Megaendoprosthesis in the treatment of bone tumors in the knee and hip region

Megaendoprotheze u lečenju koštanih tumora u regiji kolena i kuka

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Abstract

Background/Aim. For almost two decades extremity amputation has not been the only viable option for patients with bone cancer in the region of the hip and knee. Remarkable advances in implant technology, surgical reconstructive technique and adoption of new chemotherapy protocols provide a new option for surgeons who diagnose and treat bone tumors. Megaendoprosthesis has become widely accepted alternative in limb salvage surgery of the extremities. The aim of this study was to present an outcome of the treatment of bone tumors in the knee and hip region by the use of custom made megaendoprosthesis. Methods. In the period 2006–2008 we adopted new clinical practice protocols for preoperative management in candidates for tumor megaprostheses of the hip and knee including: surgical tumor staging, histopathological verification, determinants of anatomical-mechanical defect, status of soft tissues, CT evaluation of the referent measures of pelvis, femur and tibia necessary for creation of custom made endoprosthesis and surgery plan, as well as modern, less invasive surgical approach. The patients were monitored during ≥ 24 months after the surgery for detecting possible complications. Results. All procedures were performed without complications during and immediately after the surgery. During the follow-up period not less than 24 months we failed to record any significant complications. Conclusion. Custom made megaendoprosthesis are the method of choice in the treatment of bone tumors in the region of the hip and knee at the Orthopedics and Traumatology Clinic, Military Medical Academy, Belgrade. The greatest challenge – ensuring longevity of a prosthesis can be achieved not only by prevention of common complications of arthroplasty procedures but, certainly, with the introduction of new methods for preoperative planning – computer-assisted technique of measuring referent sizes and software solutions for the selection and design of custom-made components of an endoprosthesis.

Key words: bone neoplasms; orthopedic procedures; hip prosthesis; knee prosthesis; quality of life.

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Rezultati. Svi bolesnici bili su bez komplikacija tokom i neposredno po operativnom zahtevu. Tokom perioda praćenja, ne manjeg od 24 meseca, nisu evidentirane značajnije komplikacije kod praćenih bolesnika. Zaključak. Custom made endoproteze kuka i kolena predstavljaju metod izbora u lečenju koštanih tumora u regiji kuka i kolena. Najveći izazov – obezbeđivanje dugovečnosti proteze, postiže se ne samo prevencijom ubicijenih komplikacija arthroplastičkih procedura, već, svakako, i uvođenjem novih metoda u preoperativno planiranje – kompjuterski asistirane tehnike merenja referentnih veličina, i softverskih rešenja za selekciju i izradu custom made komponenta endoproteze.

Ključne reči: kosti, neoplazme; ortopedske procedure; kuk, proteza; koleno, proteza; kvalitet života.
Introduction

For almost two decades extremity amputation has not been the only viable option for patients with bone cancer in the region of the hip and knee. Remarkable advances in implant technology, surgical reconstructive technique and adoption of new chemotherapy protocols provides a new option for the surgeons who diagnose and treat bone tumors. Megaendoprosthesis has become widely accepted alternative in limb salvage surgery of the extremities. They allow restoration of function, improve the control of malignant disease and subjective patient satisfaction.

A success in limb salvage approach depends upon understanding of tumor biology and assessment of tumor aggressiveness, advances in reconstructive techniques and the development of effective chemotherapy protocols for primary and secondary bone tumors. Metal implants fixed with polymethylmethacrylate (PMMA) cement have been recognized for a long time as a successful modality of treatment of pathological bone fractures after metastasis 1.

In patients with disseminated metastatic disease, treatment should improve the quality of life in line with prognosis. In these cases the demands and needs for endoprosthesis are temporally and functionally restricted to facilitate the mobilization and health care. On the other hand, patients with newly diagnosed bone tumor, that requires resection, are often young and are expected to live with the prosthesis for many years. A substantial amount of healthy bone may need to be resected to provide a safe margin, leaving a remnant bone segment not enough to secure fixation of a megaendoprosthesis 2.

Reconstructive options after resection of tumors in the region of the hip and knee, besides a custom made endoprosthesis, include osteoarticular allografting, allograft-prosthesis composites, arthrodesis with intercalary bone graft and rotational plastic procedures. However, only resection with grafting, arthrodesis and rotational plastic procedures such as VanNes rotational plasty has many functional restrictions and can be applied only in exceptional cases. In the Military Medical Academy, Belgrade, Clinic for Orthopedics and Traumatology, if we chooselimb salvage approach, than surgical excision of bone tumors in the region of the hip and knee and defect reconstruction with custom made megaendoprosthesis is the method of choice in the treatment. Megaendoprosthesis provides numerous advantages, one of them being the possibility that a patient, soon, returns to daily activities with the full weight bearing. It is very important, because the available data show that approximately 25% of these patients live less than two years after the surgery 3. Other advantages are reliability, availability, and proven favorable cost-effectiveness ratio 4. Nevertheless, possible complications of reconstructive surgery, in general, such as infection, aseptic loosening, dislocation of prosthesis, joint stiffness or contracture, instability of components, and implant mechanical weaknesses may compromise the outcome, and the possibility of a successful revision, when the only remaining option is amputational surgery 3.

Methods

In the period 2006–2008, eight patients with primary malignant bone tumors were treated with wide resection and megaendoprosthetic reconstruction. Postoperative follow-up of each patient was at least 24 months. All patients were treated with a custom made megaendoprosthesis, a specially designed endoprosthesis based on the exact anatomical model of each patient. It was a moment of great significance for the reconstruction of the large weight-bearing joints such as the hip and knee. In our series, we did not use ready-made solutions for reconstructive procedures in the hip and knee region, since their lack of individualization significantly limits the application for the restoration of ideal relations in the joint. A properly restored joint biomechanics is one of the basic durability prerequisites of all arthroplastic procedures and tumor reconstruction, as well 4–6.

Eight patients were treated with megaendoprostheses: three patients with giant cell tumors of the distal femur, two patients with chondrosarcoma in the knee region, two patients with osteosarcoma in the region of the knee and one patient with chondrosarcoma in the region of the hip and pelvis. Selection of patients for this type of treatment was carried out after extensive diagnostic evaluations of the Sarcoma Council in our institution.

We adopted a protocol for selection and preoperative preparation of candidates for the treatment of tumors in the hip and knee region with custom made megaoendoprostheses. The protocol included surgical assessment of tumor aggressiveness, biopsy and histopathological verification, anatomical-mechanical determinants of the defect, the status of soft tissues, exact CT evaluation of the pelvis, femur and tibia in order to design a custom made megaoendoprosthesis and to plan the surgery. It was necessary to use a modern minimally invasive surgical procedure, if possible. After determination of the tumor surgical grade 7–8, and histopathological confirmation of diagnosis, special attention was paid to the exact evaluation of sizes and anatomical relations of pelvis, femur and tibia. All the patients were examined with 3D Multi Slice Computerized Tomography (3D MSCT). The dimensions of the bone tumor and boundaries were estimated and resection borders were planned. 3D MSCT reconstruction and precise computer-generated model allowed the development of components of megaendoprosthesis which fully corresponded to the anatomy of a patient (Figure 1). That greatly facilitated the surgical procedure, eliminated a number of concerns and the need for additional versatility (it referred to an intraoperative need to add or subtract additional inserts on the size of implants, which could certainly further weaken the planned construction of endoprosthesis). In order to succeed, we made an exact preoperative evaluation of lesion size, careful preoperative planning of the level and adequate fabrication of a custom made megaendoprosthesis. In order to ensure the safe margins, resection of significant segments of healthy bone was sometimes required, which could lead to abbreviations, reduced bone fixation and inability to secure megaendoprostheses components.

After the production and delivery of a custom made megaendoprosthesis, in all the cases an additional preoperative evaluation was carried out and surgery performed. All surgical interventions were performed by the team of orthopedic surgeons with extensive experience in the field of hip and knee arthroplasty procedures. Besides the standard application of reconstructive surgical techniques in the series, we respected and practiced all principles of oncological surgery (Figure 2).

**Results**

There were no intraoperative complications, neither complications in the early postoperative period (a month after the surgery). All the patients were followed minimally 24 months postoperatively. Since the classic scoring systems, routinely used for analysis of functional outcomes of hip and knee arthroplasty lack specificity sufficient for tumor arthroplasty, we evaluated postoperative function with the Muscu-
loskeletal Tumor Society (MSTS) scoring system. Numerical values from 0 to 5 points were assigned for each of the following 6 categories: pain, function, emotional acceptance, use of supports, walking ability and gait. These values were added, and the functional score was presented as a percentage of the maximum possible score. The results were graded according to the following scale: excellent – 75% to 100%; good – 70% to 74%; moderate – 60% to 69%; fair – 50% to 59% and poor – < 50% (Table 1). The overall survival of patients in the follow-up period was 100%

In the series there were seven knee megaendoprostheses, and one megaendoprosthesis of the hip. All patients underwent wide resection of tumor and megaendoprosthetic reconstruction. The procedures were conducted during 2006 and 2007. In four cases an excellent result was achieved (MSTS > 75, and mean MSTS functional score was 73.62% which was slightly lower than in similar studies (Table 2).

During the 24 months follow-up period there were no lethal outcome, although one male patient with chondrosarcoma of proximal femur 18 month after the intervention developed pulmonary metastases; shortly after the 24-months follow-up left our country and did not appear at the scheduled control visits, and we had no information about the progress of the disease or further treatment of the diagnosed metastatic disease. At the same patient we recorded hip prosthesis dislocation one month postoperatively, and after the reposition there were no more relaxations. All the patients were regularly checked up at the first month postoperatively and after three months. They were immediately allowed to walk postoperatively with the full weight bearing. In two patients during the follow-up we noted a decrease of function and that resulted in a significantly lower score at the final functional test. In one case we identified the associated cardiac pathology, and in other one obesity and low motivation for cooperation during

<table>
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<th>Table 1</th>
<th>Musculoskeletal Tumor Society (MSTS) functional score in patients treated by custom made tumor endoprosthesis</th>
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<tr>
<td>Patient (diagnosis, age and gender)</td>
<td>MSTS functional score* (%)</td>
</tr>
<tr>
<td>Chondrosarcoma partis distalis femoris sin, 57 yrs, female</td>
<td>71</td>
</tr>
<tr>
<td>Chondrosarcoma partis distalis femoris dex, 65 yrs, female</td>
<td>64</td>
</tr>
<tr>
<td>Tumor gigantocellulare partis distalis femoris sin, 25 yrs, male</td>
<td>83</td>
</tr>
<tr>
<td>Tumor gigantocellulare (Osteoclastoma) partis distalis femoris sin, 51 yrs, male</td>
<td>75</td>
</tr>
<tr>
<td>Tu gigantocellulare partis distalis femoris dex, 33 yrs, male</td>
<td>81</td>
</tr>
<tr>
<td>Osteosarcoma partis dist. fem. dex, 29 yrs, female</td>
<td>75</td>
</tr>
<tr>
<td>Osteosarcoma partis distalis femoris sin, 41 yrs, male</td>
<td>78</td>
</tr>
<tr>
<td>Chondrosarcoma partis proximalis femoris sin, 47 yrs, male</td>
<td>62</td>
</tr>
<tr>
<td>Average value of functional score</td>
<td>73.62</td>
</tr>
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*excellent – 75% to 100%; good – 70% to 74%; moderate – 60% to 69%; fair – 50% to 59%; poor - < 50%.

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<th>Table 2</th>
<th>Comparison of our results with those of other authors</th>
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<tr>
<td>Study</td>
<td>Number of patients</td>
</tr>
<tr>
<td>Hiroyuki et al.11</td>
<td>40</td>
</tr>
<tr>
<td>Schindler et al.12</td>
<td>12</td>
</tr>
<tr>
<td>Wilkins et al. 13</td>
<td>26</td>
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<tr>
<td>Khee Tan et al.14</td>
<td>19</td>
</tr>
<tr>
<td>Barjaktarović et al. (this study)</td>
<td>8</td>
</tr>
</tbody>
</table>

MSTS – Musculoskeletal Tumor Society

Reconstructive procedures in the treatment of malignant bone tumors have significantly higher incidence of complications compared to standard total joint arthroplasties. In tumor reconstructive surgery bone resections are usually broad and necessarily affect a good portion of healthy tissue, reducing the substrate for adequate fixation, and often are followed by compromising effects of radio and chemotherapy. This applies especially to slow wound healing and frequent infections. In our series, we recorded one early superficial wound infection. We isolated Staph. epidermidis. Infection was successfully treated with antibiotic therapy, without additional surgical interventions. Although we presented only light patients we are proud to highlight the absence of the most common and certainly the most difficult complications to resolve such as deep infections, periprosthetic fractures, implant fractures, nerve and vascular injuries.

Discussion

This retrospective study on a small sample certainly has some weaknesses. But the basic weakness - the small sample and relatively short duration of follow-up (24 months postoperatively) are not significant for the purpose of the study, since we wanted to examine the importance of proper selection of patients with bone tumors and the impact of the megaeendoprosthetic reconstruction designed to suit an exact anatomical model on the functional outcome and complications associated with implants. In order to check the reduction in the incidence of the most common and most serious complications of tumor arthroplasty period of 24 months is more than enough. The above complications are: infection, deep venous thrombosis, delayed wound healing and dehiscence, dislocations, periprosthetic fractures, fractures of implants and implant loosening, and they usually occur in the first 6 months postoperatively.

Megaendoprosthetic reconstruction as a method for the treatment of bone tumors has numerous advantages. It allows immediate stability, and early rehabilitation with immediate full weight bearing. We believe that the custom made endoprosthesis are far better than the prefabricated commercially available modular implants. The absence of frequent complications related to endoprosthesis (implant fracture, polyethylene wear, dislocations, loosening of components) in our series highlights the importance of anatomical joint restitution and adequate restoration of limb biomechanics in general. There is no doubt that such effect can only be achieved by custom made endoprosthesis produced upon the exact 3D model of a patient's bone.

During the follow-up period there was no need for the revision surgery, and we find that it was certainly an impressive result. We believe that the main reasons for the success were valid indications for megaeendoprosthetic reconstructive surgery, studious preoperative preparation, precise and modern surgical technique and highly skilled surgical teams. Biau et al. 15 reported 91 patients with bone tumors in the region of the knee treated with endoprosthesis (not custom made implants) and in 36 patients, endoprosthesis for various reasons had to be removed. Gosheger et al. 17 in a study on 250 patients treated with Mutars endoprosthesis (Implantcast, Buxtehude; not custom made implants) reported five-year survival rate of 68.5%, with 8% of aseptic prosthesis loosening. Mittermayer et al. 16, in a study with 251 patient treated with Kotz endoprosthesis (Howmedica, Rutherford, New Jersey) reported 76% success after ten years, and Malawer and Chou 19 in the study with 82 patients reported 67% ten year-survival of megaeendoprostheses.

We believe that it is not a small problem, as mentioned above, of long-time research (longer than five years) binding treatment for a specific type of an implant. It is a self-limiting approach that often denies choice and possibly better treatment for a patient. Orthopedic surgery and orthopedic oncology in the past two decades have made substantial progress, mostly in the technology of implants and diagnostic procedures. Neglect of fantastic technological evolution in implant design, new materials, innovations in surgical procedures and imaging techniques is unacceptable mistake that can cost a lot, patients and doctors, as well.

A successfull megaeendoprosthetic reconstruction requires a perfectly coordinated teamwork of orthopedic surgeons, radiologists, oncologists, pathologists, physiatrists and often other medical specialists, if necessary. That is why we feel the need to emphasize that the orthopedic-oncology megaeendoprosthetic reconstruction is reserved for the highly specialized institutions. They, in addition to experienced orthopedic surgeons, have the necessary resources – adequate equipment, primarily modern imaging techniques (3D MSCT, MRI), and competent specialists of different branches of medicine.

Conclusion

Custom made megaeendoprosthesis is the method of choice in the treatment of bone tumors in the region of the hip and knee. All procedures, presented in the paper, were performed without complications during and immediately after the surgery. During the follow up period not less than 24 months in all the cases we did not record any significant complications. The greatest challenge - ensuring longevity of a prosthesis, can be achieved not only by preventing common complications of arthroplasty procedures but certainly by introducing new methods for preoperative planning - computer-assisted technique of measuring the referent anatomical sizes and software solutions for the selection and design of custom-made components of endoprosthesis.

REFERENCES


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