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**ORIGINAL ARTICLE / ARAŞTIRMA YAZISI** Orthopedics / Ortopedi

# Cortical Window Reconstruction With Cement Augmented Screw Fixation After Intralesional Curettage Of Low-Grade Chondrosarcomas: A Simple Method With Clinical Results

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**ABSTRACT**

**Purpose:** Intralesional curettage with a local adjuvant is a reliable surgical method in the treatment of low-grade chondrosarcomas (LGC). In order to maintain stability, some authors recommend osteosynthesis following intralesional treatment. However, larger osteosynthesis materials may increase complications as well as disturbing postoperative MRI evaluation. In this study, we describe a simple method of cortical window reconstruction with cement-augmented screw fixation.

**Methods:** 22 patients with LGC were enrolled in this retrospective study who underwent surgical intervention between 2011-2021. All patients were treated in the same manner by intralesional curettage, cement augmentation and fixation with titanium screws embedded in the cement. The clinical outcome was assessed, using the MSTS Score.

**Results:** The mean age at diagnosis was 44,5 and the mean follow up duration was 56,2 months. The mean long dimension of the cortical window was 4,8 cm for reconstructions with one screw and 6,2 cm for reconstructions with two screws. All of the patients showed excellent clinical outcomes with a mean MSTS score percentage of 91,3. We did not encounter any major complications postoperatively. On MRI evaluations, the image distortion due to thin titanium screw was minimal and cement bone interface was clearly visible without any disturbance.

**Conclusion:** The convenient use of cement-augmented screw fixation may be a good tool for the reconstruction of cortical window in the treatment of intramedullary tumours of long bones and give a potential chance of obtaining better MRI images without any disturbances postoperatively.

**Keywords:** Low grade chondrosarcomas, cement augmented screw fixation, intralesional curettage and cementation

**Düşük Gradlı Kondrosarkomların İntralezyonel Küretajından Sonra Kortikal Pencerenin Çimento Destekli Vida İle Rekonstrüksiyonu: Basit Bir Yöntem Ve Klinik Sonuçları**

**ÖZET**

**Amaç:** Lokal bir adjuvan ile intralezyonel küretaj, düşük dereceli kondrosarkomların (LGC) tedavisinde güvenilir bir cerrahi yöntemdir. Bazı yazarlar stabiliteyi korumak için intralezyonel tedaviyi takiben osteosentez önermektedir. Ancak büyük osteosentez materyalleri komplikasyonları arttırabileceği gibi postoperatif MRG değerlendirmesini de rahatsız edebilir. Bu çalışmanın amacı LGC tedavisinde uygulanan intralezyonel küretaj cerrahisi sonrasında kortikal pencerenin çimento ile güçlendirilmiş vida fiksasyonu ile basit bir şekilde rekonstrüksiyonu yöntemini açıklamak ve sonuçlarımızı paylaşmaktır.

**Method:** Bu retrospektif çalışmaya 2011-2021 yılları arasında cerrahi girişim uygulanan 22 LGC'li hasta alındı. Tüm hastalar aynı şekilde lezyon içi küretaj, sement augmentasyonu ve sement içerisine gömülü titanyum vidalarla fiksasyon ile tedavi edildi. Klinik sonuç, MSTS Skoru kullanılarak değerlendirildi.

**Bulgular:** Tanı sırasındaki ortalama yaş 44,5, ortalama takip süresi 56,2 ay idi. Kortikal pencerenin ortalama uzun boyutu tek vida ile yapılan rekonstrüksiyonlarda 4,8 cm, iki vidalı rekonstrüksiyonlarda 6,2 cm idi. Hastaların tümü, tedavi sonrasında ortalama MSTS skor yüzdesi 91,3 ile mükemmel klinik sonuçlar gösterdi. Ameliyat sonrası önemli bir komplikasyonla karşılaşmadık. MRI değerlendirmelerinde, ince titanyum vidaya bağlı görüntü bozulması minimum düzeydeydi ve çimento kemik ara yüzü herhangi bir bozulma olmadan net bir şekilde görülebiliyordu.

**Sonuç:** Çimento destekli vida fiksasyonunun uygun kullanımı, uzun kemiklerin intramedüller tümörlerinin tedavisinde kortikal pencerenin rekonstrüksiyonu için iyi bir araç olabilir ve postoperatif herhangi bir rahatsızlık olmadan daha iyi MRG görüntüleri elde etme şansı verebilir.

**Anahtar Kelimeler:** Düşük gradlı kondrosarkomlar, çimento destekli vida fiksasyonu, lezyon içi küretaj ve sementasyon

Chondrosarcomas are one of the most common primary malignant bone tumours with variable survival rates and clinical outcomes (1). They are resistant to chemotherapy and irradiation in most cases, therefore surgery is the preferred treatment method (2). High-grade chondrosarcomas are aggressive tumours with an increased risk of metastasis and they are generally treated with wide excision (3). However, there has been a debate about the surgical treatment method for low-grade chondrosarcomas (LGC), since they are less aggressive and rarely metastasize (4-6). Intralesional treatment with or without a local adjuvant therapy is a widely preferred surgical method with a low rate of complications and recurrence (5-11). Although there are different types of local adjuvants, polymethylmethacrylate (PMMA) bone cement is one of the most common local adjuvants used after intralesional curettage (1, 8). PMMA is also useful in providing stability for screw fixations, especially in osteopenic or osteoporotic bones of spinal surgeries (12-14).

Meticulous excision of tumour content requires sufficient visualization of the tumour mass inside the bone. The necessity and type of internal fixation after curettage are controversial in the literature. While some authors believe that internal fixation should be considered in order to avoid pathological fracture risk, others found no difference between an additional osteosynthesis and the lack of it. Besides, there have recently been a number of reports related to the disadvantages of internal fixation with plate and screws (8, 10, 11).

Histopathological diagnosis of LGC poses yet another dilemma. The distinction between benign cartilaginous tumours and LGC has always been a concern for musculoskeletal histopathologists (7). For this reason, the diagnosis is primarily based on the combination of clinical, radiological and histological features. Radiological evaluation in the postoperative period is as important as it is for the diagnosis. Magnetic resonance imaging (MRI) is mandatory for the detection of local recurrences postoperatively. Even though there are modern softwares available, it is generally accepted that internal fixation devices may cause problems with the interpretation of MRI due to distortion (15, 16). Reconstruction of the cortical window with thin titanium screws embedded in the bone cement mass might be a solution for this problem.

In our study, we described a simple method of cortical window reconstruction with cement augmented screw fixation after intralesional curettage of LGC in the long bones and we aimed to investigate the results and complications of this technique.

## MATERIAL AND METHODS

We retrospectively evaluated 22 patients (10 male, 12 female) who underwent surgical intervention with intralesional curettage, bone cement augmentation and fixation of cortical window with screws embedded in the cement (Table 1). All patients were referred to our institution's musculoskeletal oncology department between the years 2011-2021 and diagnosed with low-grade chondrosarcomas with the approval of our institution's tumour council, consisting of orthopaedic surgeons, histopathologists, radiologists and medical oncologists. Patients with suspicion of high-grade chondrosarcomas and who had open biopsies or surgeries prior to surgical intervention were excluded. We also excluded patients with local recurrence or metastasis prior to the surgery and tumours located in the axial skeleton.

Pain was the most common presenting symptom (68%). All patients had preoperative AP and lateral radiographs, computed tomography (CT) of the chest, radionuclide bone scintigraphy and gadolinium-enhanced MRI of the lesion (Figure 1 and 2). The exact localization and dimension of the lesions were evaluated on preoperative MRIs and marked on the patients with a surgical skin marker prior to surgery, according to the distance between the lesion and anatomical landmarks (patella for the femur, acromion for the humerus, tibial tuberosity for the tibia and Lister's tubercle for the radius). The localizations were confirmed preoperatively under the fluoroscopic view. All surgeries were performed by the same senior orthopedic surgeon who had been a specialist in musculoskeletal oncology for many years. Under general anesthesia, skin incisions were made in accordance with the center of the tumour. After exposing soft tissues, small drill-holes were made on the cortex and combined with an osteotome to complete the rectangle-shaped cortical window. The dimensions of the cortical window were decided according to the preoperative imaging, being either equal to the size of the lesion in most cases, or having a sufficient visualization of the tumoural mass in the remaining ones. All patients had intraoperative frozen-section biopsies, all of which were identified as low-grade cartilaginous tumours. After biopsy, intralesional curettage was performed through the window and microscopic residual tumoural tissues were debrided with high speed burr both intramedullarily and on the inner layer of cortical window. Intralesional curettage was ended with high pressure lavaging of the intramedullary region with saline. One or two micro (2,5 mm), headless, self-tapping and self-drilling, cannulated and fully-threaded compression screws (Acutruck®, Acumed, Oregon, USA) according to the length of the cortical window were used after drilling. Meanwhile, a polymethylmethacrylate (PMMA) bone cement (Versabond®, Smith & Nephew, UK) was prepared and the tumour cavity was filled with the cement. The cortical window with titanium screw was then embedded on the cement, anchoring the screw into the cement mass (Figure 3). Special attention was given to the continuity of the cortex on at least three host window edges. The procedure was finalized after irrigation and bleeding control. The tumoural tissues obtained from the cavity were sent to the histology department for the permanent diagnosis. All specimens were evaluated by the same histopathologist who had nearly 20 years of experience in musculoskeletal histopathology. Specimens were evaluated and staged according to the Enneking MSTS staging system (17).

Immediate range of motion exercises began in all patients on the second postoperative day. Patients who were operated for the lower extremity were allowed for partial weight-bearing with crutches for 3 to 4 weeks and patients who were operated for the upper extremity used either a sling (humerus patients) or a static wrist splint (distal radius patient) for 3 weeks.

All patients were followed with 3-monthly plain radiographs and 6-monthly MRIs during the postoperative first year and 6-monthly radiographs and MRIs during the postoperative second year (Figure 4 and 5). After two years, the patients were examined once a year with radiographs and MRIs until the final follow-up. The clinical outcome was assessed at every examination, using the Musculoskeletal Tumour Society (MSTS) scoring system (18). Local or systemic complications such as infection, loss in the range of motion, pathologic fracture, local recurrence or metastasis were recorded.

Table 1. Summary of patient data.

| Case | Sex and Age, y | Side | Location | Follow-up Duration, mo | Number of screws embedded | MSTS | Oncologic |
|---|---|---|---|---|---|---|---|
| 1 | M, 62 | L | Proximal humerus | 84 | 1 | 26 | A |
| 2 | F, 55 | L | Distal femur | 66 | 1 | 29 | A |
| 3 | F, 56 | R | Proximal humerus | 78 | 1 | 28 | A |
| 4 | M, 44 | R | Distal femur | 69 | 1 | 30 | A |
| 5 | F, 48 | L | Femur diaphysis | 62 | 1 | 30 | A |
| 6 | F, 45 | L | Humerus diaphysis | 64 | 2 | 23 | A |
| 7 | F, 54 | R | Distal femur | 42 | 1 | 27 | A |
| 8 | M, 24 | R | Distal radius | 40 | 1 | 27 | A |
| 9 | F, 45 | R | Humerus diaphysis | 31 | 1 | 28 | A |
| 10 | M, 34 | L | Tibia diaphysis | 27 | 1 | 28 | A |
| 11 | F, 39 | L | Femur diaphysis | 38 | 2 | 29 | A |
| 12 | F, 46 | R | Proximal humerus | 64 | 1 | 29 | A |
| 13 | F, 38 | R | Tibia diaphysis | 60 | 1 | 27 | A |
| 14 | M, 52 | L | Proximal humerus | 66 | 1 | 28 | A |
| 15 | M, 39 | R | Distal femur | 48 | 1 | 28 | A |
| 16 | M, 40 | L | Distal femur | 102 | 1 | 24 | A |
| 17 | M, 43 | R | Distal femur | 40 | 2 | 27 | A |
| 18 | F, 34 | L | Distal femur | 44 | 1 | 26 | A |
| 19 | F, 40 | L | Femur diaphysis | 42 | 2 | 28 | A |
| 20 | F, 44 | L | Humerus diaphysis | 60 | 2 | 26 | A |
| 21 | M, 50 | R | Distal femur | 56 | 2 | 26 | A |
| 22 | M, 47 | R | Humerus diaphysis | 54 | 2 | 29 | A |

**y: year; mo: month; MSTS: Musculoskeletal Tumor Society Scoring System; M: male; F: female; L: left; R: right; A: alive and free of disease*

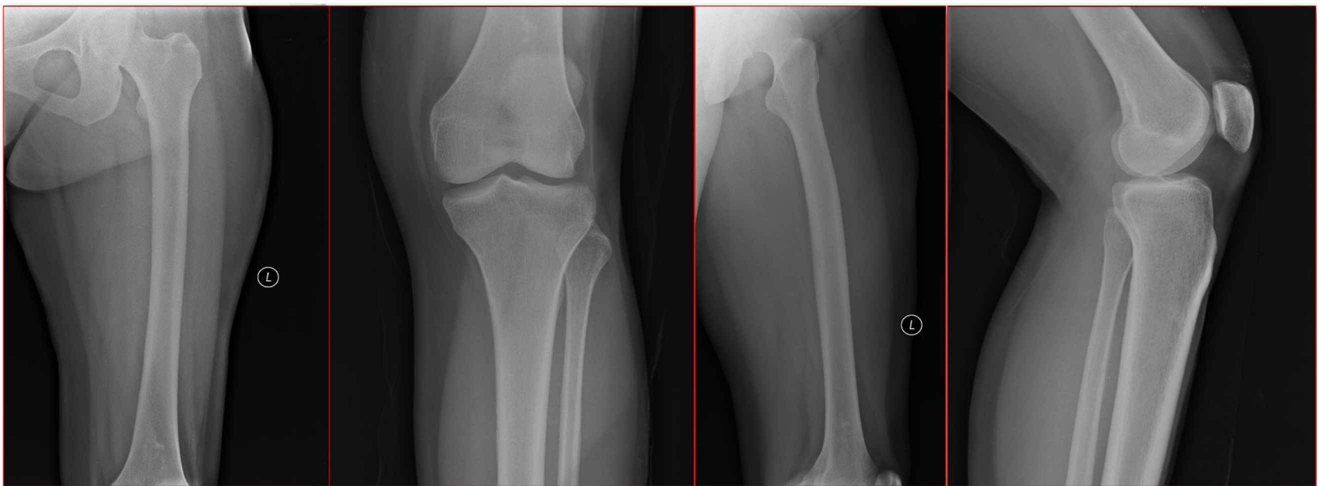

**Figure 1.** *Preoperative AP and lateral x-rays of the patient with LGC in left distal femur*

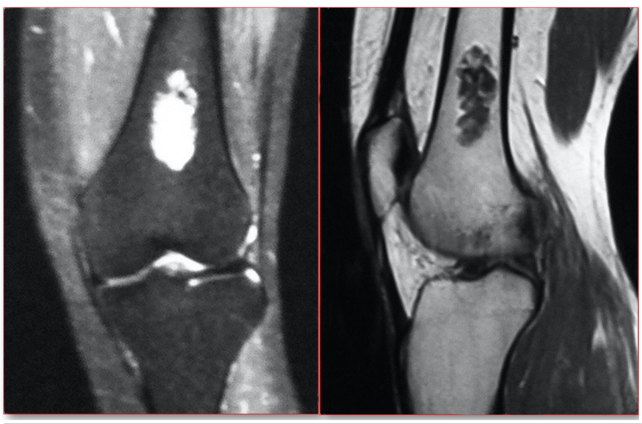

**Figure 2.** *Preoperative coronal and sagittal MRI views of the lesion*

Statistical analysis was performed using SPSS (version 25 .0 for Mac; SPSS, Chicago, IL). Descriptive statistics were stated as mean, minimum, maximum range for numerical variables and percentages for categorical variables. Mann-Whitney U test was used for the comparison of numerical variables in independent groups. A p value of <0.05 was accepted as statistically significant.

## RESULTS

The mean age at diagnosis was 44,5 (24-62) and the mean follow up duration was 56,2 months (27-102). Anatomical localizations of the tumour were 8 distal femoral metaphysis, 3 femur diaphysis, 4 proximal humeral metaphysis, 4 humerus diaphysis, 2 tibia diaphysis and 1 distal radius. All patients had grade IA tumours according to the MSTS staging system and all of the final specimens were identified as low-grade chondrosarcomas. The mean length of intramedullary tumour extension was 6,4 cm (4-8). The mean long dimension of the cortical window was 5,3 cm (2-8). One thin titanium screw was used for the reconstruction of the cortical window in 15 patients, while two screws were used in 7 patients. The mean long dimension of the cortical window was 4,8 cm (4-6,2) for reconstructions with one screw and 6,2 cm (5,8-7,2) for reconstructions with two screws. None of the patients had local persisting pain during the postoperative sixth month and all of them returned to daily activities with full range of motion by the end of the third month. They all achieved excellent clinical outcomes during the first postoperative year control with a mean MSTS score of 27,4 (range between 23-30) (91,3%). There was no statistically significant difference between lower and upper extremity MSTS scores. Scores also did not show significant difference between patients with reconstruction of the cortical windows with either one or two screws.

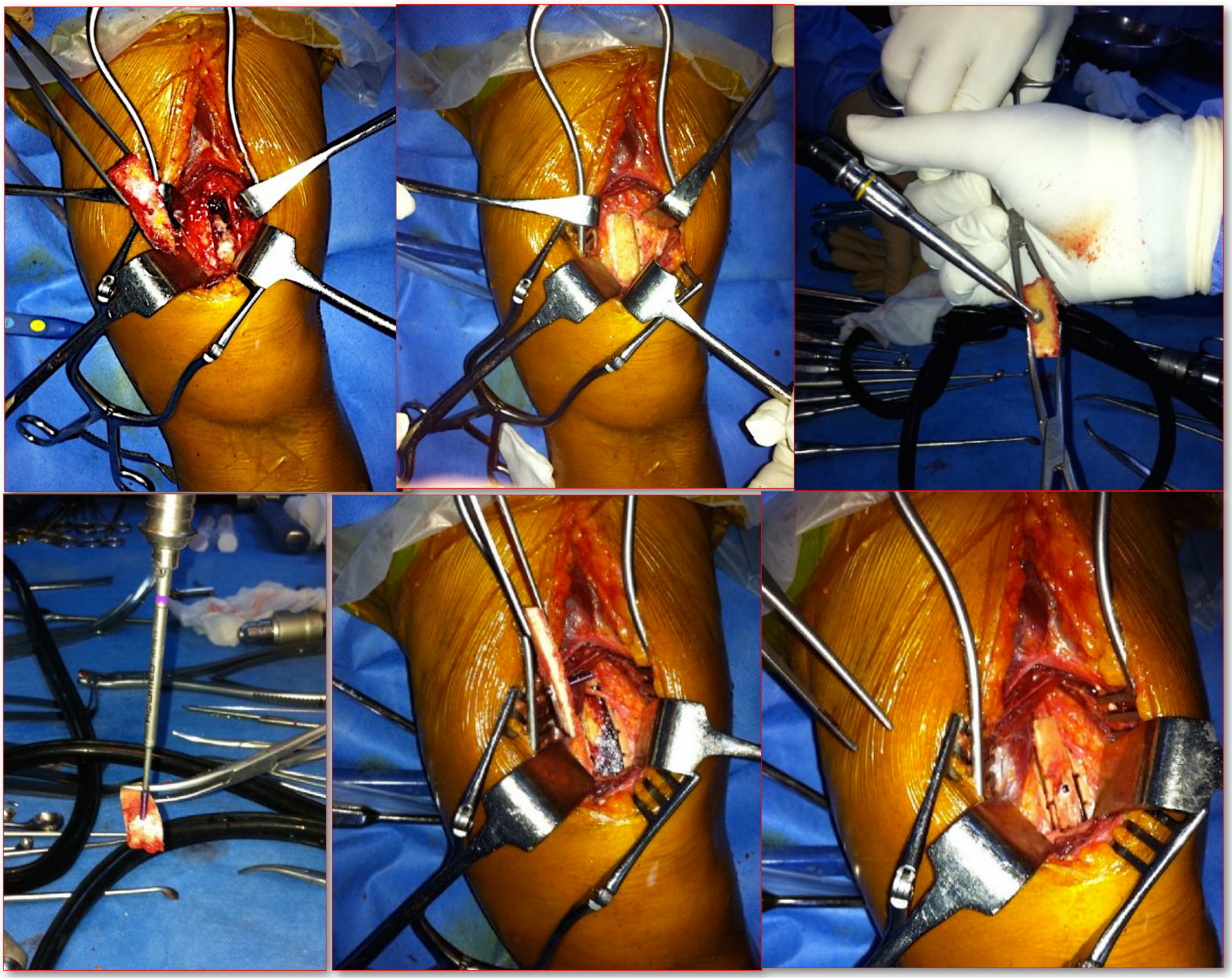

***Figure 3.*** *Opening and extraction of the cortical window. Shaving of the cortical window with high-speed burr. Application of the mini titanium screw onto the cortical window. Closure of the cortical window and augmentation of the screw to the bone cement. View of the titanium screw embedded in the bone cement and cortical window*

In one of the patients, superficial skin infection had developed during the early postoperative period, but treated well with oral antibiotics. We did not observe any other infection, hematoma, delayed healing, nerve palsy, pseudoarthrosis or other complications postoperatively. None of the patients needed a revision surgery or removal of the screw due to an irritation. All cortices were united by the end of the third month postoperatively and no pathological fracture was observed in the follow-up period. No patients developed any local recurrence or distant metastasis and all of them were alive without disease until the final examination. On radiographic evaluations during the postoperative period, the cortical windows were stable without any displacements. On MRI evaluations, the image distortion due to thin titanium screw was minimal and cement bone interface was clearly visible without any disturbance.

***Figure 4.*** *Postoperative 3rd month AP and lateral x-rays*

## DISCUSSION

Chondrosarcomas are malignant tumours of cartilaginous origin with a potential of both local aggressiveness and distant metastasis (3, 4). Treatment strategies for high-grade chondrosarcomas are well-established in the literature; while there is still a debate about the management of LGC. Since they rarely metastasize, the primary objective should be to preserve function with a less invasive surgical method when considering LGC. There are different surgical procedures described in the literature for the treatment of LGC (5-9). Shemesh et al. (2) found that recurrence rates were similar between the LGC patients treated with either intralesional curettage or wide excision in their meta-analysis. Bauer et al. (19) used this technique and achieved excellent results with a very low recurrence rate in their study consisting of 23 patients. In the study of Hanna et al. (9), 39 patients diagnosed with LGC were treated with intralesional curettage and cementation. They also reported good results without any metastasis or major complications.

Most authors agree that local adjuvants should be used for the prevention of tumoural spread after intralesional curettage of LGC. Streitbürger et al. (20) found that the 3 patients who were treated only with intralesional curettage (without the use of a local adjuvant) developed local recurrence after a mean follow-up of 26 months. However, there is no gold standard type of local adjuvant described in the literature. Cryotherapy, phenol application, cauterization, bone grafts or PMMA may be used as local adjuvants (1, 6, 8, 9). In our study, we used PMMA as the local adjuvant; therefore, we not only benefited from the cytotoxic and necrotizing effects of the cement, but also used it as an aid to our screw fixation.

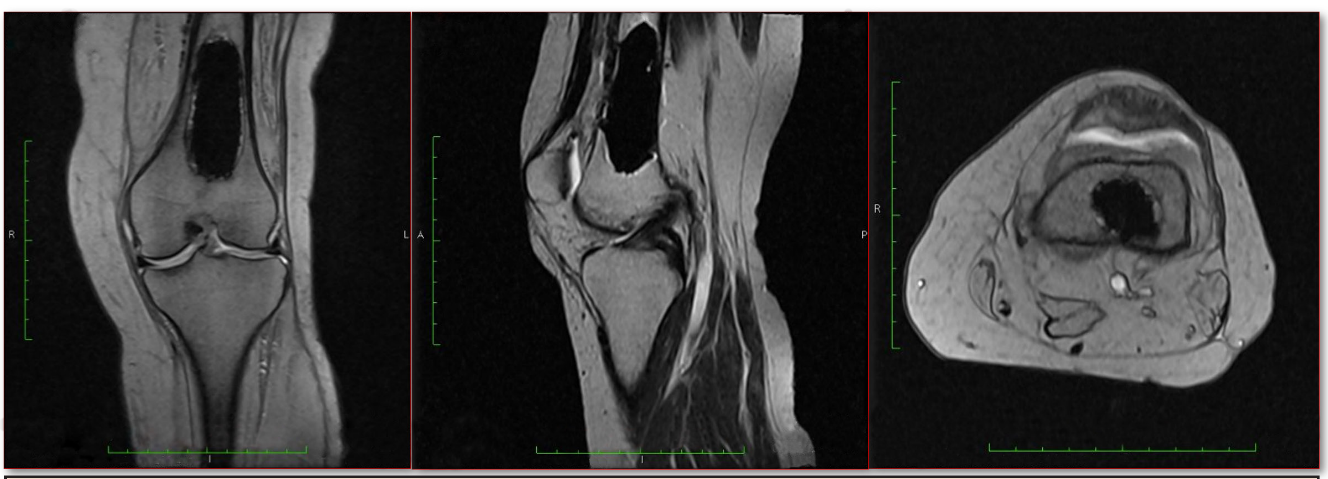

***Figure 5.*** *Postoperative 6th month coronal, sagittal and axial MRI views of the lesion*

Different cement types are used in the literature for augmentation of screws and suture anchors to improve the fixation stability of both normal and osteoporotic bones (21-23). PMMA has been the most commonly used bone cement for augmentation of screw fixation, especially in spinal and trauma surgeries (12, 24, 25). Jee Soo Jand et al. (25) used this technique in metastatic spinal tumours in the past and found good results in terms of stability in poor-quality bone caused by malignancy. Toy et al. (26) examined reconstruction strength of cements with the augmentation of crossed screws and found that screw augmentation resulted in a stronger reconstruction than that obtained with cement alone in the reconstruction of distal femoral tumor defects. With our study, we also would like to encourage the usage of cement-augmented screw fixation for tumour surgery in long bones.

The literature also lacks data about about the effect of timing of screw placement after cement injection. Linhardt et al. (14) found no significant difference between screws inserted into soft or cured PMMA. However, they detected increased bone failure when softer cement was used, and increased screw-cement junction failure when cured cement was used; leading to a potential conclusion of softer cement easing and improving fixation of both screw-cement and bone-cement interfaces. Similarly, Flahiff et al. (13) stated that augmentation of "doughy" cement to the screw had resulted in significantly stronger initial fixation compared to the hard cement. We chose to apply the screws into the doughy cement in our study.

Additional osteosynthesis after intralesional curettage was also questioned by various studies. Campanacci et al. (4) found that the risk of pathological fracture after these interventions is 1,9%. Even though the risk of pathological fracture is low, it is considered as an important advantage for these patients in terms of early postoperative mobilization by increasing the stability. In the study of Ahlman et al.'s (8), 10 patients were treated with intralesional curettage and cementation in addition to cryoablation. They recommended routine internal fixation after the procedure in order to prevent any pathological fracture and increase stabilisation. Omlor et al. (10) found that complications were almost twice as high in patients with LGC in the distal femur who were treated with additional plates and screw fixation for osteosynthesis after intralesional curettage and cementation. In another study by Omlor et al. (11), the amount of blood loss was higher and surgery time and hospitalization periods were longer in patients diagnosed with LGC and enchondromas in proximal humerus and treated with intralesional curettage and cementation with an additional osteosynthesis. They also pointed to a possible artifact issue during the postoperative MRI controls of their patients, since plates and screws were again used as fixation materials.

Orthopaedic implants may prevent accurate interpretation on postoperative MRIs due to metallic artifacts and cause significant problems in the follow-up process (16). It is known that implants made of titanium alloy create fewer artifacts than those produced by stainless steel (16). Larger implants may produce obstructive artifacts which could complicate the MRI evaluation; while smaller ones produce less severe artifacts (15). Various methods have been described for reducing metal-related artifacts and optimizing imaging techniques in postoperative patients (15, 16). Based on the information provided by these studies, we applied smaller orthopaedic implants made of titanium alloy to our patients for the fixation of the cortical windows. We did not encounter any problem regarding obstructive artifacts in our postoperative control MRIs. However, more studies are needed to determine the relationship between the distortion rate on the MRI evaluation and dimensions of the implants used in the surgery.

There are some limitations to this study. First of all, this is a retrospective study in which a surgical technique is described with a relatively small number of patients. The method of cement augmented screw fixation has been used in spinal surgeries, especially for osteoporotic bones. However, the use of this technique in long bones and tumoral defects have not been clearly described in the literature. Undoubtedly, more studies with larger control groups are needed to determine the efficacy of this method and to determine on which patients to use this technique for surgery. Another limitation in our study was that the number of screws which were used for fixation was decided upon surgeon's preference. It would have been ideal if more standardized protocols were followed for the relationship between the dimensions of the cortical windows and the number of screws that were used for fixation. Further biomechanical investigations are also necessary for detecting the characteristics of cement augmented screw usage, the reconstruction properties in the fixation of cortices of long bones and determining how these implants work in the prevention of pathological fractures, in order to achieve more standardized guidelines.

## CONCLUSION

Reconstruction of the cortical window with one or two thin titanium screws embedded in the bone cement may be a simple and reliable method of fixation in long bones without any complications regarding stability or risk of pathological fracture, in addition to the potential chance of obtaining better MRI results without any disturbances during the postoperative period. The convenient use of this method may be a good tool in the treatment of intramedullary tumours of long bones. Additional biomechanical and clinical studies need to be performed in order to evaluate the feasibility of this technique.

### DECLARATIONS

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*Conflict of Interest / Competing Interests:* None.

*Ethics Approval:* 14.10.2022 / ATADEK-2022-16/20

*Availability of Data and Material:* Available.

*Authors' Contributions:* BG (Wrote the paper, designed the study), MKO (Wrote the paper, collected the data, designed and performed the analysis and statistics).

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