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Successful three-year outcome in a patient with allogenous sternal bone graft in the treatment of massive post-sternotomy defects

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ABSTRACT

INTRODUCTION: Deep sternal wound infection is a life-threatening complication of longitudinal median sternotomy with extensive loss of sternal bone tissue and adjacent ribs. Wound dehiscence cases with no loss of bone tissue can be resolved via osteosynthesis using titanium plates. Unfortunately, this cannot be used in cases of massive bone tissue loss defects due to insufficient support for fixing the plate material caused by missing bone surface which increasing the risk of osteosynthesis failure. We describe the treatment outcome of sternal dehiscence with massive bone tissue loss defects using an allogenous sternal bone graft.
CASE PRESENTATION: A 62 year old diabetic female was operated for serious sternotomy dehiscence after surgery for aortic valve replacement. There was bone tissue loss and complications. We used allogenous sternal bone graft to close the wound. To monitor the healing of the graft, we performed SPECT/CT examinations of anterior chest wall. We describe the successful healing of the graft with the reduction of defects in osteoblastic activity by 42% 21 months after the graft implantation. The wound was found to be healed on all examinations, The chest wall is stable and the patient reports a good life quality.
DISCUSSION: An allogenous bone transplant contains no vital bone marrow cells, which eliminates immuno-genetic graft rejection by the patient. Significant osteoblastic activity was thus registered, especially in places where crushed spongy bone had been applied.
CONCLUSIONS: Transplantation of allogenous bone graft sternum in our experience is the best option for treating extensive post-sternotomy defects.

1. Introduction

Longitudinal median sternotomy is the most commonly used operating approach in cardiac surgery. However, early complications along with the development of deep sternal wound infection (DSWI), possibly accompanied by extensive loss of sternal bone tissue and adjacent ribs, remain a life-threatening complication of the primary surgery. Besides the risk of injury to the exposed right ventricle and the sewn aorto-coronary bypasses, the patient is at risk of respiratory insufficiency due to instability of the chest wall. The unstable base of the skeleton is also a source of further difficulties in the healing of subcutaneous tissue and skin.

Wound dehiscence cases with no loss of bone tissue can be resolved using AO osteosynthesis titanium plates. Unfortunately, this method cannot be used to restore the stability of the chest wall in cases of massive bone tissue loss defects. There is insufficient support for fixing material of the plates caused by the missing bone surface which increases the risk of osteosynthesis failure.

Based on the experience of orthopaedic surgery we have been using allogenous bone grafts in these situations. Described below are the three year results of treating massive post-sternotomy defects of the sternum using these grafts.

2. Case presentation

A 69-year-old female patient, an obese diabetic with a body mass index (BMI) of 31, primarily operated for aortic valve replacement with a mechanical prosthesis in January 2012, was twice revised within a week after the primary surgery. A serious sternotomy dehiscence with loss of bone tissue of the sternum and partial loss of bone tissue of ribs developed, along with a Staphylococcus epidermidis infection in the wound. This was managed in five sessions of vacuum assisted closure (V.A.C) treatment and a targeted antibiotic therapy recommended by the Antibiotic Centre. To close the wound, allogenous sternal bone graft was used and fixed using AO osteosynthesis titanium plates (Fig. 1.).

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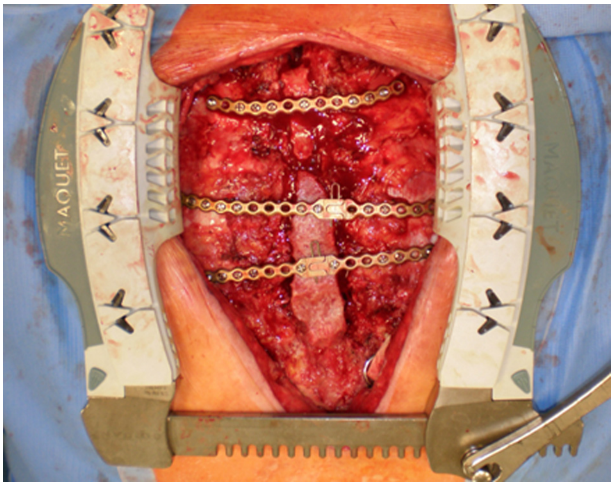

Fig. 1. Application of allogenous sternal bone graft and its fixing using titanium plates.

Prior to the implantation of the graft, it was necessary to release the pectoral musculocutaneous flaps from the skeleton rib cage to the level of the midclavicular line. The basic surgical technique was modified by a more aggressive debridement of residual chest bone or ribs (1–2 cm safety line). Afterwards, the bone graft was adjusted to the size of the bone defect and fixed with plates anchored by self-cutting or self-drilling cortical screws. The lines of contact between the graft and recipient tissues were filled with crushed spongy bone prepared from an allogenous femoral graft. Two subpectoral redon drains were inserted for seven days. Soft tissues were closed by direct suture of the subcutaneous tissue and skin. Within the postoperative period, we was strongly recommended avoidance of excessive coughing or any rough mechanical strain on the sternal wall. Antibiotics were administered for three weeks after the surgery.

Postoperative monitoring was carried out during regular clinical examination visits 3, 6 and 12 months after surgery and then once a year. The wound had healed on all occasions, the chest wall was stable, the patient had no emphysema and her upper limb mobility was not limited.

In the context of the long-term monitoring, in addition to routine clinical examinations, a planar whole-body bone scan with SPECT/CT of the thorax was performed following the administration of 750 MBq Technetium 99 m-bisphosphonate on a GE Infinia Hawkey gamma camera equipped with low-energy, high resolution parallel-hole collimators. Planar images were acquired in 1024×256 matrix. SPECT data with low-dose CT for attenuation correction and morphological correlation were acquired in 128×128 matrix.

Planar anterior whole-body (left view in Fig. 2A,B,C) and SPECT (right view in Fig. 2A,B,C) images performed 3 months after graft implantation, showed a central photon-deficient area with surrounding tracer uptake (Fig. 2A). Images obtained 21 months after surgery showed improvement of tracer uptake to the full within the sternal manubrium, and partial uptake in the sternal corpus (Fig. 2B). Quantitatively, a photon-deficient area measured as a region of interest (ROI) reduced to 58% - from 1440 mm^2 to 835 mm^2 (Fig. 2C).

3. Discussion

Median sternotomy is hils the most common incision performed in cardiosurgery due to its technical simplicity and excellent exposure of the heart, great vessels and pulmonaryhils [1].

Wire re-cerclage was a commonly used method for addressing sternal approximation in patients with sternal dehiscence after DSWI. However, the quality of residual sternal bone or its loss makes re-cerclage troublesome or even risky for achieving sternal stability. The occurrence of extensive adhesions below the sternum in DSWI patients increases the risk of damage to the right ventricle and bypass grafts when peri-, trans- and parasternal wiring techniques are used [2–4].

Non-complicated sternal dehiscence following DSWI can be stabilized with transverse titanium plates (Titanium Sternal Fixation system^{TM}, DePuy- Synthes). Chest stability after a healed DSWI improves respiratory function, augments wound healing processes, shortens in-hospital stay, and improves patient life quality [5–7]. Unfortunately, this method cannot be used in cases of massive bone tissue loss defects. Insufficient support for fixing material of the plates caused by the missing bone surface increases the risk of failure of osteosynthesis. Shear forces may loosen screws and threaten stability [8].

A conventional surgical approach to manage the large residual bone defect leaves the sternotomy wound unstable and employs the greater omentum or a muscle flap to fill any dead spaces. This approach resulted in sternal instability and flap-related morbidity even when wounds were well-healed [9,10].

Some case reports have included the use of an autologous bone iliac crest graft or allogenous fibula graft to supply residual bone defects after DSWI [11,12]. Use of an allogenous sternocostal bone graft for sternal reconstruction after chondrosarcoma removal was also reported [13]. The sternal allograft transplantation with no wound healing complications has been described an alternative for chest wall reconstruction [14,15].

Treatment of massive bone loss after DSWI using an allogenous bone graft to fill in the sternal defect and fixing the sternum with a titanium plate system ensures stability of chest cage stability. An allogenous bone transplant contains no vital bone marrow cells, which eliminates difficulties with immuno-genetic acceptance of the graft by a patient; it is a biological tissue transfer, which even under conditions of maximum precautions poses a minor risk for transmission of viral and bacterial infections.

Strict absence of early microbial infection is an essential condition for the implantation of the graft. In our department, an established wound care protocol with the use of V.A.C. has been used on a long-term basis [16]. Bandage changes are performed under general anaesthesia in the operating room. During each bandage change session, devitalized lines/borders of edges of bones and soft tissues are radically removed. Superficial wound swabs, samples of bone and cartilage fragments collected during each bandage change are sent for microbiological examination in order to achieve three consecutive negative results. Only then the patient is indicated for implantation of an allogenous bone graft. The informed consent of the patient is an indispensable part of the process.

An allogenous graft must meet the legislative criteria of the Czech Republic and the European Association of Tissue Banks [17,18]. Prior to graft harvesting, each donor is cross-checked for registration within the national registry for organ donation refusal. All deceased donors treated for infectious disease, sepsis, malignant tumours, or systemic and autoimmune diseases at the time of death are withdrawn from the donor list. Donor blood serum samples are tested for antibodies and HIV types 1 and 2, hepatitis B surface antigen (HbsAg), hepatitis C antibodies (anti-HCV), and HTLV I and II antibodies. Harvest of a sternal bone graft is performed under strictly sterile conditions by a team from the National Cell and Tissue Centre in Brno. The graft is harvested under sterile conditions and stored in the freezer at −80 °C. Prior to its clinical use, the graft is thawed at 4–6 °C for 12 h, soaked with a 1% gentamicin solution, prepared for its final shape, and stored in the freezer again at −80 °C. If bacterial sampling is negative, the graft is thawed for 12 h

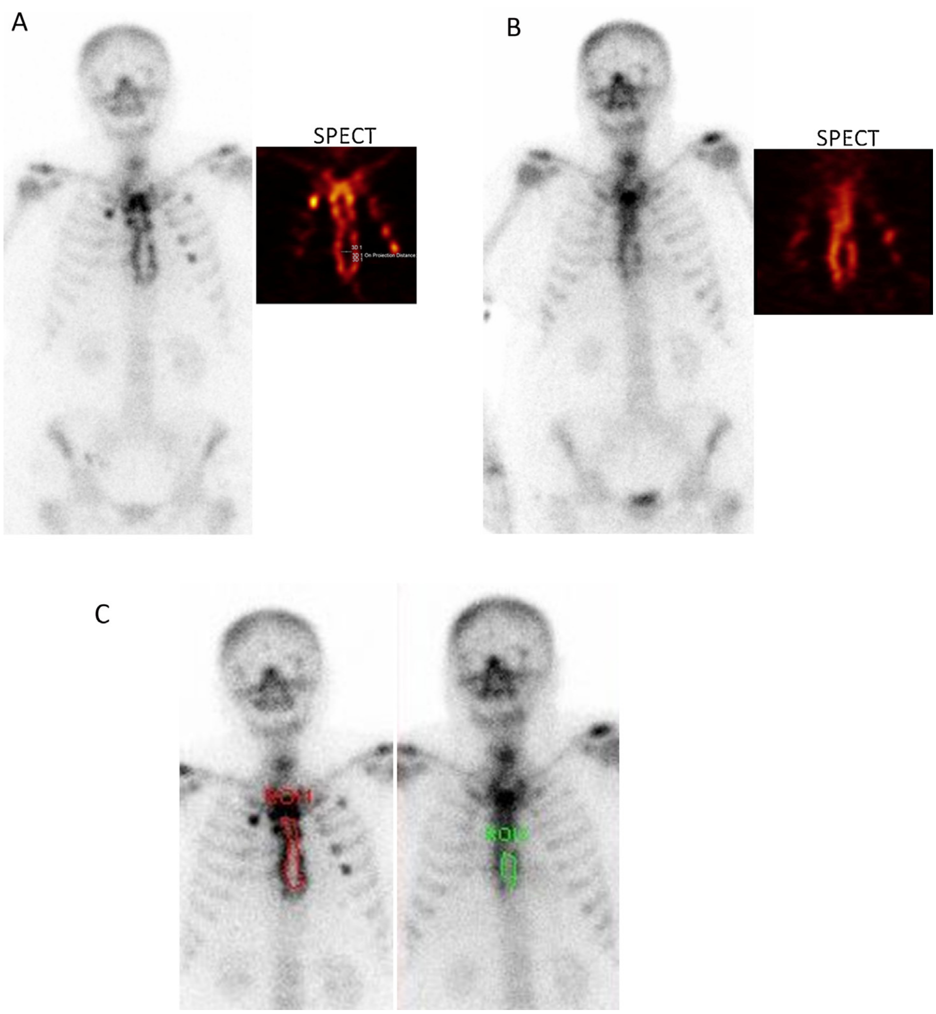

Fig. 2. (A) Planar anterior whole-body (left) and SPECT (right) images 2 months after graft implantation. Central photon-deficient area with surrounding tracer uptake. (B) Check examination 21 months after graft implantation–improvement of tracer uptake (full in manubrium sterni, partially in corpus sterni). (C) Quantitatively 21 months after. A photon-deficient area measured as a region of interest (ROI) reduced to 58%.

before transplantation, and submerged in a bath with 1% neomycin solution immediately before surgery.

Drawing on the basis of references in the field of orthopaedic surgery, we have chosen SPECT/CT of the chest wall to monitor the activity of healing of the graft administering Technetium 99 m-bisphosphonate whose penetration into bone tissue enables accurate assessment of osteoblast metabolism [19]. Examination confirmed successful healing of the graft along with reduction of the defect in osteoblastic activity. Significant osteoblastic activity was then registered, especially in places where crushed bone spongy bone had been applied which verified its superior healing effect.

4. Conclusion

Since 2012 to date, we have performed a total of nine allogenous sternal graft transplantations. Monitoring of the case described took place over three years. The patient reports a consistently high quality of life.

Radical debridement of the wound edges and recurring negative results of microbial examination of bone fragments are fundamental principles of this method. A vital factor in the healing of bone tissue is adequate plate fixation of the graft to the outside of the skeleton ribcage. Crushed spongy bone applied to the line of contact between the graft and recipient tissues also demonstrated great healing efficacy.

Conflicts of interest

Martin Kalab – none declared.
Jan Karkoska– none declared.
Milan Kamínek– none declared.
Petr Santavý – none declared.

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Author contribution

Martin Kalab – data collection and analysis, writing, corresponding author, photos, manuscript revision.
Jan Karkoska– writing.
Milan Kamínek– writing, data collection, SPEC/CT figures.
Petr Santavý – writing, data analysis.

Consent

A copy of the written consent is available for review by the Editor-in-Chief of this journal on request. Patients' and volunteers' names, initials, or hospital numbers are not used. Images of patients or volunteers are not used.

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