

FRESH OSTEOCHONDRAL ALLOGRAFT (FOCA) TRANSPLANTATION OF THE KNEE A RARE USED TECHNIQUE IN EUROPE WITH LONG TERM GOOD RESULTS

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AUTHOR

Pablo E. Gelber - Hospital de la Santa Creu i Sant Pau, Barcelona, Spain

SUMMARY

Background: Articular cartilage injuries of the knee frequently affect young, active populations, with localized defects occurring in approximately 20% of arthroscopic cases. While knee arthroplasty in this demographic is associated with high failure rates and low satisfaction, fresh osteochondral allograft (FOCA) transplantation offers a biological alternative for restoring joint surfaces using metabolically active chondrocytes.

Objective: This review evaluates the clinical indications, surgical methodologies, and long-term outcomes of FOCA transplantation for the treatment of localized femoral, patellar, and tibial osteochondral defects.

Key Points: FOCA is indicated for large or uncontained lesions, failed cell-based repairs, and salvage procedures. Success depends on maintaining chondrocyte viability through storage at 4°C or 37°C, with transplantation ideally occurring within 14 to 28 days of harvest. Surgical techniques include the dowel (plug) method for contained defects and the shell (resurfacing) method for extensive or asymmetric lesions. Addressing concomitant pathologies, such as axial malalignment, ligamentous instability, and meniscal deficiency, is mandatory to prevent graft failure. Long-term data indicate survival rates for femoral condyle grafts of approximately 82% at 10 years and 66% at 20 years. Outcomes for the patellofemoral joint are generally less favorable, particularly in bipolar reciprocal lesions, with 10-year survival rates reported at 78.1%.

Conclusion: FOCA transplantation is an effective biological reconstruction for large knee defects in young patients, potentially delaying prosthetic replacement. Optimal outcomes require precise patient selection, correction of joint biomechanics, and meticulous surgical execution to ensure graft incorporation and functional restoration.

KEYWORDS

Cartilage, Articular; Transplantation, Homologous; Knee Joint; Osteochondritis Dissecans; Bone Transplantation

INTRODUCTION

Injuries in the articular cartilage of the knee are frequent in young and active people [1]. It is a common finding during knee arthroscopic surgery, with a reported prevalence of up to two third of the cases. Regarding only localized cartilage defects, they can be seen in around 20% of patients [2]. In these young group of people, knee arthroplasties show low satisfaction rates and high failure rates due to accelerated loosening or wear [3, 4].

Multiple surgical options have been developed for localized articular cartilage defects, including autologous chondrocyte implantation, subchondral marrow stimulation, osteochondral autograft transplantation, and fresh osteochondral allograft (FOCA) transplantation. FOCA is an effective biologic, durable treatment option for localized femoral, patellar or tibial osteochondral defects [5]. It is performed in a single-stage technique and may be preferable to other surgical alternatives, particularly in the setting of unshouldered lesions, extensive subchondral edema, or extensive bone loss that requires restoration.

One of the main advantages of using FOCA is the presence of metabolically active chondrocytes without concurrent donor site morbidity [6]. Most soft tissue and bone allografts can be easily storage in tissue banks for long periods of time under cooling techniques. For the cartilage tissue cooling eliminates the cell viability, which is crucial for the success of transplantation. Fresh storage of the osteochondral allograft, on the other hand, preserve this cell viability. However, this presents critical limitations from a logistic point of view. Due to this limitations and other reasons, FOCA other than in USA is scarcely available worldwide. While efforts are being done in some countries to provide FOCA to surgeons, it is still only available in Spain and few others places in Europe. This review provides an overview of the indications, different techniques and outcomes of FOCA that has been performed in USA for more than 40 years now, but is surprisingly still in its babyhood around Europe and other areas of the world.

WHEN AND WHY

Indications

The goal of surgery is restoration of a joint without the need of metallic implants, symptom relief and functional improvement, with the possibility of delaying or eliminating the need for future knee arthroplasty. Because this procedure is versatile, indications for FOCA transplantation have been expanded to include complex biologic restoration of the knee joint [7-9].

Currently, FOCA is the only available biologic option for salvage procedures following failed cell-based repair (e.g. autologous chondrocyte implantation), prior osteochondral transplantation for large chondral or osteochondral defects, or failed fixation of large, deep osteochondritis dissecans (OCD) or other osteochondral lesions [10]. Table 1 summarizes the possible indications for FOCA.

- Patients between 15 and 50 years of age, who are not candidates otherwise for arthroplasty surgery.
- Localized grade III and IV chondral lesions. Kissing lesions can also be included.
- Chondral or osteochondral lesions larger than 2 cm² regardless of whether they are contained or not contained.
- Stage IV osteochondritis dissecans (OCD) or failed previous OCD fixation.
- Spontaneous osteonecrosis of the knee.
- Large posttraumatic osteochondral injuries
- Revision after failed chondral repair surgeries.

Table 1: Indications for FOCA

The FOCA procedure is highly demanding with regards to logistic, surgical technique and costs. Once transplanted, the FOCA needs a perfect condition and environment to successfully be incorporated to the host recipient to play its protective role for the knee joint. In this sense, there are some conditions that make patients to be excluded without exception (Table 2).

- BMI > 30 kg/m².
- Large degenerative lesions comprising all three knee compartments.
- Systemic inflammatory diseases, presence of infection or history of osteomyelitis in the graft recipient area and active neoplasia.
- Medical conditions that could affect the incorporation of the graft such as insulin dependent diabetes or smoking. Regarding smokers, they must stop smoking at least 1 month before surgery and for 6 months after the procedure to decrease the risk of infection and non-union [11].

Table 2. Contraindications for FOCA

Storage techniques and basic science

The two more common methods for storing allografts are fresh frozen and cryopreservation. With fresh frozen produces the loss of cellular life fails to preserve the chondral tissue [12]. Cryopreservation has also not been proven effective in maintaining cell viability in chondral tissue [13]. A third method of storage is the fresh osteochondral allograft preservation. In this technique, the graft must be harvested within 24 hours from death and stored at 4°C. The graft must be transplanted within the first 2 to 4 weeks since harvesting, depending on the method of processing. In addition, the quality and microbiological controls take an extra week. This makes the margin available for surgery to be between 1 and 3 weeks. Currently, some tissue banks have validated an alternative method of storage at 37°C to keep the FOCA viable for up to 2 months [14, 15]. The use of this technique has also some further limitations from a logistic point of view. Obtaining the appropriate graft, both in morphology and cartilage quality, is one of the major limitations of this surgical technique FOCA transplantation can replace damaged articular cartilage and subchondral bone with mature hyaline cartilage with viable chondrocytes. This technique allows to cover virtually all types of defects, restore complex surfaces and non-contained defects [16-25]. Likewise, it does not cause donor site morbidity as in autologous transplantation, while

FOCA causes a minimal immune response in the recipient without clinical relevance [26]. From the immunological point of view, it is not clear if there is an immune response that might put the graft viability at risk. In any case, there have been no report of rank immune rejection of a FOCA of the knee. Regarding the bone component, being a non-vascularized graft, osteocytes of the allograft bone component do not survive, but the bone tissue remains structurally intact and is mechanically resistant. Over time, the host bone will be replaced by the creeping substitution process [27].

HOW TO DO IT

Technical aspects

To prevent graft failure, concomitant pathology that involves the joint must be addressed during graft transplantation or with a staged procedure. As in other chondral repair procedures, axial and coronal malalignment, meniscal tissue loss or ligament instability must be carefully assessed. These factors must be evaluated and treated appropriately. In the same procedure, FOCA transplantation can be performed with a ligamentous reconstruction, meniscal transplant and/or corrective osteotomies [28].

Alignment is critical, and corrective osteotomies must be performed even in small malalignments as little as 2 degrees [29]. They can be ideally performed concomitantly in the same surgical procedure. Alternatively, the osteotomy can be done in a first stage, and the FOCA can be performed after 3 or 4 months.

There are two ways of transplanting FOCA into the host area:

- **Dowel or Plug technique**

is recommended for isolated, well-defined and easily accessible defects (Figure 1). Eventually, when the defect is asymmetric, the “Snowman or Mastercard” technique using two transplants overlapping each other can be performed (Figure 2). However, a higher revision rate has been reported with this later technique [30].

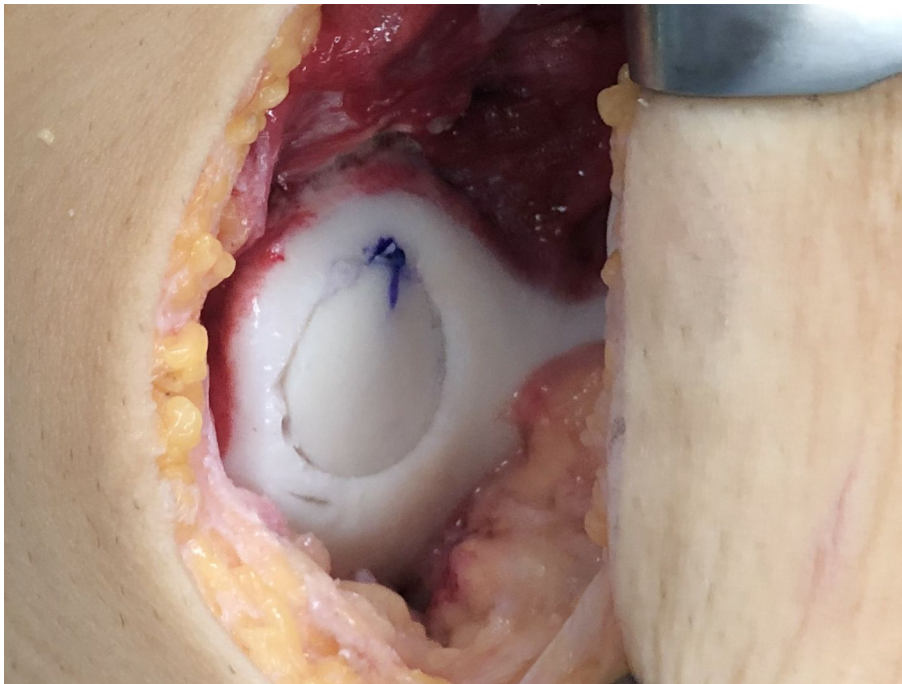


Figure 1: Right knee - Dowel technique In this case, one 24mm-diameter FOCA plug was transplanted in the lateral aspect of the trochlea.

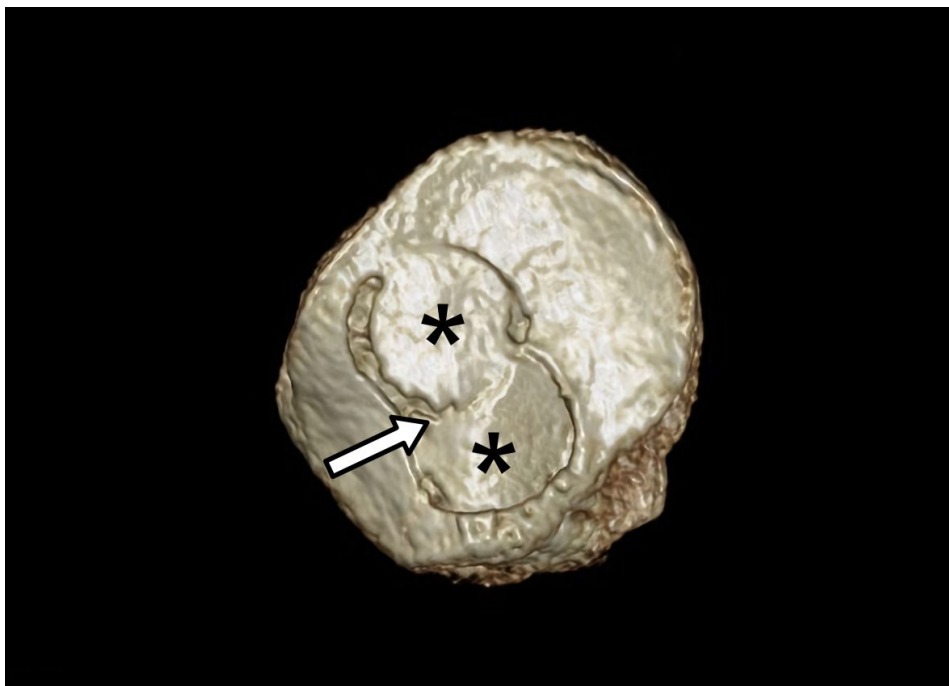


Figure 2: 3D TC scan of a right patella – “Snowman or Mastercard” technique In certain asymmetric osteochondral injuries, two plugs (*) are partially suprajacent to each other (arrow) as a valuable option.

The dowel technique involves the following general surgical steps (Figure 3):

a) Recipient area:

The appropriate sizing guide is chosen and placed on the injured zone and the drilling pin is inserted. A cannulated flat drill bit is used to prepared the cylindrical defect with the selected diameter (Figure 3a,b)

b) Graft preparation:

A coring reamer with the same diameter as used for the recipient area preparation is used to obtain the osteochondral bone plug (Figure 3c)

c) Graft placement:

The plug is introduced first with thumb pressure obtaining a pressfit fixation. A light tap can be used to fully insert the graft until it is flush with the surrounding cartilage (Figure 3d).

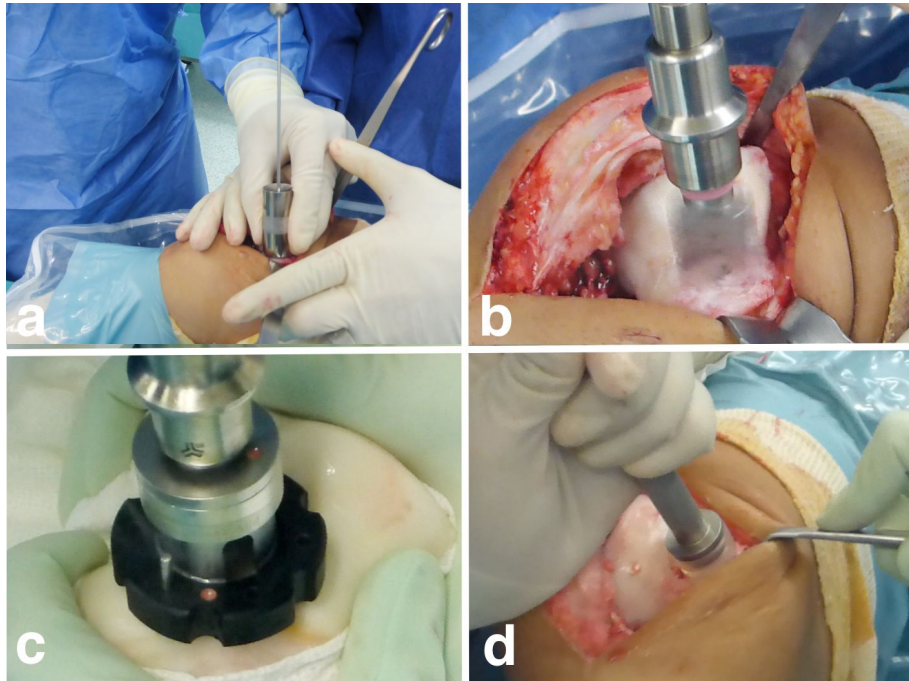


Figure 3: Dowel FOCA technique(A) Shows the selection of the appropriate sizing guide with the central pin (B) reaming the recipient area with a flat drill bit with the selected diameter (C) the graft is then prepared with its corresponding coring reamer matching the prepared defect (D) Pressfit reduction of the osteochondral plug is accomplished using thumb pressure or light tap until the surface is flush with the surrounding cartilage.

• Shell or Resurfacing technique

is recommended for large or multiple lesions in which a dowel technique is not suitable to cover the entire defect (Figure 4). This technique involves a recipient area and graft preparations that have to be tailored according to the specific location and size of the defect.

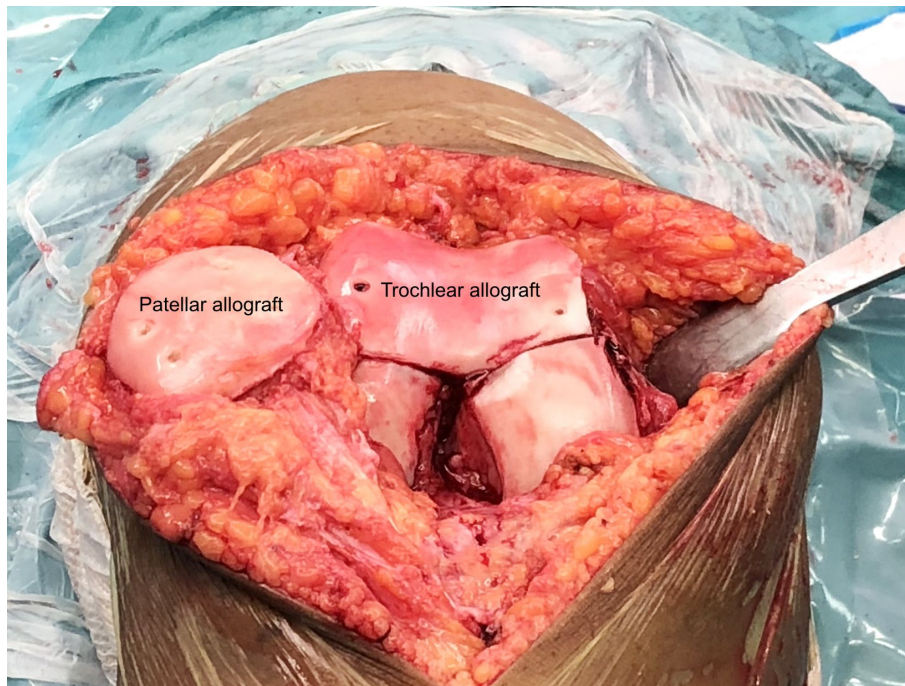


Figure 4: Right knee - Complete FOCA resurfacing of the patellofemoral joint using the shell technique is indicated when invalidating knee pain is due to severe large bipolar defects of both joint surfaces.

In all cases, it is mandatory to remove the bone marrow from the subchondral bone of the allograft as much as possible to decrease any risk of immune rejection. This is accomplished with high pressure pulsatile irrigation with at least 6 liters of normal saline. This step is performed on the bone side of each allograft before implantation in the recipient area.

PATELLOFEMORAL TRANSPLANTATIONS

When a FOCA in the patellofemoral compartment is planned, maltracking should be ruled out, since it may be the underlying cause of early allograft failure. In these cases, FOCA should be combined with soft tissue techniques such as lateral retinal release or lengthening and reconstruction of the medial patellofemoral ligament. Tibial tuberosity transfers are also indicated to correct abnormal patellar height and/or anteromedialization in case of TT-TG distance greater than 15mm [32]. It has been reported that up to 40% of FOCA for the patellofemoral joint are combined with additional surgeries to improve patella tracking [39].

For the patellofemoral joint the plug technique is always preferred (Figure 5). However, in large patellofemoral injuries involving 2/3 of the patella, broad lesions of a dysplastic trochlea or in locations of difficult access, the shell technique is mandatory. The shell technique for the patella is identical to that used in prosthetic surgery when a patellar implant is used for replacement. After measuring the patellar surface and thickness, a parallel osteotomy is made using a patellar guide from a knee replacement instrument set. To minimize the risk of fracture, a residual thickness between 12 and 15 mm should be maintained [8]. Similarly, parapatellar denervation is performed with electrocautery to reduce the risk of anterior knee pain [40].



Figure 5: Left patella - plug technique The plug technique is used whenever possible and is also the preferred technique used in the patella.

Bipolar chondral lesions of the patella and trochlea may be considered a relative contraindication due to the limited success of clinical outcomes and the considerable percentage of failures [37]. This is particularly true when they are compared with isolated Dowell technique transplantation performed in the femoral condyles [38]. The direct relationship between allograft size and graft failure has also been demonstrated for the patellofemoral joint [33]. Then, FOCA procedure in large bipolar patellofemoral injuries have to be done only when an invalidating knee pain makes no other choice reasonable (Figure 4 and 6) [7].

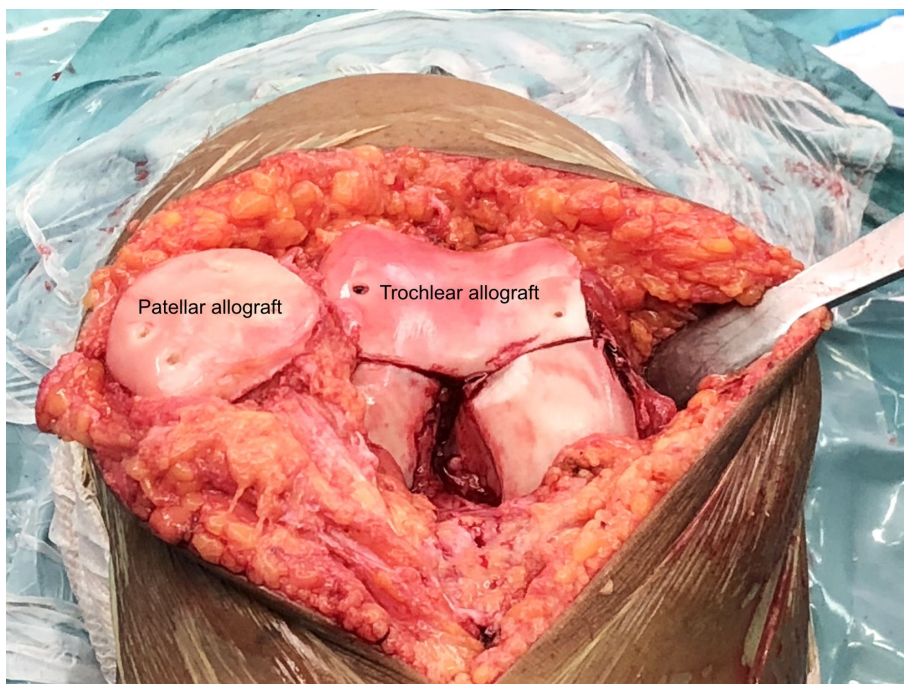


Figure 4: Right knee - Complete FOCA resurfacing of the patellofemoral joint using the shell technique is indicated when invalidating knee pain is due to severe large bipolar defects of both joint surfaces.

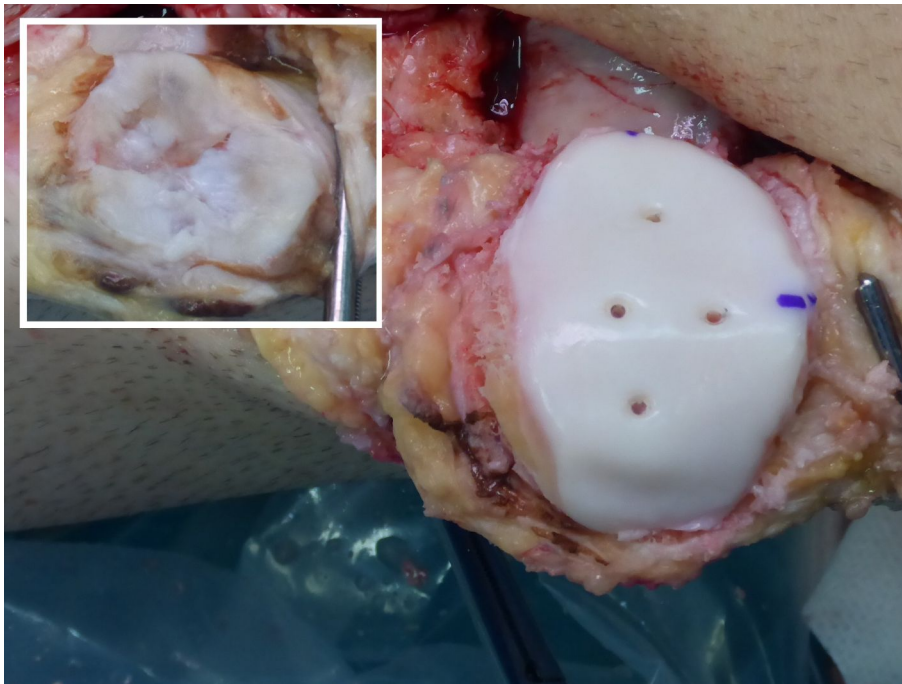


Figure 6: Right knee – patella with shell technique. In large defects, more frequently in the patella (upper left), the shell technique is preferably performed.

Chondral or osteochondral defects in the patellofemoral joint have shown less favourable outcomes compared to other areas of the knee. Pain from the patellofemoral joint is usually multifactorial, and this makes the decision-making process more challenging [31]. There are only case series reporting on the use of large FOCA of the patellofemoral joint [32-35]. However, this is a common finding for any chondral procedure of the patellofemoral joint. In this sense, recent studies have shown very consistent long-term results of FOCA, which are comparable or even better to other chondral repair procedures. Gracitelli et al. [32] reported a survival rate of 78.1% at 10 years and 55.8% at 15 years. For isolated trochlear defects, Cameron et al. [36] showed even higher survival rate of 100% at 5 years and 91.7% at 10 years. These results should encourage the use of FOCA for the patellofemoral joint also.

TIBIOFEMORAL TRANSPLANTATIONS

Similarly, to other areas of the knee, the plug technique should be chosen whenever possible. Conversely, in cases of large and uncontained femoral condyle injuries, the shell technique has to be performed (Figure 7). As commented before, alignment is a key factor for a favourable outcome and survival rate of the transplanted allograft [29].

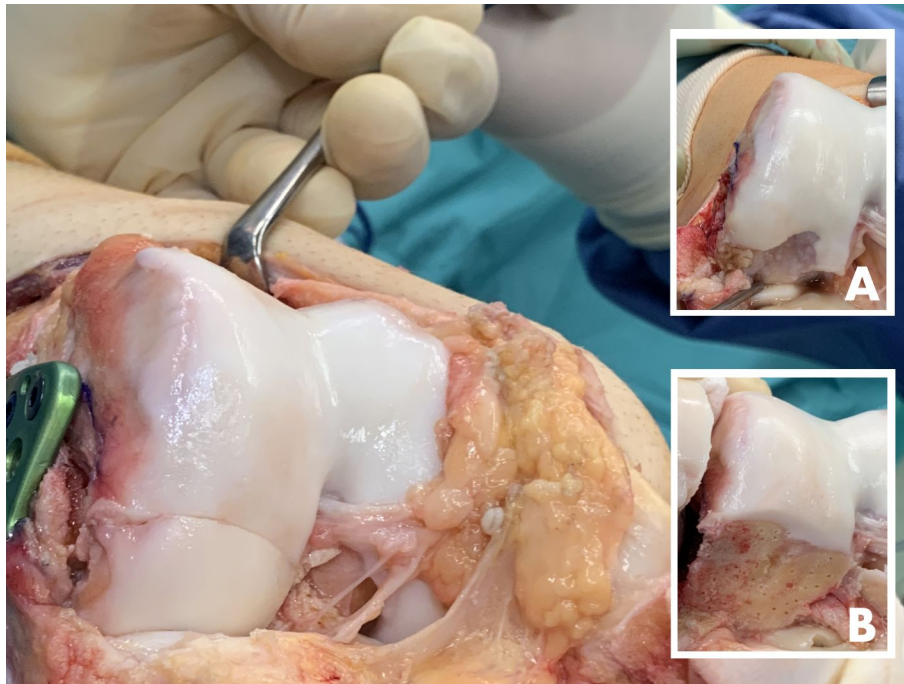


Figure 7: Right knee - large defect of condyle(A) Case with large uncontained defect of femoral condyle, (B) host preparation to receive the allograft and finally a large FOCA in shell technique in place (large picture).

Although no randomized controlled trials have been reported with the use of FOCA transplantation, several studies have reported short, mid and long term follow up data. Most of them have reported outcomes in the femoral condyles. For this indication FOCA shows high survival rates with good functional results. In fact, patients are expected to restore their pre-injury activity in up to 80% of the cases [41-43].

One of the largest series reported 129 cases of FOCA procedures in the femoral condyles, showing a survival of 82% at 10 years, 74% at 15 years and 66% at 20 years [23]. Factors leading to graft failure included low activity patients, age older than 30 years, BMI > 35 and knees with 2 or more previous surgeries [44]. Regarding the series with longest follow-up with mean 21.8 years, a survival of 91% at 10 years, 84% at 15 years, 69% at 20 years and an estimated 59% at 25 was reported [45]. This series included highly active patients only which were younger than 40 years old.

Some studies have been published regarding FOCA to replace large osteochondral lesions of the tibial plateau, a more infrequent condition that also required a more demanding surgical technique [9].

The dowel technique for tibia plateau involves following general surgical steps (Figure 8):

a) Bed preparation

A vertical bone cut is performed in the center of the corresponding tibial spine. The horizontal osteotomy is performed with a minimum cut to obtain a flat surface with healthy bleeding cancellous bone (Figure 8a)

b) Graft preparation

It is performed according to the dimensions previously measured in the recipient area. This will be a delicate step and it is always advisable to calculate for some oversizing. This oversizing can be corrected during the graft placement. (Figure 8) Finally the graft is placed in the defect and visually observed and checked under fluoroscopic control

c) Graft fixation

Ideally achieved with 2 headless titanium compression screws with a variable threaded pitch (Acutrak Standard, Acumed, Oregon), which provides strong compression. Alternatively, 4mm cancellous screws can be used (Figure 8d).

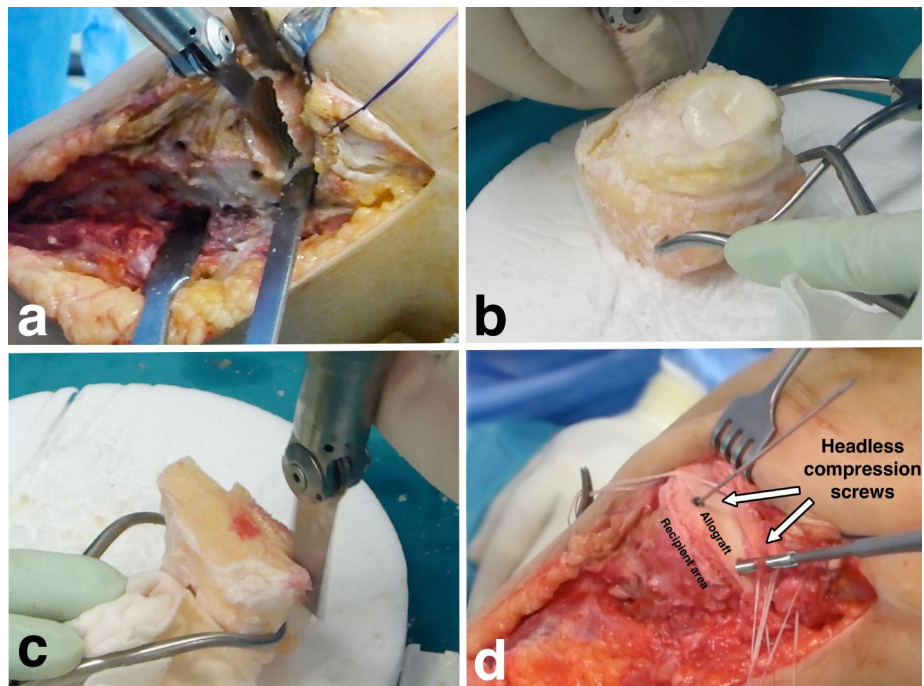


Figure 8. Left knee - lateral tibial plateau transplantation(A) shows the horizontal cut of the tibia plateau with a minimum cut to obtain a flat, bleeding bone from the injured tibial plateau; (B & C) Graft preparation done accordingly to the prepared and trimmed defect; (D) Fixation of the osteochondral graft with two titanium headless compression screws (Acutrak Standard, Acumed).

In most of the cases, the FOCA procedures were performed after tibial plateau fractures with posttraumatic chondral lesions. Shasha et al. [46], with a mean follow-up of 12 years, obtained a survival rate of 80% at 10 years and 65% at 15 years. Comparable results were observed in the Gross et al. study [22] but one third of the patients needed total knee arthroplasties after 10 years from the index procedure.

CONCLUSION

FOCA transplantation is a useful procedure for large osteochondral defects of the knee in young and active patients to delay artificial prosthetic joint replacement. Proper patient selection, accepting contraindications as well as evaluation and reducing risk factors for early failures (malalignment, ligamentous insufficiency and meniscal tissue loss) are essential to ensure graft survival and good clinical outcomes. FOCA for femoral defects have excellent results at medium and long term follow up. Slightly worse outcomes can be expected for the patellofemoral joint, and more specifically for bipolar osteochondral injuries.

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