Polymethylmethacrylate Cement Augmented Fixation of Implants

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The paper presents our results with polymethylmethacrylate cement augmentation osteosynthesis around the knee joint and to discuss the advantages and complications encountered. We presented the benefits and limitations of cement augmented fixation constructs around the knee because of the lack of such studies that focus on this particular anatomical location. We consider that the cases described can contribute to a greater understanding when searching for solutions targeted on the knee defects. In conclusion, we find polymethylmethacrylate cement augmentation of implants to provide excellent fixation around the knee both for tumoral resections as well as for managing complex trauma cases.

Keywords: polymethylmethacrylate spacers, osteosynthesis, knee joint

The most common solution for large bone defects around the knee joint from septic nonunions or significant tumoral resections without direct articular involvement involves filling with polymethylmethacrylate cement. This is a versatile and inexpensive substance mostly used in orthopedics for cementing total joint replacements. For the lower limb, the knee is the only articulation where cemented arthroplasty is the current golden standard, whereas the hip and ankle have proved longer survival with uncemented designs. In addition it is used as dispenser vehicle and preservation of soft tissue volume in septic revision. Another successful solution where PMMA has proved reliable is vertebral augmentation [1].

The knee joint is the largest synovial articulation of the body. In is required to withstand high forces during daily activities. Whenever large bony defects are present, these pose double challenges for reconstruction. The first is represented by mechanical strength of the construct and the second by the need to restore normal alignment of the lower limb. With cyclic loading, outliers of more than 3 degrees comparative to contralateral may lead to unbalanced stress distribution and early failure. Apart from degenerative disease this situation is encountered mainly in metaphyseal bone defects of the distal femur and proximal tibia caused by septic malunions and borderline tumoral malignant resections. These situations are encountered especially in relatively young and active adults, for which above the knee amputations and revision arthroplasty would present unacceptable treatment options. Such aggressive therapeutical approaches might lead to severe functional and emotional limitations.

Even in our knee surgery center we encounter such cases somewhat sparsely. Nevertheless, whenever this is the case, the therapeutic options are limited and pose great difficulty on both surgeon and subject. On this topic the literature is scarce, with most studies limited to case series. There is even less data focusing this topic on the knee. With such prerogatives it is therefore expected not to have yet a consensus based on clinical evidence.

We therefore aimed to present our results with polymethylmethacrylate cement augmentation osteosynthesis around the knee joint and to discuss the advantages and complications encountered.

Experimental part

Material and method

Over a period of 7 years we identified 5 cases that were operated in our service and met the inclusion criteria: augmented cement internal fixation around the knee.

There were three cases of trauma that resulted in distal femur fractures. One case had a supracondylar fracture that was surgically treated and developed infection. After implant removal (DCS), debridement and external fixation the local sepsis subsided. Open reduction and internal fixation was performed after 3 months and the bone defects were filled with calcium phosphate cement proximal and polymethylmethacrylate around the distal screw and stabilized with a longer titanium DCS (fig.1). The subject returned after 6 years with pseudarthrosis and degradation of the construct (fig.2 to 4). Intraoperatively we found the calcium phosphate cement degraded whereas the PMMA maintained mechanical integrity despite the construct degradation. The titanium implant had produced some signs of metallosis that was concluded to be caused by neglected late presentation [2]. The subject was stabilized with external fixation with secondary planned bone grafting.

Another case had a complex knee crush which required reconstruction of the popliteal artery. The open condylar fracture was stabilized with external fixation and reconstructed in a second surgery. There was significant bone loss that was filled with calcium phosphate cement as well as polymethylmethacrylate and stabilized using a locked angle plate. The third case was an open supra and intercondylar fracture that developed infection. After debridement the condylar defect was packed with calcium cement and stabilized using locked angle plate.

The others were two cases of giant cell tumors: one of the lateral femoral condyle and one of the medial tibial plateau (fig.5 to 8). Both resulted in uncontained defects. One is planned for secondary conversion to a tumoral prosthesis. The choice of polymethylmethacrylate (PMMA) filling was based on favorable outcomes in the literature. It is also inexpensive, simple to apply and with low risks. This can postpone the need for invasive prosthetic implants. With regard to blade plate augmentation, the choices were based on availability of the implant, good stability of the construct and relatively ease of insertion.

For contained defects of the lateral condyle of the femur, studies have showed that simple pin augmentation after

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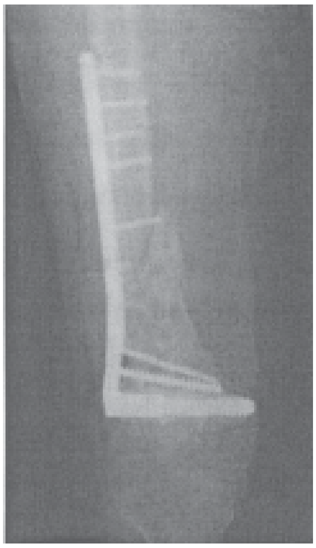

Fig.1 AP x-ray after the cemented fixation of a cured septic nonunion of the distal femur: the proximal part of the defect has been augmented with a modern osteoinductive calcium cement paste whereas the distal void has been cemented using polymethylmethacrylate. Limb alignment is preserved despite the large bone defect in the supracondylar region.

Fig.2 AP x-ray at 6 years follow-up: the bony defect did dot heal and late material failure can be observed on the diaphysis; the cemented (PMMA) distal screw has held in place. The subject has marked various deviation and is unable to bare weight

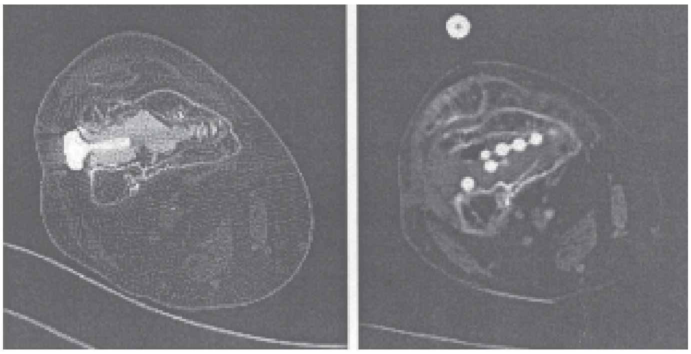

Fig.3, 4. Axial CT of the same case presented above at the level of the PMMA cemented distal screw before and after (fig.4) thorough debridement and preparation for bone grafting. The large void that resulted after cement removal has been temporarily filled with antibiotic PMMA beads and stabilized with bridging external fixation. The resultant cortical bone envelope was to precarious to attempt internal fixation by locked plating

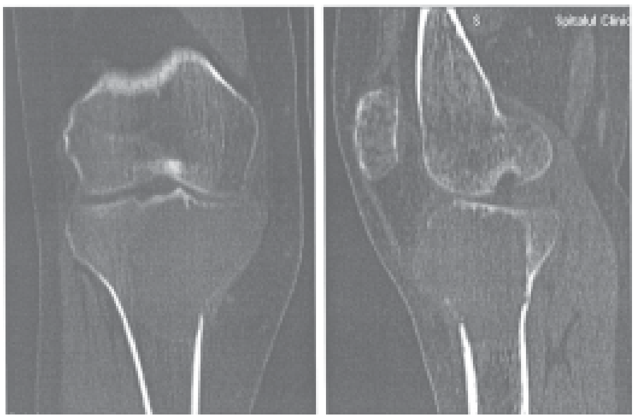

Fig.5,6. Coronal and saggital (fig.8) CT view of a young female subject with large giant cell tumor of the proximal tibia. The bone defect includes the whole medial tibial condyle and much of the lateral too and extends proximal up to the articular cartilage

cemented giant cell tumor defects does not lead to improved stability [3]. Further research has also showed that locked plates added to polymethyl-methacrylate packing of these voids leads to constructs that fail to higher mechanical loads compared to pins or screws augmentation. In addition, plating failed in a pattern without articular fracture [4].

Results and discussions

The giant cell tumor cases had the best results (table 1). For the trauma subjects the outcomes were determined by associated factors. At final follow-up all cases were ambulating using assistive devices (cane or crutches). The polymethylmethacrylate maintained its mechanical integrity despite construct failure.

There is currently a general reluctance against amputation and in favor of salvage procedures in subjects with severe trauma of the extremities. This is mainly related to subject perception of the radical treatment. Even if multiple surgeries will be required and there is no guarantee for a late amputation, subjects will prefer to try. Bosse et al have showed that the Sickness Impact Profile between the amputation and reconstruction groups was comparable at two years and recommend for subjects at high risk for amputation to be advised as such [6].

One topic that has been purposely excluded from our material was the use of polymethylmethacrylate in filling defects during revision total knee replacements. This was determined by the high number of such cases and relatively standardized treatment in the literature: up to one centimeter can be successfully packed with PMMA augmented with screws [7]. When the revisions are infected the most used treatment protocol is a two staged procedure involving: removal of the implant and inserting an antibiotic impregnated polymethyl-methacrylate

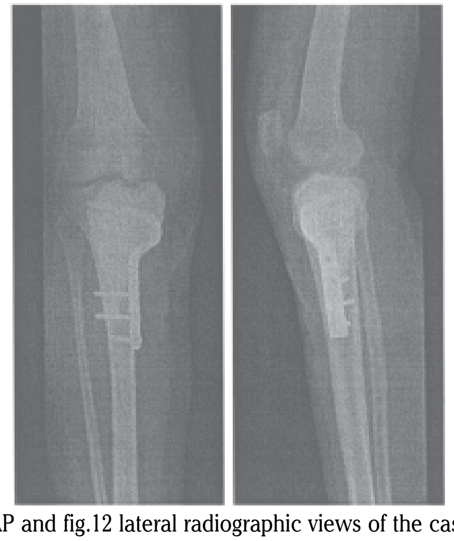

Fig.7, 8. AP and fig.12 lateral radiographic views of the case above showing solid fixation and complete cement filling with preservation of a normal lower limb alignment

cement spacer to maintain the capsule volume followed in a second procedure by insertion of a revision implant [8]. With regard to periprosthetic femoral fractures in elderly with severely osteoporosis retrograde intra-medullary cement augmented nailing has been proposed. This reduces the operative stress on the patient and stabilizes the fracture comparable to a long stemmed revision implant [9].

	Age	Gender	Cause	Level	Construct	Follow-up	ROM	Weight-bearing	Reintervention	Secondary bone grafting
1	26	Female	Giant cell tumor	Proximal tibia	Blade plate + PMMA	2 years	110	Partial	No	No
2	46	Male	Giant cell tumor	Distal femur	Blade plate + PMMA	5 years	100	Partial	Yes	No
3	51	Male	Trauma	Distal femur	DCS + PMMA, cement	6 years	100	Partial	Yes	Yes
4	48	Male	Trauma	Distal femur	Angle stable plate + cement	1 year	40	Partial	No	No
5	42	Male	Trauma	Distal femur	Angle stable plate + cement	2 years	100	Partial	Yes	No

Table 1
SYNTHETIC DATA OF THE CASES AND FINAL FOLLOW-UP OUTCOME

Fixation in osteoporotic bones can be very poor. A study on proximal humerus fractures showed superior failure under cyclic loading when PMMA-cement was used to augment the implants. Furthermore, the improvement of screw fixation is increasing with decreasing bone mineral density [10]. A biomechanical study for reducing cut-out in proximal femoral fractures tested conventional hip screws against polymethylmethacrylate augmented. Under physiological cyclic loading the cement augmented constructs proved superior [11]. Another approach was made by adapting a standard hip implant for polymethyl-methacrylate fixation. A multicenter study used it in pertrochanteric fractures in octogenarians and found no complications until consolidation [12]. An interesting approach was a compilation for extraction torque and pull-out load of femoral neck fracture with and without cement augmentation fixation. The polymethyl-methacrylate (PMMA) proved superior to both calcium phosphate cement and conventional technique [13].

In a review Curtis et al recommend an interdisciplinary approach for fracture treatment of subjects with osteoporosis. They consider adapted anchoring, techniques; improved load distribution and augmentation using bone cements alone cannot suffice [14].

As depicted above, the management of bone defects of the extremities poses great challenges. Subjects prefer limb salvage procedures even when facing delayed amputations. Fixation in insufficient poor quality bone requires a combination of implants and fillers. In this augmented constructs there are still no ideal materials to substitute the missing bone. Nevertheless, polymethyl-methacrylate cement proves to be the most validated, versatile and safe.

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Manuscript received: 28.05.2103