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Original Scientific Paper

PATELLOFEMORAL KNEE PROSTHESIS – WHY IS IT RARELY USED?

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SUMMARY – The aim of this research is to present the initial results of patellofemoral (PF) knee joint prosthesis implantation, as well as a review of recent literature. In the ten-year time period from 2012 to 2021, we implanted 8 PF prostheses, which account for 0.7% of all implanted knee prostheses. Out of the eight patients, two were male and six were female. The average age of the patients was 55.3 (47–70) years, with the average BMI being 26.4 (22.9– 31.9) kg/m2. Four patients had the procedure done on their right leg, and the other four on their left leg. The indication for surgery was secondary osteoarthritis following dysplasia or patellar instability in 5 patients, post-traumatic osteoarthritis in one patient, grade II chondromalacia with chronic anterior knee pain in one patient, and patella baja following surgical treatment in one patient FU was 5.87 (1–10) years. The patients underwent functional testing, Womac, KSS, Tegner and VAS. We analysed 7 patients, one of whom underwent conversion to TEP after 5.5 years. Range of motion was 0/128 (120–135) deg. Through clinical and radiological follow-ups, we found that the prostheses were stable throughout the follow-up period, with a normal patellar tracking. Preoperative WOMAC score was 38.4 , postoperative score was 95.5 points ($p < 0.0001$); preoperative KKS 1 (pain) score was 34.25, postoperative score was 94 ($p < 0.0057$); KKS 2 (function) score was 53.75, postoperative score was 95 ($p < 0.0485$), preoperative Tegner activity level was 1.86, postoperative level was 3 ($p < 0.0002$); preoperative VAS score was 7.14, postoperative score was 1.86 ($p < -0.0001$). PF arthroplasty has proven to be a successful option for treating isolated patellofemoral osteoarthritis, In recent years, the design of the prosthesis have been improving, which leaves open the possibility of this method of treatment being used more frequently and the indications being expanded.

Keywords: *patellofemoral prosthesis, patellofemoral osteoarthritis, anterior knee pain, personal experiences, literature review*

Introduction

The knee joint consists of the femorotibial joint and the patellofemoral joint. The obvious question is whether it is rational to replace the entire knee joint by implanting a total endoprosthesis (TEP) in the case of the development of primary or secondary osteoarthritis of only one compartment, or to resort to the implantation of only the part of the joint that was damaged by implanting a partial prosthesis.

Unicondylar prostheses of the femorotibial joint (PEP) have a clear place in knee arthroplasty. But patellofemoral prosthesis (PF) is implanted much less frequently.

The first generation of patellofemoral prostheses was introduced in the 1970s. With the first PF prostheses, only the patellar component was replaced. Due to the contact between the hard prosthesis of the patella and the soft cartilage of the trochlea, such prostheses have not proven successful. Afterwards, patel-

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lar and femoral component replacement models were developed. The so-called inlay prostheses followed the shape of the subchondral bone and therefore depended on the anatomy of the trochlea. The prosthesis was thin, deep, with poor geometry and therefore problems with the patellar gliding path in terms of poor congruence of the articular bodies and consequent instability of the patella with patellofemoral pain[1]. Later, a second generation of patellofemoral prosthesis was developed, which required sawing the entire trochlea in the frontal plane, similar to the implantation of a total prosthesis. The so-called onlay prosthesis replaces both the cartilage and the subchondral bone. The new trochlea is more biomechanically adapted and follows the valgus of the gliding path. The lateral facet is elevated and thus ensures a stable gliding path of the patella. The design of the trochlea is more in line with the physiological relationships. It also extends further proximally and distally, so that the patella always glides along the prosthesis without articulating with the native cartilage. The patellar insert has the shape of a symmetrical or asymmetrical dome, which ensures a gliding path with a self-centering mechanism[2,3].

The advantage of a PF prosthesis is the preservation of the healthy part of the joint and better kinematics of the joint by preserving tibiofemoral articulation, the meniscus and the cruciate ligaments. It allows for less perioperative blood loss, a shorter rehabilitation period and a safer return to better physical activity, which conditions better overall functional results.

The indication for implanting a patellofemoral prosthesis is isolated primary patellofemoral osteoarthritis, or secondary osteoarthritis caused by trauma, patellofemoral dysplasia, patellar instability, chondrocalcinosis or residual anterior knee pain following chondral damage or failed surgical procedures. Contraindications include septic arthritis, systemic arthritis, ligament insufficiency, subtotal meniscectomy and neuropathic arthropathy[3]. Particular caution is required in the presence of femorotibial arthrosis and angular disorders of the knee joint.

Preoperative treatment

A clinical examination should confirm localised patellofemoral pain. If the pain also originates from the femorotibial joint, isolated PF arthroplasty is not an option. Patellar tracking and possibly instability, Q-angle, quadriceps inhibition test, fear test and patellar height are evaluated.

A standing-up X-ray image in the anteroposterior (AP) direction with a laterolateral (LL) image is essential. The femorotibial space is examined for femorotibial osteoarthritis, which should be grade I to III according to Kellgren and Lawrence. The LL image allows for the assessment of patellofemoral arthrosis, as well as the patellar height according to the Insall-Salvati ratio. This should be confirmed by an axial image of the patella at 30 and 60 degrees of flexion, which, apart from chondral damage, enables the assessment of patella and trochlea dysplasia, as well as its patellar tracking. There are 4 different types of PF osteoarthritis[4]. The first one, lateral PF osteoarthritis, is associated with dysplasia, medial PF osteoarthritis is associated with a varus knee, global PF osteoarthritis is associated with primary osteoarthritis, but also with post-traumatic osteoarthritis and RA, and the fourth type is central focal osteoarthritis which appears in those who squat and kneel frequently.

If there is a suspicion of angular deformity of the lower extremity, a long leg standing X-ray image should

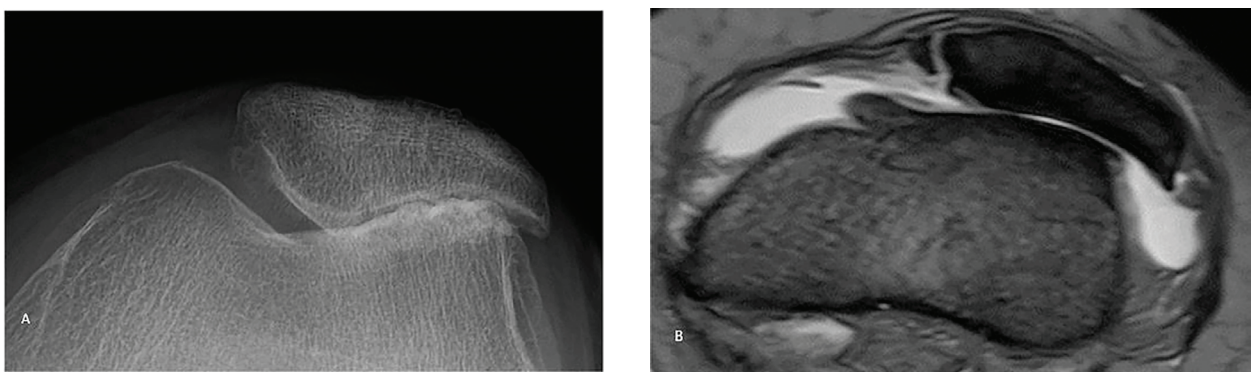

Figure 1. Radiological axial scan of the patella in 45 degrees of flexion (A), and an MR view of the patellofemoral joint in an axial section (B). Visible dysplasia of the patellofemoral joint with secondary osteoarthritis.

be done. MRI of the knee is definitely recommended in order to rule out injuries to the meniscus, ligaments or focal chondral lesions on the femorotibial side, and additionally we get an insight into the condition of the cartilage on the patellofemoral side. It is also necessary to measure the TT-TG distance[3]. (Figure 1)

Surgical technique

The surgical procedure was performed according to the manufacturer's instructions: the patient is in the supination position and a holder is recommended. A 2 cm shortened anterior approach is performed above the base of the patella to the tibial tuberosity. A parapatellar anterior approach is used to enter the joint, which is extended proximally into the quadriceps tendon. Alternatively, a midvastus approach is used. The synovial membrane proximal to the trochlea is removed to expose the anterior cortex of the femur. In order to reconstruct the trochlea, it is necessary to determine the transepicondylar line and the Whiteside line, which determines the bottom of the trochlea and thus the gliding path of the patella. With the help of special instruments, the trochlea is sawn in the frontal plane parallel to the transepicondylar line up to the height of the anterior cortex of the diaphysis. The resected part is replaced with a prosthesis, available in several sizes, that reconstructs the trochlea. It is necessary to make sure that the prosthesis does not extend beyond the edge of the resected part of the bone. It should be kept in mind that in male patients the trochlea is deeper and in female patients it is shallower, that is to say that the height of the lateral and medial facet of the patella is lower. Moreover, in females, due to the width of the pelvis, the Q-angle is larger and patella alta is more common, all of which affects the patellar tracking and can more often cause instability of the patella itself. In the case of patellar instability, the tibial tuberosity can be medialized as needed to ensure a gliding path. In the case of patella alta, the insertion of the patellar ligament can be distalized as needed, and in the case of patella baja, it can be proximalized (Figure 2). In all patients, patellar arthroplasty was performed according to the same method used for TEP implantation. The patellar polyethylene insert was medialized in order to ensure a better gliding path. Cemented femoral and patellar components were used in all cases.

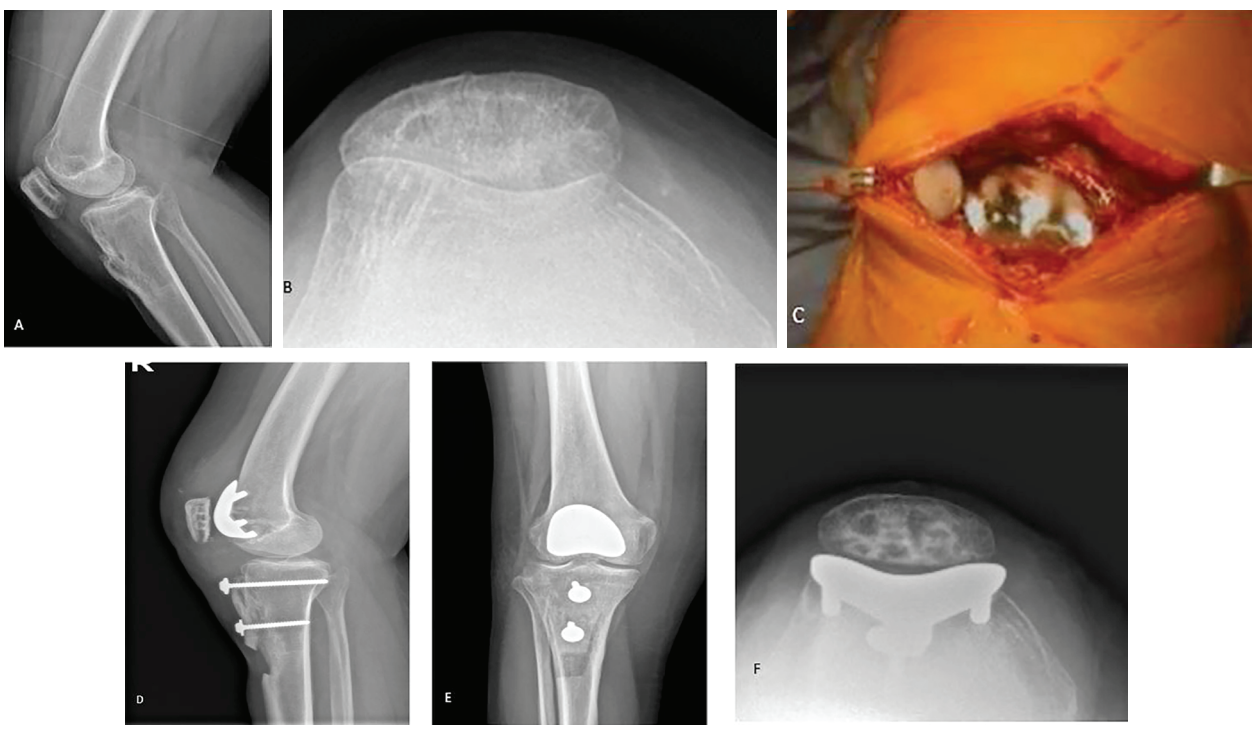

Figure 2. Patella baja following the transposition of the tibial tuberosity with chronic anterior knee pain (AB). Implanted PF prosthesis (C). Postoperative radiographic image of the implanted PF prosthesis with proximalization of the tibial tuberosity (D,E,F)

Postoperatively, partial weight-bearing of up to 20 kg when walking is allowed for the first two weeks, after which there can be a progressive increase in weight-bearing in accordance with pain intensity. Full range of motion is achieved through physical procedures within 6 weeks, when crutches are generally no longer necessary.

Material and methods

In the ten-year time period from 2012 to 2021, we implanted eight PF prostheses in two male and six female patients with the average age of 55.3 (47- 70y) years. Four left and four right knees were done. The average BMI was 26.4 (22.9–31.9) kg/m^2. In the same time period, we implanted 862 (86%) total primary knee prostheses and 133 (13%) partial unicondylar prostheses. The aforementioned eight PF prostheses account for 0.7% of all implanted knee prostheses.

The indication for surgery was secondary arthrosis following dysplasia or patellar instability in five patients, post-traumatic osteoarthritis in one patient, grade II chondromalacia with chronic anterior knee pain in one patient, and patella baja following surgical treatment of patellar instability and residual anterior knee pain in one patient. In this patient, an additional procedure was performed in terms of proximalization of the tibial tuberosity in order to ensure a physiological gliding path.

We implanted four Sigma (DePuy Synthes, Warsaw, USA) and four Gender Solutions (Zimmer Biomet, Warsaw, USA) PF prostheses. All surgical procedures were performed by one surgeon.

We carried out a retrospective analysis. The average follow up time (FU) was 5.87 (1–10) years.

The patients were continuously monitored through outpatient clinical examinations and, in the end, all patients underwent functional testing, WOMAC, KSS, Tegner and VAS.

The study was carried out upon approval of the Ethics Committee of the Institution No. 03/2022, with the consent of the subjects.

The authors exclude a potential conflict of interest in conducting this study.

Results of the study

We analysed 7 patients, given that one patient underwent conversion to total knee endoprosthesis due to progression of medial femorotibial osteoarthritis after 5.5 years. The average range of motion in the knee was 0/128 (120–135) degrees. Through clinical and radiological follow-ups, we found that the prostheses were stable throughout the follow-up period, with a normal patellar gliding path.

Preoperative WOMAC score was 38.4 and postoperative 95.5 points ($p < 0.0001$); preoperative KKS 1 (pain) score was 34.25, postoperative score was 94 ($p < 0.0057$); KKS 2 (function) score was 53.75, postoperative score was 95 ($p < 0.0485$), preoperative Tegner activity level was 1.86, postoperative level was 3 ($p < 0.0002$); preoperative VAS score was 7.14, postoperative score was 1.86 ($p < -0.0001$).

As for complications, in one patient, 5 months after the surgical procedure, we performed an arthroscopic adhesiolysis due to extension contracture of the range of motion of 0/50 degrees with good postoperative results.

Discussion

Practice shows that PF prostheses are rarely implanted, whereas unicondylar and total knee joint prostheses are implanted much more frequently. By comparing register data on prostheses in seven countries, Levis et al.[5] show that the number of PF prostheses in relation to the total number of implanted prostheses ranges from 0.066% in Finland to 0.64% in Norway. This is also evident in the case of our subjects, where it amounts to 0.7% of all implanted endoprostheses of the knee joint. The question is whether the implantation of the PF prostheses produces worse postoperative results and whether this is the reason why this surgical procedure is rarely performed. Dahm et al.[6] compare the functional results of implanting TEP knee and PF knee prostheses and prove a faster return of joint function with implanting a PF prosthesis and better functional results than with implanting a TEP. According to McAlindon et al.[7], 11% of male and 24% of female patients with symptomatic osteoarthritis have PF osteoarthritis. The question is whether to implant a PF or TEP in the case of isolated patellofemoral arthrosis. A meta-analysis by Peng et al.[8] based on 7 studies showed no differences in complications, percentage of revisions, and patient satisfaction. However, patients with a PF prosthesis have better functional results, including increased physical activity. They recommend a PF prosthesis to younger patients with greater physical demands. Then why is the patellofemoral prosthesis used this rarely?

The implant model significantly affects the result. In a prospective study of an inlay PF prosthesis follow-up in the duration of two years, Feucht et al.[9] found a significant improvement in functional results. They note that worse functional results are expected in patients with patella alta, trochlear dysplasia, or a lateralized position of the tibial tuberosity with a larger Q-angle. On the other hand, this was refuted by Imhoff et al.[10] in their prospective study that compares two groups of patients with a PF prosthesis. The first one underwent an isolated surgery and the second one underwent associated patella stabilisation surgeries due to patellofemoral and femorotibial malignancy. After a follow-up period of 2 years, both groups of patients were equally satisfied with the surgery, scored significantly better in functional tests, and showed the same speed of return to physical activities. This is consistent with our experience following the proximalization of the tibial tuberosity due to patella baja. We also believe that within the framework of PF prosthesis implantation, a normal gliding path should be achieved, if necessary, through associated surgeries.

With PF arthroplasty, the question is whether to perform arthroplasty only on the trochlea or to perform it on the patella as well. The dilemma was clarified by the results of a multi-center study conducted by Imhoff et al.[1] on 263 subjects with a follow-up period of at least 2 years. They found complications in 11% of the subjects, but in 82% of the cases, this involved patients who did not undergo patellar resurfacing. In PF arthroplasty, it is necessary to replace both the trochlea and the patella.

The question is which PF prosthesis of the second generation provides better results: an inlay or an onlay trochlear design. Feucht et al.[11], in their prospective study of two groups of patients, each consisting of 14 subjects, compared the inlay design (Hemi CAP Wave, Arthrosurface) with the onlay design (Joutney PFJ, Smith & Nephew). After a two-year follow-up period, they found significant improvement in the function and pain with both types of prostheses. A significantly lower number of femorotibial arthrosis progression was found with the inlay design. This is explained by the possibility of greater malposition of the femoral component with the onlay design. According to the account of Sergio et al.[12], in recent years, there has been an evident use of onlay prostheses of the PF joint type Avon (Stryker) and Zimmer PFJ , which have proven to be more contemporary in design.

In the case of patellofemoral and femorotibial arthritic changes, it is possible to use a combination of a PF prosthesis and a unicondylar prosthesis. In their meta-analysis of 90 papers, Thiemphont and Price[13] objectified bicomponent arthroplasty, a combination of PF and Uni prosthesis medially. They cite numerous advantages in preserving the cruciate ligaments and healthy parts of the joint, which causes better proprioception and better functional results, i.e. the patient's return to lighter sporting activities.

Among the early complications specific to this surgery, the most common is instability of the patellar glide, as well as anterior knee pain, patellofemoral "pop", and rupture of the extensor apparatus[3]. This applies in particular to patella alta, uncorrected alignment of the extensor apparatus (Q-angle) or rotational error of the femoral component.

Peripatellar pain can be caused by an excessively thick patella, which causes increased internal rotation of the tibia in flexion, which was warned against by Wandenneucker et al.[14].

Dahm et al.[6] described an increased strength in the knee extension with PF arthroplasty compared to TEP. They also noticed a more frequent occurrence of femorotibial arthrosis in patients who did not have associated patellofemoral dysplasia. On the other hand, Beckmann et al.[15] noticed a far greater number of complications in patients who had patella alta with lateralization in terms of poor functional postoperative results, and concluded that such patients should not undergo the procedure. Similar conclusions were also made by Imhof et al.[16] in their multi-center study. Beitzel et al.[17] prospectively followed two groups of patients, where one group showed no signs of patellar instability and the other one did show signs of instability. He got even better functional results in the group that showed patellar instability with additional surgical stabilizations than in the group with no instability.

Bernard et al.[18] confirm the aforementioned. They followed 153 PF prostheses in 119 patients (61% according to Insall-Salvati had patella alta) during 5 years. They found no differences in functional scores and prosthesis survival.

A higher BMI significantly affects postoperative functional results according to Imhof et al.[1]. A study carried out by Marullo et al.[19] followed two groups of patients, where 25 of them had a BMI of >30 kg/m^2 and 95 had a BMI of <30 kg/m^2. Functional scores were significantly better after surgery in both groups

of subjects, with no significant difference between the groups. Complications in adipose patients were 20%, of which 16% were due to progression of arthrosis. In the non-adipose group of patients, the complications were 4% and there was no progression of arthrosis.

We did not have patients with a higher BMI. It is likely that such patients will appear over time. In that case, worse postoperative results can be expected in accordance with previous research.

The question is whether PF arthroplasty is a temporary or a definitive solution. Laursen[20] prospectively followed 18 patients with HemiCAP patellofemoral arthroplasty. Within 6 years, 28% of them underwent conversion to TEP. The author concludes that PF arthroplasty is a temporary solution for younger people with a damaged cartilage. By analysing large registries of endoprosthesis such as the Australian Prosthetic Registry, Lewis PL et al.[21], based on the follow-up of 3251 PF prostheses, found records of 482 revisions. The main reason for revisions was the progression of arthrosis (56%), loosening (17%) and pain (12%). In 206 patients (42%), a revision of the patellar component was also performed. It was observed that new TEP revisions were needed more frequently, i.e. twice as often, compared to primary arthroplasty with TEP. Something similar was observed in the case of TEP revision of the knee after the implantation of a unicondylar prosthesis. CR and CS type prostheses were used.

Dy et al.[22] compared the complications following PF and TEP knee implantations in 28 retrospective studies. It has been proven that there are many more complications in PF arthroplasty with first generation implants. With the second generation, the percentage of complications is similar to the one in the case of TEP knee implantation. This most often involves the progression of arthrosis, which is treated by conversion to TEP of the knee. A revision of the PF prosthesis, lateral release, open or arthroscopic debridement and bone or soft tissue correction are performed less frequently to correct the extensor system.

Imhoff et al.[23] prospectively followed 34 patients with an inlay PF prosthesis for 5 years. Six patients underwent conversion to TEP and the survival rate was 83% according to Kaplan-Meyer. Functional tests were significantly better, with significantly less pain, and, subjectively, over 80% were satisfied with the surgery. No signs of femorotibial arthrosis progression were found, except in those 6 conversions, and their analysis did not show any risk factors for arthrosis progression. The same author et al.[16], in the most recent multi-center study on 263 patients who underwent the procedure according to the inlay technique with a HemiCAP prosthesis, shows similar results.

The early results of implanting a newer type of PF prosthesis are also presented by Osarumwerse et al.[24]. Functional results were significantly better, including patients with a higher BMI >30 kg/m^2. In the early follow-up period of 2 years, no complications due to the design of the prosthesis or the operative technique were observed. Revision was necessary for 4% of the subjects.

Bendixen et al.[25], in a meta-analysis of 50 articles (3 registers and 47 clinical studies), analysed the complications following the implantation of a PF prosthesis. Based on the studies and registries that analyse the results of treatment with a PF prosthesis, they collected a total of 1299 revisions. In 42% of the cases, the reason for revision was the progression of osteoarthritis, in 16% pain, in 13% aseptic loosening, and in 12% surgical error. In addition to the surgical technique, complications are significantly affected by the design of the implant. Progression of osteoarthritis can be a consequence of long survival of the PF prosthesis or, on the other hand, an incorrect indication for a PF prosthesis. It is important to define an isolated PF osteoarthritis in the indication for this type of surgery, either primary or secondary. The stair climb test is interesting: if the patient reports pain on the medial side of the knee when walking up the stairs, it is probably a PF arthrosis, and if the pain appears when going down the stairs, FT arthrosis is more likely.

Based on the aforementioned, the most common of the late complications is the progression of femorotibial osteoarthritis. In our small study, we also had a progression of femorotibial osteoarthritis, which required conversion to TEP. A less common complication was patellar instability, loosening of the prosthesis components, and wear of the polyethylene insert of the patella itself.

Revision of the PF prosthesis is usually not technically demanding. In the event of wear of the polyethylene patellar component and patellar instability, both components can be replaced. However, the conversion of PF prosthesis to TEP is most often performed, but the polyethylene insert of the patella remains if it is preserved. Generally, a primary total knee endoprosthesis of the same design or manufacturer is installed. In this way, the patellar component remains, and the

femoral component is pre-sawed based on the principle of orientation towards the anterior cortex. Further sawing of the bed is performed as usual. Generally, there is no major bone defect. In our small study, we also had a patient who underwent conversion to standard primary TEP after 5 years and 6 months.

The shortcoming of this study is certainly a small number of subjects, with a relatively satisfactory FU. However, our results are still consistent with large global meta-analyses. Please note that the number of PF prostheses in most workplaces is small. Given that there is a consensus in the literature that newer types of prostheses have a longer survival rate with good functional results, this opens up the possibility of a more frequent indication for this type of surgical treatment.

Conclusion

PF arthroplasty has proven to be a successful option for treating isolated patellofemoral arthrosis, whether primary or secondary, due to trauma or anatomical abnormalities such as dysplasia or poor patellar glide, if non-operative treatment or joint preservation surgery did not produce results. The goal of PF arthroplasty is to reduce pain and improve joint function while preserving other parts of the knee joint, and thus the proprioception and kinematics. In recent years, the design of the prosthesis and the surgical technique have been improved, so the surgical results are better, which leaves open the possibility for this method of treatment to be used more frequently and the indication area to be expanded.

Disclosure of conflict of interest

The study was carried out upon approval of the Ethics Committee of the Institution No. 03/2022, with the consent of the subjects

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Sažetak

PATELOFEMORALNA ENDOPROTEZA KOLJENA – ZAŠTO SE RIJETKO KORISTI?

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Cilj je prikazati početne rezultate ugradnje patelofemoralne (PF) proteze koljenskog zgloba, ali i pregled novije literature. U desetogodišnjem vremenskom razdoblju 2012 do 2021. godine ugradili smo 8 PF proteza, što iznosi 0.7% svih ugrađenih proteza koljena, 2M i 6 Ž, životne dobi 55.3 (47-70) god., 4 L i 4 D. BMI 26.4 (22.9 - 31.9). Indikacija za operaciju bila je sekundarna artroza nakon displazije ili instabiliteta patele kod 5 bolesnika, posttraumatski osteartritis kod jednog, kod jednog hondromalacija II st. sa kroničnom prednjom koljenskom boli, i kod jedne bolesnice patella baja nakon kirurškog liječenja. FU iznosio je 5.87 (1-10) godina. Bolesnici su testirani funkcionalnim testovima, Womac, KSS. Tegner i VAS. Analizirali smo 7 bolesnika, kod jednog je učinjena konverzija u TEP nakon 5.5. god. Opseg pokreta je 0/128 (120-135) st. Kliničkim i radiološkim kontrolama utvrdili smo stabilne proteze čitavo vrijeme praćenja, uz uredan klizni put patele. WOMAC score prijeoperacijski iznosio je 38.4, poslijeoperacijski 95.5 (p<0,0001), KKS 1 (pain) prijeoperacijski iznosio je 34.25, poslijeoperacijski 94 (p<0,0057), KKS 2 (function) 53.75, poslijeoperacijski 95 (p<0,0485), Tegner activity prijeoperacijski 1.86, poslijeoperacijski 3 (p< 0,0002), VAS prijeoperacijski 7.14, poslijeoperacijski 1.86 (p<-0,0001). PF artroplastika pokazala se kao uspješna mogućnost liječenja izolirane patelofemoralne artroze, Zadnjih godina usavršio se dizajn proteze, što ostavlja mogućnost da se ova metoda liječenja koristi češće i indikacijsko područje proširi.

Ključne riječi: *patelofemoralna proteza, patelofemoralna artroza, prednja koljenska bol, vlastita iskustva, pregled literature*