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REVIEW ARTICLE

NEUROMA OF THE INFRAPATELLAR BRANCH OF SAPHENOUS NERVE AFTER KNEE JOINT SURGERIES. METHODS OF DIAGNOSIS, PREVENTION AND TREATMENT

NERWIAK GAŁĄZKI PODRZEPKOWEJ NERWU ODPISZCZELOWEGO PO OPERACJACH KOLANA. PRZEGLĄD METOD DIAGNOSTYKI, PREWENCJI I LECZENIA

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ABSTRACT

Introduction

Knee arthroscopy is a minimally invasive method of treatment of large joint disorders that allows to increase accuracy of the surgical procedure and diminish the chances of complications. Nevertheless, after the procedure some patients still experience pain or limited manoeuvrability for which several causes (e.g. inadequate rehabilitation, infection, arthrofibrosis or neuroma) have been identified.

Aim

In this review, we focused on the symptoms associated with IBSN neuroma that arise during arthroscopic surgery, and described how to prevent, diagnose, and treat them.

Materials and methods

The analysis was done based on literature review. A review of the literature was conducted in December 2022, through a search of the PubMed, MEDLINE, Cochrane, and Google Scholar databases, with no date limits.

Results

Neuroma of the infrapatellar branch of the saphenous nerve (IBSN), mainly caused by physical damage to the nerve bundle during arthroscopy, has been recognized as an often underdiagnosed cause of prolonged pain in the postoperative knee joint.

Conclusions

Several actions can be implemented to prevent the formation of IBSN neuromas, like proper position of the limb during the surgery, proper arthroscopic portal placement, incision in the hamstring harvest during ACL reconstruction, proceeding with IBSN stump, use of ultrasound during the procedure. The treatment of IBSN neuromas covers surgical and non-surgical methods.

Keywords: knee joint, knee arthroscopy, prolonged knee pain, infrapatellar branch of saphenous nerve neuroma.

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STRESZCZENIE

Wstęp

Artroskopia stawu kolanowego to małoinwazyjna metoda leczenia schorzeń kolana, która pozwala na zwiększenie dokładności zabiegu operacyjnego i zmniejszenie ryzyka powikłań. Niemniej jednak po zabiegu niektórzy pacjenci nadal odczuwają ból lub ograniczoną zdolność ruchu, dla których zidentyfikowano kilka przyczyn (np. nieodpowiednia rehabilitacja, infekcja, zwłóknienie stawu lub nerwiak).

Cel

W tym artykule skupiliśmy się na objawach związanych z nerwiakiem IBSN, które pojawiają się podczas operacji artroskopowej oraz na tym, jak im zapobiegać, diagnozować i leczyć.

Materiał i metody

Analizy dokonano na podstawie przeglądu literatury w grudniu 2022, wykorzystując bazę PubMed, MEDLINE, Cochrane, oraz Google Scholar bez ograniczeń w dacie opublikowanych badań.

Wyniki

W ostatnim czasie nerwiak gałęzi podrzepkowej nerwu odpiszczelowego (IBSN), spowodowany głównie fizycznym uszkodzeniem wiązki nerwowej podczas artroskopii, został uznany za często niedodiagnozowaną przyczynę przedłużającego się bólu pooperacyjnego stawu kolanowego.

Wnioski

Aby zapobiec powstawaniu nerwiaków IBSN, można zastosować kilka działań, takich jak prawidłowe ustawienie kończyny podczas operacji, prawidłowe ustawienie portalu artroskopowego, nacięcie ścięgna podkolanowego podczas rekonstrukcji ACL, prawidłowe postępowanie z IBSN, zastosowanie ultradźwięków podczas zabiegu. Leczenie nerwiaków IBSN obejmuje metody chirurgiczne i niechirurgiczne.

Słowa kluczowe: staw kolanowy, artroskopia kolana, przedłużający się ból kolana, nerwiak gałązki podrzepkowej nerwu odpiszczelowego

Introduction

Arthroscopic knee surgery has improved the standard of treatment for large joint disorders. This method not only allowed to increase the precision of the performed procedure, but also reduced the risk of complications that often accompany operations on open joints. Despite the fact that knee arthroscopy is minimally invasive, orthopaedists still meet patients who feel pain or limited mobility in the knee joint after the procedure. Diagnosed causes of such limitations after knee arthroscopy include: inadequate rehabilitation, infection, spontaneous osteonecrosis of the knee (SONK) (Di Caprio *et al.,* 2017), reflex sympathetic dystrophy (Pandita and Arfath 2013) or arthrofibrosis or neuroma of the nerves innervating the knee joint. In this article, we focused on the symptoms associated with neuroma of the infrapatellar branch of the saphenous nerve (IBSN) arising during arthroscopic surgery and the methods of its prevention, diagnosis and treatment.

Material and methods

A review of the literature was conducted in December 2022, through a search of the PubMed, MEDLINE, Cochrane, and Google Scholar databases, with no date limits.

The following indexing terms were used: "knee arthroscopy pain", "infrapatellar branch of saphenous nerve neuroma", "IBSN neuroma", "prolonged knee pain" and "lower limb neuroma". Titles and abstracts were used to select articles that met the search goal.

The selected articles were read in their full version and their bibliographic references were searched manually for additional relevant publications. Only articles that had a full version or at least the abstract in English were selected.

The anatomy of the IBSN

The infrapatellar branch of the saphenous nerve is a branch of the femoral nerve. The femoral nerve descends from the anterior spinal nerve roots of the lumbar plexus (L2-L4). At a distance of about 8 cm from the inguinal ligament, the femoral nerve passes into the saphenous nerve, which is a sensory nerve innervating the medial part of the lower leg and foot. Five centimeters below the entrance to the adductor canal, the saphenous nerve pierces the anterior wall of the adductor canal, which is accompanied by the descending knee artery (Schuenke *et al.,* 2010). Then it runs in the sulcus between the vastus medialis and the adductor maximus, behind the sartorius, passing with it to the medial part of the knee. At the level of the inferior patellar, the saphenous pole nerve pierces the deep fascia of the limb and gives off the infrapatellar branch.

IBSN provides a sensory innervation of the anterio-medial aspects of the knee joint, from the patella to the tibial tuberoses and the anterio-inferior part of the knee joint capsule.

IBSN has different anatomical variants. The two most often transverse branches intersect the deep fascia of the limb at the level of the patellar tendon and form the infrapatellar plexus. The direction of the IBSN branches is not constant and depends on the anatomical location of a given part of the nerve. A variant commonly described in the literature indicates that at the beginning of the course the IBSN branches are located almost horizontally. Located medial to the patellar tendon, the branches arise at a 45° angle and run distal-lateral. At the level of the patellar tendon, the IBSN branches become horizontal again. Surgeons should be thoroughly familiar with the anatomy of IBSNs to avoid iatrogenic nerve damage and subsequent neuroma development (Kerver *et al.,* 2013).

The causes of the IBSN neuroma

IBSN neuroma can be caused by trauma to the knee, including deep skin damage, but most often it is caused by unintentional injury during knee surgery. Up to 28% of patients report dysesthesia after arthroscopic meniscal removal, and 37%–86% of patients have similar symptoms after arthroscopic anterior cruciate ligament (ACL) reconstruction (Kerver *et al.,* 2013). IBSN neuroma after ACL reconstruction is a fairly common complication and should be considered when patient has anaesthesia, dysesthesia, immobile pain or allodynia. These complaints are often described in the literature as infrapatellar pain syndrome (IPS), which occurs after ACL reconstruction, knee arthroplasty, arthroscopy and other knee surgeries. Neuroma as a spherical formation on the nerve is not always the cause of pain, which may also be secondary to the compression of the scar on the neuroma, nerve ischemia or ectopic calcium channels (Xiang *et al.,* 2019). The patient usually reports complaints from 1 to 12 months after surgery.

The diagnosis of the IBSN neuroma

The unclear clinical picture of IBNS neuroma often leads to misdiagnosis or under diagnosis (Trescot *et al.,* 2013). This chapter summarizes the methods most commonly used to determine the origin of infrapatellar pain syndrome. Physical examination of the knee joint with a positive Tinel's sign over the anatomical location of IBNS suggests impaired conduction of nerve impulses and a neurological basis for infrapatellar pain. In addition, the nature and dynamics of pain progression can help distinguish its source from neuromas, which develop months after surgery and cause tingling, burning, and numbness unlike other types of pain and causes (Xiang *et al.,* 2019). Additionally, neuroma nodules can be identified and precisely located on MRI images in many patients (Xiang *et al.,* 2019). High-resolution ultrasonography is used also a method used to identify nodules as an enlargement of the cross-sectional area of the nerve. Combined with physical examination, the high availability and low risk of ultrasound make it the preferred primary diagnostic method for IBNS neuromas (Xiang *et al.,* 2019). Moreover, pain relief after performing saphenous nerve block by local anaesthetic injection is a confirmation of neurological source of patient's symptoms (Batistaki *et al.,* 2019).

The prevention of the IBSN neuroma

In this chapter we present ways to prevent the formation of IBSN neuromas.

A proper position of the limb during the surgery

There are many ways to prevent iatrogenic neuroma IBSN during arthroscopic surgery. The basic method is to put the limb in the right position during surgery, i.e. one that makes it easier to locate the arthroscopic canals. The patient's heels should be at the end of the operating table and the pelvis should be pulled up to the edge of the operating table. The circumferential leg holder allow to stabilize the leg. The position of the legs should be comfortable so that the operator can perform a valgus or varus shin to expose the arthroscopic canal. In addition, to facilitate finding the arthroscopic canal, it is worth considering marking anatomical points (patellar outline, tibial tuberosity, patellar tendon, lines of medial and lateral joints) (Ward and Lubowitz 2013a; Ward and Lubowitz 2013b).

The arthroscopic portal placement

As already mentioned, there is no single anatomical variant of IBSN. This fact is associated with a higher risk of IBSN damage during surgery and subsequent neuroma development. IBSN mapping allowed to determine the zone of lower risk of IBSN damage during arthroscopic incision of the canal. However, the hypothesis that there are safe zones (without the possibility of damaging the IBSN) for incision was rejected. The greatest risk of IBSN damage occurs during operations in the medial part of the knee and vertical incision. The safest zone for the placement of the medial portal is the medial area of the knee at the level of the tibial tuberosity with a 45° oblique incision. The second site with a lower risk is the medial region of the apex of the patella, where a horizontal incision is preferred. The surgeon must remember that the incision should depend on the direction of the nerve at each knee location (Kerver *et al.,* 2013). These lower risk zones have been described by Kerver group and in most cases they include lower risk zones indicated by H. Mochida and S. Kikuchi (Figure 1), who located them medially, approx. 30 mm from the medial edge of the patella in the middle of the height of the patella and (Mochida and Kikuchi 1995).

The incision for the hamstring harvesting during ACL reconstruction

Brandon Michael Henry and his team described which incision to consider when harvesting a hamstring muscles. In our study, the frequency of IBSN injuries was analyzed depending on the incision over the pes anserinus. In the majority of cases (64%), the IBSN lesion developed as a result of a vertical cut. The horizontal cut caused 50% of the IBSN damage and the diagonal cut 27.5%. These data suggest that the use of an oblique incision when harvesting the hamstring may help to avoid IBSN damage (Henry *et al.,* 2018).

Proceeding with IBSN stump as a way of neuroma prevention

One of the methods of neuroma prophylaxis is putting the nerve stump in a "cap". This cap can be autologous or synthetic. The autologous cap

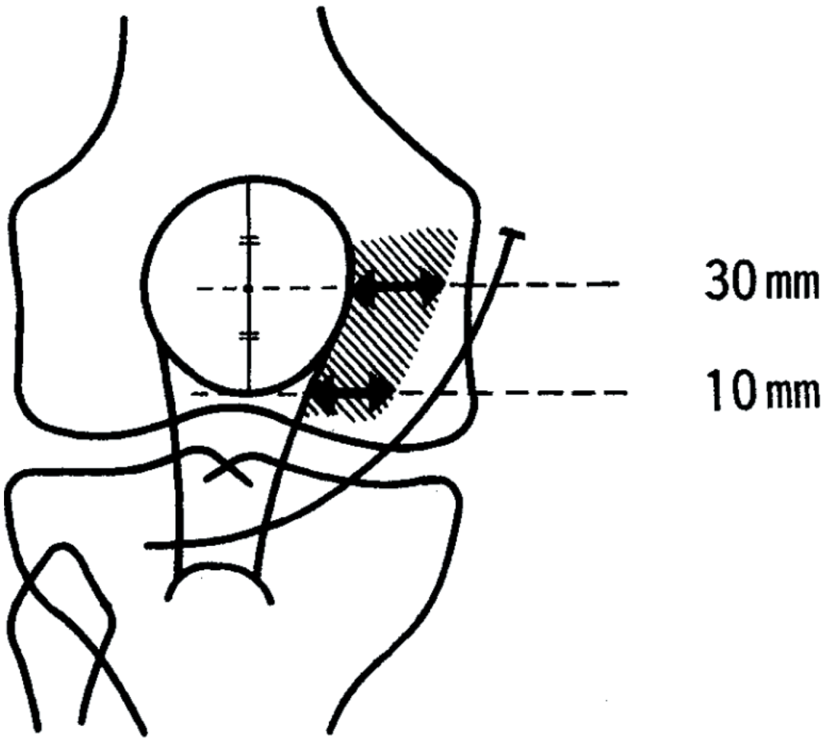

Figure 1. Areas described as safezones by H. Mochida and S. Kikuchi (Mochida and Kikuchi 1995).

is made up of: muscles, veins, and fascia. The synthetic cap is of collagen or silicone origin. The use of a laser on the nerve stump is also effective in preventing neuroma. Electrocoagulation, ligation, or freezing of the nerve stump may reduce the size of the neuroma but will not prevent neuroma development (Lewin-Kowalik *et al.,* 2006).

Other methods of IBSN neuroma prevention
To avoid IBSN damage during arthroscopy, ultrasound should be considered. Pękala and E. Miza (2017) conducted a simulation study in which they assessed the USG of 60 lower limbs. This revealed the course of IBSN and made it easier to decide which incision is the best solution in a particular case (Pękala *et al.,* 2017). On the other hand, O.H. Sherman studied the complications of arthroscopic surgery and indicated transcutaneous illumination as a means of identifying the nerve before making a posteromedial portal incision (Sherman *et al.,* 1986).

The treatment of the IBSN neuroma
The first attempts to treat neuromas focused on the upper extremity and neuroma resulting from its amputations. An early treatment that is still an important part of the surgical treatment of neuromas was simple excisional neurectomy, which in early trials showed excellent or satisfactory results in 65% of patients as an isolated procedure (Tupper and Booth 1976). Later reports showed good or excellent results in 82% of patients after excision of a neuroma prior to implantation of the damaged nerve into the muscle (Dellon and Mackinnon 1986). Over time, approximately 200 neuroblastoma treatment techniques have been evaluated for various indications (Guse and Moran 2013). The variety of techniques used suggests that the treatment of postoperative neuroma remains a problem that does not have a universal solution.

The surgical treatment of IBSN neuromas
Surgical treatment of IBSN neuroma should be initiated in patients with neuroma pain or loss of nerve function that cannot be controlled by non-surgical methods. According to a meta-analysis conducted in 2018 (Poppler *et al.,* 2018), surgical treatment was successful in

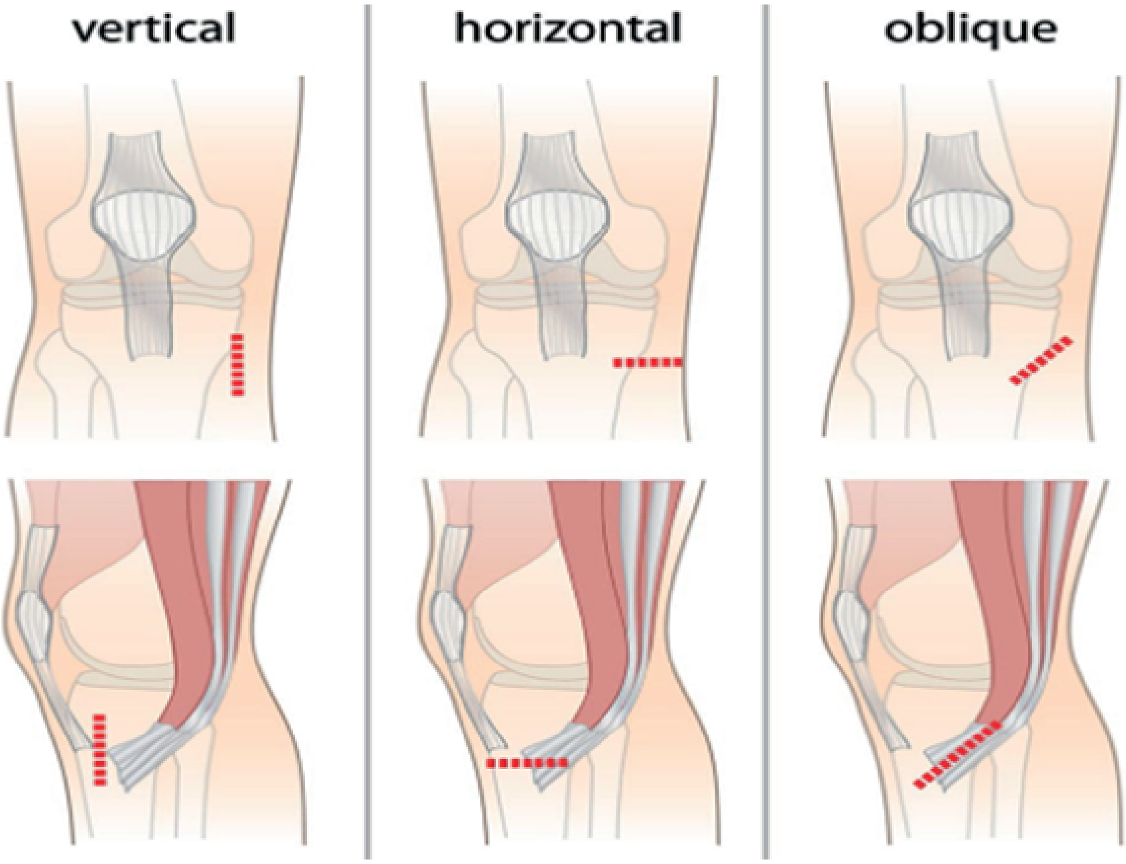

Figure 2. Types of incisions in the hamstring harvest during ACL reconstrucions (Henry *et al.,* 2018). Red dashed lines indicate the position of the incisions. The anterior view of the right knee is presented.

77% of patients, while a recent study of 32 patients after lower-leg neuroma surgery showed 59% long-term success in 19% of patients who still reported severe persistent pain (Anantavorasakul *et al.,* 2020). The treatment algorithm for neuroma depends on the location of the neuroma (neuroma of the stump or neuroma in continuity), and thus the availability of the distal end of the nerve after excision of the neuroma (Eberlin and Ducic 2018; Challoner *et al.,* 2019). There are cases of treatment of IBSN neuroma by excision alone, but the literature indicates that as an isolated method it may not be sufficiently effective (Vernadakis *et al.,* 2003), but it is still the starting point in most cases of surgical treatment of neuroma.

If the distal end remains accessible, a common technique for the surgical treatment of IBSN neuroma is to reconstruct the nerve with a nerve graft or conduit that follows neurotomy. Due to the increased morbidity at the donor site after autografting (Ducic *et al.,* 2020), allograft reconstruction (Safa and Buncke 2016; Ducic *et al.,* 2019; Souza *et al.,* 2016) or collagen nerve conduits (Rbia *et al.,* 2019) may be the preferred technique for the treatment of neuroma. Another option that avoids severe neuropathic complications at the donor site may be vein conduit autografts, which, according to many studies, can successfully replace traditional nerve grafts (Sabongi *et al.,* 2015; Ahmad and Akhtar 2014). Furthermore, tissue-engineered nerve cords with stacked nanofibers may be alternative grafts of the future, as studies in animal models show that stacked fibers may provide a better microenvironment for effective regeneration of Schwann cells and axons, hence potential use in the treatment of neuroma (Quan *et al.,* 2019). In the case of neuroma of continuity, finding the most accurate nerve reconstruction technique is especially important to restore the altered nerve function and thus prevent neuroma recurrence.

If the neuroma is located on the terminal branches of the nerve, which means that the distal end is not accessible, a common technique is to implant the nerve stump into nearby tissues after excision of the neuroma (Eberlin and Ducic 2018). Implantation of the stump into the tissue is intended to provide biomechanical protection, and thus prevent neuroma recurrence and improve blood supply supporting regeneration. According to the literature, options include muscle (Dellon and Mackinnon 1986), bone (Mass *et al.,* 1984) and vein (Koch *et al.,* 2004), with a muscle predominance in the surgical treatment of terminal neuromas (Ives *et al.,* 2017). In the case of leg neuromas, the implantation muscle is the quadriceps femoris. However, several studies have shown that vein translocation may be more effective in the treatment of neuroma (Balcin *et al.,* 2009; Prasetyono *et al.,* 2014). Another option may be surgical resection with nerve capping techniques, using materials such as a vein (Galeano *et al.,* 2009) or epineural grafts (Lewin-Kowalik *et al.,* 2006) as stump caps for treatment and recurrence prevention. In the post-knee arthroscopy neuroma study, the nerve allograft was first sutured to the nerve stump and then embedded into the nearby muscle with fibrin glue, the extra length of the nerve was intended to force the nerve stump to use its energy for growth and regeneration rather than producing another neuroma (Schur *et al.,* 2021). In rat models, there are indications that the nerve conduits with aligned nanofibers used in nerve stump capping method may regulate the biochemical RhoA/ROCK signaling pathway involved in the formation of painful neuroma, which means that it may be a future strategy in the prevention and treatment of stump neuroma (Zhou *et al.,* 2020, Yan *et al.,* 2014).

A case report of a patient with IBSN neuroma after total knee arthroplasty, which may have resulted from scar tissue compression, described neurectomy, adhesiolysis, and spacer replacement with complete resolution of pain and stiffness after treatment (Xiang *et al.,* 2019). However, in another study evaluating IBSN neuralgia caused by nerve compression of scar tissue, neurolysis was reported as a method of treatment (Bertram *et al.,* 2000). The literature shows that in such cases, a polymer sheet or biological tissue can be used to wrap the nerve (Eberlin and Ducic 2019) in order to prevent further adhesion of the scar and the formation of a post-neurolysis neuroma. In addition, there is a study that indicates that neurolysis may be a more appropriate option than resection in the treatment of a neuroma of continuity in a nerve without an action potential distal to the neuroma, as it promotes the restoration of nerve function (Lipinski and Spinner 2014; Kline and Nulsen 1972). Other case studies of neuroma of the lower extremities represent rather a combination of methods to achieve successful neuroma treatment. One case report in a patient with IBSN neuroma after arthroscopy recommends injecting a 1% solution of bupivacaine into the area of the neuroma, followed by resection of the neuroma and disruption of the distal end with a Pean surgical instrument, which has shown success after 18 months of follow-up (Grabowski *et al.,* 2018). Another case report of a patient with IBSN neuroma after exostectomy of the tibial tuberosity through a median incision showed no recurrence of pain within 18 months after isolated neurolysis of one affected branch and neurolysis with resection and burial of the distal end of the nerve in healthy tissue. a second branch of IBSN (Ngbilo *et al.,* 2019).

Non – surgical treatment of IBSN neuromas

There is no conservative treatment algorithm for patients with IBSN neuroma. Care is tailored to the patient's individual needs and includes methods used to treat anterior knee pain and neuropathic pain in general. Non-surgical techniques described in the literature include oral pharmacotherapy, bracing, acupuncture, transcutaneous electrical nerve stimulation (TENS), massage, corticosteroid injections, viscose supplementation, platelet-rich plasma therapy and botulinum toxin. There are indications that local treatment of IBSN neuroma with injections of corticosteroids may be an effective method of treatment (Clendenen *et al.,* 2015). A 2019 meta-analysis on lower leg neuroma (Morton's neuroma) identified corticosteroids as the most effective treatment. Another study of two cases of IBSN neuroma demonstrated the effectiveness of ultrasound-guided saphenous nerve block with ropivacaine 0.375% and triamcinolone 20 mg, which in one case had to be supplemented with corticosteroids (Bertra *et al.,* 2000). The results of these studies indicate the need for further research on local injection treatment of IBSN neuroma. Another promising method with initial success in a series of cases may be IBSN cryoablation with nerve detection using a non-invasive peripheral nerve stimulator (McLean *et al.,* 2020).

Conclusions

Recently, IBNS has been recognized as an often underdiagnosed cause of prolonged pain in the postoperative knee joint. Despite the lack of universally accepted gold standards for diagnostics and treatment regimens, it is high-resolution ultrasound, local anesthesia and surgical treatment that can be distinguished as the most frequently used terms in the study of this phenomenon. Neurological IBNS is mainly caused by physical damage to the nerve bundle during arthroscopy (or other surgical procedure). It should be considered in cases of patient-reported and presented analgesia, dysesthesia, pain limiting movement or allodynia. Herein, a number of methods to prevent nerve damage (limb positioning during surgery, arthroscopic portal placement, graft incision technique, nerve punches, ultrasound-guided incisions, type of incisions) to preserve and protect tissue during surgery are presented. The described methods will reduce the risk of iatrogenic IBSN injury, thanks to which patients will avoid delays in postoperative rehabilitation. In addition, it is a matter of minimizing the cost of treating complications and obtaining the expected satisfaction of patients.

There is no definitive and universal treatment regimen for IBSN neuroma in the literature, but various methods have been described that can be used with positive results. The reason for this may be the need for an individual approach to the patient, because the perception of pain is subjective, but also the fact that the problem of IBSN neuroma itself and the need for preventive actions go unnoticed.

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