by the position of the incision [5, 7]. While some authors believe that the length of the surgical incision does not have a significant effect [12], others have proven that a smaller incision reduces the risk [7] and that inadequate manipulation of the stripper for taking HT can cause saphenous nerve injury [6, 7].

The exploration of this nerve would be ideal for prevention, but the sensory branch of saphenous nerve is small and difficult to identify. Nevertheless, a group of Iranian authors prolonged the surgery by five minutes to find and explore it with a classic incision of 3 cm in length. During 98 surgeries, the nerve was not located 54 times, but found in 44 cases and protected with a rubber band. Postoperatively, only 20% of patients had a sensory deficit, in contrast to 72% where it was not found and protected [8]. There is also evidence that the incidence of nerve injury can be reduced by 13% only by following the surgical approach during the harvesting of a graft [17]. The posterior approach to HT harvesting can preserve the sensory branches [32]. Some authors believe that, due to the frequency of neurological complications, a completely different graft should be chosen instead of the usual ones [1]. For example, the quadriceps tendon graft does not endanger the path of propagation of the nerve branches or an al-

lograft should be used [10]. Comparing the quadriceps tendon and HT groups, the quadriceps tendon group had only 17% paresthesia versus 76% among HT [1]. The above may suggest that the cause does not lie solely in the choice of the graft, because if it were so, the nerve would never have been damaged in the quadriceps tendon autograft and allograft groups. The cause of some paresthesia probably lies in the coincidence of the path of nerve propagation with the place where the tunnel is drilled in the tibia, the arthroscopic portal, postoperative swelling that compresses it, or other reasons [7].

Prevention does not depend on the choice of one of the two most commonly used grafts, because no significant difference in the incidence of saphenous nerve injury was found by comparing BPTB and HT groups [10, 12]. Previously, it was thought that the main disadvantage of HT autograft harvesting was damage to the infrapatellar branch [17, 26], but it has been proven that this complication may also occur in as many as 90% of cases using traditional harvesting of BPTB (with vertical incision) [4, 15, 16]. Formerly, it was believed that the main disadvantage of the classic BPTB technique was anterior knee pain and extension deficit [17], but these complications can occur with both operative methods [4, 10, 12, 15, 16, 21, 22]. The advantages of the BPTB technique lie primarily in the firmer fixation of the graft and its faster biological incorporation [24, 33]. The potential disadvantages are patellofemoral pain, damage to the extensor apparatus of the knee, calcification of the patellar tendon, and patellar fracture [22, 27]. Also, a common complication, especially in female patients, is the weakness of the quadriceps muscle, which can last for two years after surgery [4].

Therefore, even with the BPTB technique, which was used in our patients, this nerve is not safe. A group of Israeli authors also registered numbness among 77% of patients, 19% with a complete spontaneous recovery after 8 months, while two years after surgery as many as 58% had a permanent loss of sensation below the knee. These authors, like us, prefer the BPTB technique in young active athletes, although by the time they return to sports, after 8 months, they have recorded complete nerve recovery in less than a quarter of cases, only in 24% undergoing BPTB and 23% in the HT group [13]. In order to prevent saphenous nerve injury, a group of Japanese authors [14] changed the traditional vertical incision for harvesting BPTB with two horizontal, and managed to reduce the complication rate to only 17%. French authors [4, 15] used a similar minimally invasive technique, using two 2 cm long vertical incisions (proximal that does not exceed the apex of patella and the distal in the area of the tibial tubercle), managed to significantly reduce the nerve damage. A new minimally invasive technique for harvesting BPTB graft uses only one patellar incision introducing a special instrument. In a group of 18 patients undergoing a classic method, there were 16 cases of numbness, and in minimally invasive there was only one [16].

Although there are no absolutely safe operative techniques, it is comforting that the majority of surveys confirmed that none of the subjects with damage to this nerve had impairment in daily activities attributable to sensory changes, nor delayed their rehabilitation due to this problem [12, 13, 19]. In another study, only one out of 60 respondents complained that the sensory change significantly affected his daily life [34]. It is similar in our sample, so after infrapatellar branch injury, no specific treatment is required [12, 13, 29, 34].

Most studies have proven that age, gender, BMI, as well as additional meniscus injuries, and the timing of ACL reconstruction, have no significant impact on the incidence of this neurological complication [1, 5, 7]. This is consistent with our results, with the exception of body height and body mass. We also noted that the complication was more frequent in females (82%) than in males (69%). The cause of this difference has not yet been established, since cadaveric studies indicate that there is no difference in skin innervation between the sexes [35]. Swedish researchers also found that there is no statistically significant difference between the occurrence of numbness in relation to gender, age, and the time from injury to surgery, but that there is a significant difference in relation to the level of activity before the injury, which was not the case in our study [36]. Most of our respondents were operated on in the first three months after the injury. On average, they waited for surgery 20 months and 14 days. In an Iranian study [5], in which the average time from injury to surgery was similar (22 months), this complication was observed in 83% of patients [5]. In another study, with a shorter elapsed period to surgery (11.2 months), slight numbness of the skin was reported by 42% of respondents, moderate by 13%, and severe by only 1% [33].

We found a statistically significant correlation between the appearance of numbness and the height of the examinees. The average height of our respondents was 180.65 cm (154 cm to 207 cm). The tallest (over two meters) stated that numbness generally never occurred, while the shortest (below 160 cm) experienced it very often (83%). The tallest subject who always feels numbness below the knee is 202 cm tall and plays basketball. An anatomical study showed that the average distance between the apex of patella and the infrapatellar branch of the saphenous nerve is 21.9 mm (15 - 30 mm), and between the branch and the top of the tibial tubercle it is 16.2 mm (0 - 27 mm) [6]. However, there are no data on the height of cadavers, so we cannot say with certainty whether the height of a person has a role in the anatomical variation of nerve path. Nevertheless, from the aspect of sports our respondents were engaged in, the highest incidence of numbness was found among skiers. Among 33 skiers, the complication occurred in 85% with an average height of 177 cm. Numbness occurred most rarely among respondents who play basketball, because out of 124 basketball players, 80 (65%) had this complication. The basketball players were on average 8.42 cm taller than the skiers, with an average height of 185.78 cm. The heaviest examinee that experienced numbness weighed 145 kg and was also injured during skiing.

The main advantage of this research is based on the fact that most other studies followed the saphenous nerve injury on a smaller sample, and were not able to compare the incidence among the lowest, highest, heaviest and thinnest respondents [37]. The limitations of this retrospective study lie in the fact that the area of the affected skin was not measured, nor were data collected at multiple time intervals. Therefore, we were unable to monitor whether the numbing sensation and numbing area decreased over time. In future research, it would be desirable to provide an objective answer as to whether the propagation path of infrapatellar branch differs between high and short i.e. obese and malnourished cadavers.

Conclusion

Injury to the infrapatellar branch of the saphenous nerve during the anterior cruciate ligament reconstruction is not a rare complication. It occurred in 72% of our operated patients, of which 27% felt constant numbness below the antero-lateral side of the knee one year after surgery. This complication is significantly more frequent in persons with lower body height and weight. There is no statistically significant difference in the occurrence of skin numbness according to age, body mass index, side of the injured knee, time of surgery, level of sports activity and competition ranking. Currently, there is no absolutely safe surgical procedure that prevents damage to this nerve, but there are techniques that involve its identification, or minimally invasive procedures which significantly reduce the frequency of this iatrogenic complication. Surgeons should warn all candidates for this procedure, especially those who are shorter and thinner, that there is a significant risk of numbness, which is unlikely to affect their knee function and quality of life.

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Rad je primljen 30. X 2022.
Recenziran25. II 2023.
Prihvaćen za štampu 7. V 2023.
BIBLID.0025-8105:(2023):LXXVI:1-2:35-41.

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