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Case report

RIA grafting for the treatment of a large bone defect in the distal radius—First case report of a new treatment option

W. Hanna *, C.A. Mueller

Städtisches Klinikum Karlsruhe, Department for Trauma, Hand- and Orthopaedic Surgery, Germany

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1. Case report

A healthy 41-year-old man was brought to the emergency department after he fell from a height of ~3 m onto his left arm. He had extensive soft-tissue injury with an open (Gustilo-Anderson IIIB)[9,17] injury to his left distal forearm. A plain radiograph showed a distal Galeazzi fracture with a multi-fragment distal radius shaft fracture and a distal radial ulnar joint (DRUJ) dislocation. The patient was taken immediately to the operating room for wound debridement, reduction and fracture stabilization with an external fixation.

One week later the external fixation was removed after which plate-osteosynthesis of the distal radius and transfixation of the dislocated DRUJ with K-wires were performed.

Seven weeks after the primary injury a deep infection occurred. Several debridements over a three-week period were necessary to obtain a clean wound. Consequently, 10 weeks after the accident, plate removal and a repeat external fixation were necessary. By now osteomyelitis was evident and a 7 cm long bone sequestrum of the distal radius shaft had to be resected (Fig. 1a). One week after sequestrectomy we performed step one of the Masquelet two-stage procedure for long bone reconstruction. After complete removal of all devitalized bone and soft tissue we inserted a PMMA spacer, premixed with Gentamycin, into the bone defect as phase I (Fig. 1b). Referring to literature on the Masquelet protocol we waited six weeks before performing phase II. RIA bone graft was then harvested from the ipsilateral femur and combined with BMP-7. The membrane was incised, the spacer removed and RIA graft was used to fill the bone defect. For internal fixation of the distal radius we used an angle-stable plate (Fig. 1c).

The post-operative course was satisfying. The forearm wound healed without signs of infection. Post-operative radiographs at 6 months (Fig. 2) showed excellent bone consolidation. A hematoma formation at the RIA donor site, 5 days after the RIA procedure, required surgical evacuation. Three month after the RIA procedure the patient resumed his work activity as a high school teacher. Six month after the last operation the patient was without pain and with satisfactory functional outcome in respect to the severity of the injury and subsequent events. The ROM of the pro- and supination (20–0–20°) were compromised as well as the dorsal (20°) and palmar flexion (25°) of the wrist joint.

2. Discussion

Segmental bone defect treatment options can be divided into two general categories – bone transportation or defect filling. Although no validated treatment algorithms exist for segmental defect nonunions, many surgeons use the following guidelines. Defects less than 2 cm are often treated with autologous bone grafting, defects between 2 and 6 cm are treated with either large autologous bone grafting or bone transport (Ilizarov technique). Defects larger than 6 cm are treated with bone transport or with a free vascularized bone transfer (fibula).[5]

The treatment of forearm nonunions with segmental defects are challenging procedures in orthopaedic surgery. Reviewing the literature of this subject reveals that despite the use of various techniques, the results are not completely satisfying and there is still debate regarding which type of technique to use.[6]

With the advent of a new bone-graft harvesting device – the Reamer–Irrigator–Aspirator (RIA, Synthes®) – an additional source of bone is now available to treat fracture nonunions and segmental large bone defects. Prior to the development of the RIA, bone harvest was typically taken from the pelvis, either anterior iliac crest or posterior iliac crest. Each site has its own advantages and disadvantages but both have significant risks of donor site pain and other morbidities.[1,2,3,16,23,25,31,32]

The RIA was developed to provide suction, irrigation reaming as a clinical instrument to avoid documented problems associated with increased intramedullary pressure, local bone injury and systemic disturbances.[13,15,24,30] Because RIA functions by flushing the cutting head with irrigation, which is then evacuated coincident to the vacuum which maintains low canal pressure, the osteogenic reamings may be captured with an in line filter.

* Corresponding author at: Klinikum Karlsruhe, Department for Trauma, Hand- and Orthopaedic Surgery, Moltkestr. 90, D-76133 Karlsruhe, Germany.
Tel.: +49 (0)721 974 0.
E-mail address: wadih.hanna@klinikum-karlsruhe.de (W. Hanna).

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Fig. 1. (a) Seven weeks after the primary injury: plate removal and sequestrectomy of 7 cm of infected bone. (b) Step one of the Masquelet two-stage procedure: implantation of a PMMA spacer with Gentamycin. (c) Six weeks after step one of the Masquelet two-stage procedure: defect filling with RIA graft combined with BMP-7 and angle stable plate osteosynthesis.

Reported amounts in the filter vary from 30 to 90 cc. in one study.[18] The yields from the tibia being appreciably less than the femur.[2,14] The intramedullary graft has an abundance of progenitor cells and growth factors.[10,22,29,39] Emerging evidence from various papers establishes that a particular benefit from reamed particles is the existence of viable osteoprogenitors within the bone matrix itself, not merely in the marrow, which is well accepted.[11,29,36,39] Further studies on the biomechanical effect of RIA graft harvesting have shown no critical weakening of the donor femur after graft harvest, if certain parameters are respected.[11,7,30,33,36,39] These and other findings suggest that RIA may be the new gold standard for bone grafting of segmental defects[4,24,25,34,31] where appreciable volume is required.

Nonunions treated with RIA graft have reported high union rates.[4] Belthur et al. found 90% of RIA recipient sites healed versus 80% of ICBG sites in their series.[2,3]. McCall reviewed 21 patients treated for bone defects ranging from 2 cm to 14.5 cm with RIA graft. He found 85% healed at eleven months.[23] The literature continues to expand on this method, which seems promising although a definitive study has yet to be done.

Describing the Masquelet technique, Pelissier et al. proposed the use of a combination of induced membranes and cancellous autografts to bridge diaphyseal defects of up to 25 cm in length.[21,26] In this technique, a methylmethacrylate cement spacer induces formation of a membrane, creating a pocket for subsequent grafting. Pelissier et al. and Viateau[26,28,37,38] have determined that these membranes possess a rich capillary network and have high concentrations of growth factors. The role of the induced membrane is therefore, both to protect the graft from the environment and to revascularize it. The first role of the spacer is mechanical, preventing fibrous-tissue invasion of the recipient site. The second role is biological, inducing the surrounding membrane. Moreover, because the spacer behaves as a foreign body, the absence of inflammation and infection after 2 months signals adequate local conditions for accepting the bone graft. The cement spacer should remain in place for 4–8 weeks to allow the membrane to fully develop both biochemically and physically. In 2000, Masquelet et al.[21] reported a union rate of 100% in a series of 35 patients with upper and lower extremity segmental defects that measured 4 to 25 cm in length. The authors found that the rate of bone healing did not correlate with the length of the defect in patients treated with induced membranes and external fixation. Masquelet and Begue[18] followed this initial study with a prospective analysis of 11 patients treated using the same protocol but with the addition of BMP-7. The authors reported a 91% rate of bony union in defects that measured 5–18 cm. Other investigators have reported similar results with variations of the original technique. Stafford and Norris[35] described a series of 27 lower extremity nonunions with segmental bone loss treated with RIA-harvested bone graft and either IM nailing or plate-and-screw

Fig. 2. Radiological result six month post-op.

fixation constructs. They reported a healing rate of 90% at 1-year follow-up.

Injuries to the wrist and hand with segmental bone loss caused by trauma or infection have also been managed with the induced membrane technique.[8,19,20] Flamans et al.[8] treated eight cases of open phalangeal fractures with loss of substance and three cases of bone and joint infection (thumb, wrist, fifth finger). Two cases failed to achieve bone union, no septic complications occurred and all septic cases were controlled. This technique has also been used successfully for reconstruction of devastating foot injuries, with full weight bearing permitted by 9 months post-operatively.[12,27]

Usually the technique applied to our patient is used for the treatment of femur or tibia defects. The presented case illustrates the potential of the RIA graft even in the treatment of segmental bone loss >6 cm of the forearm. This method, combining RIA graft in an induced membrane, for treating a forearm bone defect has been described but once,[34] to our best of our knowledge. We believe this is the first complete case report on use of the technique for managing significant bone loss resulting from trauma and subsequent debridement of infected bone in the forearm.

Conflict of interest

None declared.

References

1. Arrington ED, Smith WJ, Chambers HG, Bucknell AL, Davino NA. Complications of iliac crest bone graft harvesting. Clinical Orthopaedics and Related Research 1996;300–9.
2. Belthur MV, Conway JD, Jindal G, Ranade A, Herzenberg JE. Bone graft harvest using a new intramedullary system. Clinical Orthopaedics and Related Research 2008;466:2973–80.
3. Conway JD. Autograft and nonunions: morbidity with intramedullary bone graft versus iliac crest bone graft. Orthopedic Clinics of North America 2010;41:75–84 [table of contents].
4. Cox G, Jones E, McGonagle D, Giannoudis PV. Reamer–irrigator–aspirator indications and clinical results: a systematic review. International Orthopaedics 2011;35:951–6.
5. DeCoster TA, Gehlert RJ, Mikola EA, Pirela-Cruz MA. Management of posttraumatic segmental bone defects. The Journal of the American Academy of Orthopaedic Surgeons 2004;12:28–38.
6. Faldini C, Miscione MT, Acri F, Chehrassan M, Bonomo M, Giannini S. Use of homologous bone graft in the treatment of aseptic forearm nonunion. Musculoskeletal Surgery 2011;95:31–5.
7. Finnan RP, Prayson MJ, Goswami T, Miller D. Use of the reamer–irrigator–aspirator for bone graft harvest: a mechanical comparison of three starting points in cadaveric femurs. Journal of Orthopaedic Trauma 2010;24:36–41.
8. Flamans B, Pauchot J, Petite H, Blanchet N, Rochet S, Garbuio P, et al. Use of the induced membrane technique for the treatment of bone defects in the hand or wrist, in emergency. Chirurgie de la Main 2010;29:307–14.
9. Gustilo RB, Gruninger RP, Davis T. Classification of type III (severe) open fractures relative to treatment and results. Orthopedics 1987;10:1781–8.
10. Hak DJ, Pittman JL. Biological rationale for the intramedullary canal as a source of autograft material. Orthopedic Clinics of North America 2010;41:57–61 [table of contents].
11. Hoegel F, Mueller CA, Peter R, Pfister U, Suedkamp NP. Bone debris: dead matter or vital osteoblasts. Journal of Trauma 2004;56:363–7.
12. Huffman LK, Harris JG, Suk M. Using the bi-masquelet technique and reamer–irrigator–aspirator for post-traumatic foot reconstruction. Foot and Ankle International 2009;30:895–9.
13. Husebye EE, Lyberg T, Madsen JE, Eriksen M, Roise O. The influence of a one-step reamer–irrigator–aspirator technique on the intramedullary pressure in the pig femur. Injury 2006;37:935–40.
14. Kovar FM, Wozasek GE. Bone graft harvesting using the RIA (reaming irrigation aspirator) system – a quantitative assessment. Wiener Klinische Wochenschrift 2011;123:285–90.
15. Krause JO, Perry CR. Distal femur as a donor site of autogenous cancellous bone graft. Journal of Orthopaedic Trauma 1995;9:145–51.
16. Lowe JA, Della Rocca GJ, Murtha Y, Liporace FA, Stover MD, Nork SE, et al. Complications associated with negative pressure reaming for harvesting autologous bone graft: a case series. Journal of Orthopaedic Trauma 2010; 24:46–52.
17. Marsh JL, Slongo TF, Agel J, Broderick JS, Creevey W, DeCoster TA, et al. Fracture and dislocation classification compendium-2007: Orthopaedic Trauma Association classification, database and outcomes committee. Journal of Orthopaedic Trauma 2007;21:S1–33.
18. Masquelet AC, Begue T. The concept of induced membrane for reconstruction of long bone defects. Orthopedic Clinics of North America 2010;41:27–37.
19. Masquelet AC, Ferreira AC. Principles of repair of a compound defect as a secondary procedure: the multiple stages approach, Severe Traumatic Defects of the Upper Limb. United Kingdom: Martin Dunitz, an imprint of Taylor & Francis Group; 2003. pp. 287–294.
20. Masquelet AC, Obert L. Induced membrane technique for bone defects in the hand and wrist. Chirurgie de la Main 2010;29(Suppl. 1):S221–4.
21. Masquelet AC, Fitoussi F, Begue T, Muller GP. Reconstruction of the long bones by the induced membrane and spongy autograft. Annales de Chirurgie Plastique et Esthetique 2000;45:346–53.
22. Masquelet AC, Benko PE, Mathevon H, Hannouche D, Obert L. Harvest of corticocancellous intramedullary femoral bone graft using the reamer–irrigator–aspirator (RIA). Orthopaedics & Traumatology Surgery & Research 2012; 98:227–32.
23. McCall TA, Brokaw DS, Jelen BA, Scheid DK, Scharfenberger AV, Maar DC, et al. Treatment of large segmental bone defects with reamer–irrigator–aspirator bone graft: technique and case series. Orthopedic Clinics of North America 2010;41:63–73 [table of contents].
24. Muller CA, Green J, Sudkamp NP. Physical and technical aspects of intramedullary reaming. Injury 2006;37(Suppl. 4):S39–49.
25. Myeroff C, Archdeacon M. Autogenous bone graft: donor sites and techniques. Journal of Bone and Joint Surgery 2011;93:2227–36.
26. Pelissier P, Martin D, Baudet J, Lepreux S, Masquelet AC. Behaviour of cancellous bone graft placed in induced membranes. British Journal of Plastic Surgery 2002;55:596–8.
27. Pelissier P, Bollecker V, Martin D, Baudet J. Foot reconstruction with the "bi-Masquelet" procedure. Annales de Chirurgie Plastique et Esthetique 2002; 47:304–7.
28. Pelissier P, Masquelet AC, Bareille R, Pelissier SM, Amedee J. Induced membranes secrete growth factors including vascular and osteoinductive factors and could stimulate bone regeneration. Journal of Orthopaedic Research 2004;22:73–9.

29. Porter RM, Liu F, Pilapil C, Betz OB, Vrahas MS, Harris MB, et al. Osteogenic potential of reamer irrigator aspirator (RIA) aspirate collected from patients undergoing hip arthroplasty. Journal of Orthopaedic Research 2009;27:42–9.
30. Pratt DJ, Papagiannopoulos G, Rees PH, Quinnell R. The effects of medullary reaming on the torsional strength of the femur. Injury 1987;18:177–9.
31. Quintero AJ, Tarkin IS, Pape HC. Technical tricks when using the reamer irrigator aspirator technique for autologous bone graft harvesting. Journal of Orthopaedic Trauma 2010;24:42–5.
32. Seiler JG, Johnson F J3rd. Iliac crest autogenous bone grafting: donor site complications. Journal of the Southern Orthopaedic Association 2000;9:91–7.
33. Silva JA, McCormick JJ, Reed MA, Morse AS, Heffernan MJ, Lavado RD, et al. Biomechanical effects of harvesting bone graft with the reamer/irrigator/aspirator on the adult femur: a cadaver study. Injury 2010;41(Suppl. 2):S85–9.
34. Stafford PR, Norris BL. Reamer–irrigator–aspirator as a bone graft harvester. Techniques in Foot and Ankle Surgery 2007;6(2):100–7.
35. Stafford PR, Norris BL. Reamer–irrigator–aspirator bone graft and bi Masquelet technique for segmental bone defect nonunions: a review of 25 cases. Injury 2010;41(Suppl. 2):S72–7.
36. Tuli R, Seghatoleslami MR, Tuli S, Wang ML, Hozack WJ, Manner PA, et al. A simple, high-yield method for obtaining multipotential mesenchymal progenitor cells from trabecular bone. Molecular Biotechnology 2003;23:37–49.
37. Viateau V, Guillemin G, Calando Y, Logeart D, Oudina K, Sedel L, et al. Induction of a barrier membrane to facilitate reconstruction of massive segmental diaphyseal bone defects: an ovine model. Veterinary Surgery 2006;35:445–52.
38. Viateau V, Bensidhoum M, Guillemin G, Petite H, Hannouche D, Anagnostou F, et al. Use of the induced membrane technique for bone tissue engineering purposes: animal studies. Orthopedic Clinics of North America 2010;41:49–56 [table of contents].
39. Wenisch S, Trinkaus K, Hild A, Hose D, Herde K, Heiss C, et al. Human reaming debris: a source of multipotent stem cells. Bone 2005;36:74–83.