Replacement of a destroyed scaphoid by a 3D modelled prosthesis

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SUMMARY

Preiser disease is a rare condition where ischaemia and necrosis of the scaphoid bone occurs without previous fracture. A female patient in her 30s presented with severe right wrist pain caused by Preiser disease. Initially, she was treated by a pedicled vascularised bone graft, but unsuccessfully. Four years after the initial diagnosis, the affected scaphoid was replaced by a 3D modelled prosthesis. Three years after the operation, the patient had significant pain reduction, good wrist function and grip strength. Final X-rays demonstrated no signs of dislocation of the implant or signs of periprosthetic arthritis. Studies have shown that once scaphoid non-union advanced collapse occurs, treatment should consist of either a proximal row carpectomy or scaphoidectomy and four corner fusion. In our case, despite collapse and previous surgery, replacement of the single affected bone by a 3D modelled prosthesis lead to good return of function.

BACKGROUND

The major blood supply to the scaphoid is via the radial artery. The intraosseous vascularity of the entire proximal pole is from branches of the radial artery entering through the dorsal ridge. The vascular anatomy explains the cause of necrosis of the proximal pole after a fracture of the scaphoid (figure 1).[1] In Preiser disease, avascular necrosis of the proximal pole occurs without a fracture.[2] In cases where scaphoid non-union advanced collapse occurs, based on limited evidence (eg, case reports), it is advised to perform a salvage procedure.[2] While replacement of destroyed elements by prostheses is common practice in dentistry, it is new in wrist surgery. The option is in principle dismissed by fear of dislocation of the implant or periprosthetic arthritis.

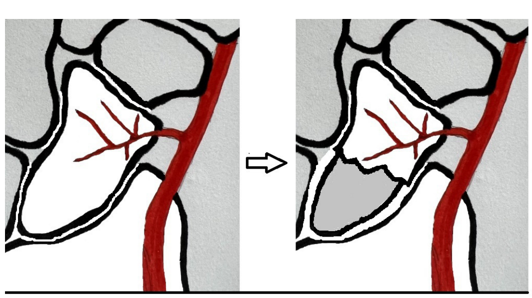

Figure 1 The scaphoid receives blood supply entering through the distal portion of the scaphoid. The proximal pole depends on intraosseous blood flow, and therefore, scaphoid fractures are the most common cause of avascular necrosis of the proximal pole of the scaphoid (illustration by author).

CASE PRESENTATION

A female patient in her 30s presented with severe right wrist pain that had started without a history of trauma/fracture. Wrist radiographs demonstrated sclerosis and fragmentation of the proximal pole of the scaphoid without evidence of fracture, which underlined the diagnosis of avascular necrosis of the scaphoid. Initially, she was treated by a pedicled vascularised bone graft, but a continuation of pain and decreased function remained. An X-ray 2 years postsurgery demonstrated progression of the avascular necrosis of the proximal pole of the right scaphoid (figure 2). Wrist pain made it impossible to function both professionally and in her favourite pastime volleyball. In a search for a solution, we looked for a prefabricated scaphoid prosthesis, but discovered that it was no longer in production. We then came in contact with a firm that produces 3D modelled acetabular implants for orthopaedic surgeons in our hospital (Link, Hamburg, Germany). Based on a CT scan of the unaffected left wrist, they were able to model the right scaphoid and also to create a tunnel from the tuberosity ventrally to the scapho-lunate region dorsally. This tunnel enabled the surgeon to fix the scaphoid implant with a strip of the flexor carpi radialis in a similar version as in the three ligament tenodesis. Four years after the initial diagnosis, the affected scaphoid was replaced by the 3D modelled prosthesis (figure 3).

MANUFACTURING OF THE PROSTHESIS

The customised scaphoid replacements are modelled using CT data for each individual patient. The 3D model of the patient's scaphoid includes a hole for suture passing of the flexor carpi radialis tendon for fixation purpose.

The custom-made scaphoid implants are manufactured by additive technique using an electron beam melting process.[3,4] This technology is based on forming layers of powder and alternate melting of these layers by an electron beam with bonding to the previous layer as defined by the computer model of the part.

These implants are manufactured from titanium alloy powder (TiAl6V4—Tilastan-E) according to the process described leading to creation of the customised shape of the implant. Postprocessing includes steps of polishing and hot isostatic pressing method to improve mechanical implant properties[3,4] as well as application of a golden coloured ceramic PorEx (titanium niobium nitride) coating,

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Figure 2 Preoperative X-ray where the arrow demonstrates the site with sclerosis and fragmentation of the proximal pole of the right scaphoid.

which significantly reduces the metal ion release of the substrate and shows low friction properties.[5 6]

Further postprocessing steps comprise cleaning, washing, packaging and sterilisation according to certified processes at the manufacturer (Link, Hamburg, Germany).

OUTCOME AND FOLLOW-UP

At 3 years follow-up, pain intensity had decreased from 8 to 1, patient rated wrist/hand evaluation from 87 to 59, quick Disabilities of the Arm, Shoulder and Hand from 77.5 to 43.2, grip strength from 14.7 to 19.3 n, wrist flexion from 10 to 25 degrees and wrist extension from 60 to 63 degrees. Final X-rays demonstrated no signs of dislocation of the implant or signs of periprosthetic arthritis (figure 4).

DISCUSSION

The scaphoid receives blood supply from branches of the radial artery, most entering through the distal portion of the scaphoid. The proximal pole is a vascular terminal zone dependent largely on intraosseous blood flow. Preiser disease is theorised to result from a disruption of this blood supply.[2] Whereas Preiser disease is a rare condition, scaphoid non-union resulting from a fracture is not. In both situations, replacement of (a part of) the scaphoid has been described with varying success. Haussman used a silicone prosthesis of the proximal pole leading to synovitis.[7] Sattel first described the use of a prefabricated titanium implant.[8] Spingardi applied this total scaphoid titanium arthroplasty and even in cases followed more than 10 years observed no problems related to radial surface wear, carpal reabsorption cysts or intolerance to the implant material.[9] More recently, Rosello applied a 3D-printed prosthesis of the scaphoid which was a copy of the prefabricated Sattel prosthesis which by that time was no longer available.[10] The drawback of a prefabricated

Figure 3 A model of the hand and wrist showing the 3D-printed prosthesis in position.

Figure 4 X-ray views at 3 years follow-up demonstrating no signs of dislocation of the implant or signs of periprosthetic arthritis.

prosthesis is that it never fits perfectly. The presently described prosthesis is modelled using CT data following the anatomy of each individual patient. Theoretically, this will lead to much less periprosthetic arthritis.

Both salvage techniques which are standard care in scaphoid non-union advances collapse have functional disadvantages. A proximal row carpectomy reduces length of the forearm and thus strength. A scaphoidectomy and four corner fusion also reduces length and requires immobilisation, causing stiffness. The fact that both grip strength and mobility improved in our case suggests that this method is promising and future experimental studies are ungoing.

Learning points

- Scaphoid non-union advanced collapse does not necessarily require a salvage procedure.
- Based on a CT scan of the unaffected wrist, it is possible to model the scaphoid that has to be replaced.
- Fear of dislocation of the implant or periprosthetic arthritis appears to be unfounded.

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Case reports provide a valuable learning resource for the scientific community and can indicate areas of interest for future research. They should not be used in isolation to guide treatment choices or public health policy.

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