Case Report

Radial diaphysis infected non-union treated with combination of Masquelet technique and autologous bone grafting harvested by RIA: A case report

Klein Nitai *, Keltz Eran, Keren Yaniv

Orthopedics Division, Rambam Hospital, Rambam Health Care Campus (RHCC), HaAliya HaShniya St 8, 3109601 Haifa, Israel

ARTICLE INFO

Keywords:
RIA
Masquelet
Non-unions
Infected non-unions
Graft
Radius

ABSTRACT

We present a case of infected non-union of radial diaphysis following closed fracture and open reduction and internal fixation (ORIF) of the fracture. Treatment included combining the Masquelet technique of induced membrane and autologous bone graft using Reamer-Irrigator-Aspirator harvesting technique. At 10 months post PMMA extraction and autografting (i.e.: second stage) full union was achieved with excellent functional results.

Introduction

A particular challenge in non-unions is large cortical bone defects requiring bone graft. These defects may be the result of primary bone loss (osteoclastic tumor, trauma, etc.) or secondary (infected or aseptic non-union, bone resection etc.)

To the best of our knowledge, no consensus of validated treatment algorithms exists for segmental defect following non-unions.

Common guidelines used in decision making are defects less than 2 cm may be treated with autologous bone graft, between 2 and 5 cm require massive autograft and defects >6 cm require vascularized bone grafts, Ilizarov bone transport and in some cases amputation. While these methods have proven results, they are not without limitations. In large cortical defects (critical-size defects (CSDs)), reconstructed with an autologous graft, even with adequate bone stock, soft tissue cover and vascularization, bone union may be incomplete, due to graft resorption. Ilizarov bone transport may be used but it is technically demanding and may be arduous for both the patient and surgeon [1].

The induced membrane (IM) technique described by Masquelet et al. in the early 2000s, is another tool available in treatment of critical defects. The IM provides a superior healing site due to: a) Richly vascularized layers; b) fibroblasts, myofibroblasts and type-IV collagen in the outer membrane, with synovial-like epithelium inner membrane predominant in type-I collagen; c) growth factors VGEF and TGF-β1 observed in high concentration by two weeks and BMP-2 at four weeks. Another important observation is that grafts inside the membrane do not undergo resorption, a crucial fact in CSDs. Additionally, in-vitro membrane extracts stimulated bone marrow cell proliferation and differentiation to osteoblastic lineage [1,2].

When autologous bone graft is warranted, iliac crest bone graft (ICBG), from the anterior or posterior crest have long been the “gold standard” as they are relatively easy to harvest and have osteoconductive, osteoinductive and osteogenic properties. Additional donor sites exist (e.g.: distal radius, proximal tibia), and while these different approaches each have their strengths and limitations, overall,
the most common complication associated with the autograft harvest is pain at the donor site, with less frequent complications including nerve injury, hematoma, infection, and fracture.

With the introduction of intramedullary canal reaming by Kuntschēr in the 1940s, concerns over increased canal pressure and risk for fat embolism appeared. The provided technical guidelines to minimize the associated risks were not evident until the 1970's with the publication by Danckwardt-Lilliestrom et al. [3]. The RIA (Reamer-Irrigator-Aspirator) [DePuy Synthes, 325 Paramount Drive, Raynham, MA, U.S], provides a clinical tool which mitigates these concerns.

RIA is designed to reduce intramedullary canal pressure by continuous suction. Fenestrated reamer head enables irrigation at the cutting edge reducing the temperature and potential for thermal necrosis. The reaming contents are evacuated further alleviating canal pressure. Perhaps the other major advantage of RIA, and possibly clinically more useful, is the expansion in recent years as a tool for autologous bone graft harvesting. Adding a closed inline filter and collection device, autologous bone graft in large quantities can be obtained. The major complication is iatrogenic femur fracture but the risks remain extremely low and can be greatly mitigated by proper surgical technique [4].

Increasingly used for autograft harvesting, RIA has demonstrated success in recalcitrant non-unions. Among the advantages theorized are (a) reduced donor site morbidity, (b) cellular and biochemical properties like ICBG, (c) large volumes of graft. Furthermore, studies found no critical weakening of the femur donor site [5,6].

Case

47-year-old otherwise healthy male was admitted to our institution, with left radius-ulna diaphysis fracture.

Following initial work-up, he was taken to surgery. Open reduction and internal fixation (ORIF) of the fractures was obtained using LCP 3.5 mm plates [DePuy Synthes, 325 Paramount Drive, Raynham, MA, U.S] for both the ulna and radius fractures.

Anatomic radial and ulna length with satisfactory soft tissue coverage and wound closure was achieved.

On subsequent follow up visits, pain with offensive smelling draining sinus from the surgical site and non-union on plain radiographs (Fig. 1) and CT was observed. Diagnosis of infected nonunion of the radius was established.

Fig. 1. Lateral left forearm x-ray showing oligotrophic (due to septic) non-union.
The patient was taken back to surgery with findings of radial non-union, hardware loosening and bone resorption. Radial plate and screws were removed, and debridement to healthy-looking bleeding bone margins performed. Antibiotic eluding PMMA spacer was placed in the bone gap with wound closure and bracing.

Bacterial cultures from the debrided bone showed growth of Methicillin sensitive Staphylococcus aureus (MSSA). An infectious disease consult was obtained, and the patient completed an eight-week IV Cefazolin and PO Rifampin course.

Following completion of the antibiotics course, good secondary healing of the wounds was achieved, with normal neurovascular examination and no clinical or laboratory signs of infection. Tenderness above the fracture site and limited range of motion was noted. Satisfactory healing of the infection allowed moving forward to the second-stage 2 months after first-stage procedure.

Using a standard Thompson approach to the forearm, an induced membrane (IM) covering the entirety of the cement spacer was observed. Careful incision of the membrane was performed with removal of this cement spacer (Fig. 2) and while preserving the membrane the cavity was gently debrided and curated to bleeding bone edges (Fig. 3).

RIA to the femoral canal was used for autologous bone graft harvesting. The IM cavity was filled using the graft and sutured. Fixation was achieved with a 3.5 mm LCP.

Follow-up showed good ossification progression, gradual improvement in pain and range-of-motion (ROM) until full union was finally observed 10-months following second-stage procedure (Fig. 4).

Discussion

Diaphyseal non-unions of the forearm following ORIF are relatively rare although some large cohorts reported a rate of up to 2–10%. It is a disabling complication that causes pain, limited ROM of the forearm and impacts elbow, wrist and hand functions [7]. Infected non-unions, which represent a sub-category of this problem, are even rarer and no large cohorts report exist to the best of our knowledge. The presence of large CSDs following debridement of infected non-union may present a major challenge [8].

The use of RIA for autograft harvesting reduces the potential pitfalls of ICBG harvesting while providing easy-to-obtain large quantities of material (Fig. 5).

One study found that use of autograft from RIA compared with ICBG achieved the same union rates (P = 0.61) with less donor-site pain (P < 0.001), greater graft volume and shorter harvest time. RIA was also superior for large harvest volume in a cost analysis perspective [9].

This case presents the merging of two established treatment methods (Masquelet & RIA harvesting) which produced excellent
Fig. 3. IM cavity and defect following PMMA removal.

Fig. 4. AP & lateral plain radiographs of the left forearm showing full union at 10-months post second stage procedure.
results. The coupling of these methods meets the so-called “Diamond Concept” of fracture healing using the Masquelet technique proposed by Klein et al. [10].

This is an exciting alternative treatment method for CSD in general and infected non-unions particularly, of a relatively uncommon site (i.e.: forearm). Although data is limited for this type of non-unions and further investigation is warranted, these results coupled with minimal donor site morbidity, is a promising path and another available tool (Fig. 6).

Declaration of competing interest

The authors declare that they have no conflict of interest.

References

[1] A.C. Masquelet, T. Begue, The concept of induced membrane for reconstruction of long bone defects, Orthop. Clin. North Am. 41 (1) (2010) 27–37, https://doi.org/10.1016/j.ocl.2009.07.011.

[2] A. Masquelet, N.K. Kanakaris, L. Obert, P. Stafford, P.V. Giannoudis, Bone repair using the masquelet technique, J. Bone Jt. Surg. Am. 101 (11) (2019) 1024–1036, https://doi.org/10.2106/JBJS.18.00842.

[3] V. Vécsei, S. Hajdu, L.L. Negrin, Intramedullary nailing in fracture treatment: history, science and Küntscher’s revolutionary influence in Vienna, Austria, Injury 42 (Suppl 4) (2011) S1–S5. Accessed July 24, 2021, http://www.ncbi.nlm.nih.gov/pubmed/21939796.
[4] M. Rd, N. Pj, The reamer-irrigator-aspirator in nonunion surgery, Orthop. Clin. North Am. 50 (3) (2019) 297–304, https://doi.org/10.1016/j.ocl.2019.03.001.
[5] D. R, Complications following autologous bone graft harvesting from the iliac crest and using the RIA: a systematic review, Injury 42 (Suppl 2) (2011), https://doi.org/10.1016/J.INJURY.2011.06.015.
[6] P.R. Stafford, B. Norris, Reamer-irrigator-aspirator as a bone graft harvester, Tech Foot Ankle Surg. 6 (2) (2007) 100-107, https://doi.org/10.1097/bfs.0b013e331806213b3.
[7] KP Droll PPJEHESSMM, Outcomes following plate fixation of fractures of both bones of the forearm in adults, J. Bone Jt. Surg. Am. 12 (12) (2007) 2619–2624, https://doi.org/10.2106/jbjs.f.01065.
[8] P. Mi, O. Ea, M. Dr, Infected nonunions of diaphyseal fractures of the forearm, Arch. Orthop. Trauma Surg. 130 (7) (2010) 867–873, https://doi.org/10.1007/s00402-009-1016-4.
[9] J. Dawson, D. Kiner, W. Gardner, R. Swafford, P.J. Nowotarski, The reamer-irrigator-aspirator as a device for harvesting bone graft compared with iliac crest bone graft: union rates and complications, J. Orthop. Trauma 28 (10) (2014) 584–590, https://doi.org/10.1097/BOT.0000000000000086.
[10] C. Klein, M. Monet, V. Barbier, et al., The masquelet technique: current concepts, animal models, and perspectives, J. Tissue Eng. Regen. Med. 14 (9) (2020) 1349–1359, https://doi.org/10.1002/TERM.3097.