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TECHNICAL NOTE • WRIST - ARTHROPLASTY

Surgical technique: about a new total and isoelastic wrist implant (Prosthelast®)

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Abstract
This study describes a new total wrist implant (Prosthelast®) designed to reduce the risk of distal migration of the carpal component. The Prosthelast® implant consists in a one-block radial implant replacing the metaphysis and the articular surface fixed to a radial elastic centromedullar wire and a carpal component in titanium with an articular condylar surface in polyethylene. We operated on five patients (three male patients and two female patients) and followed them up for 12 months on average. Two of the patients presented with rheumatoid arthritis of the wrist, and an ulnar osteotomy (Darrach procedure) was carried out at the same time of the arthroplasty. All clinical variables improved postoperatively (Quick DASH score, pain score, range of motion) except from wrist flexion which was reduced. No patients underwent revision surgery. Two patients presented with a periprosthetic radiolucent loosening around the radial component, but no implant migration was observed. Overall, the preliminary results of our case series show that the new Prosthelast® implant presents comparable short-term results to those described in the literature. We will follow up the patients to verify that long-term results are as satisfactory as the short-term results.

Keywords Implant · Wrist · Isoelastic · Carpal implant · Radial implant

Introduction

Since 2000, total wrist replacement implants have improved, reaching survival rates of 5 years in more than 90% of the cases [1–3]. The three most widely spread types of wrist implants (Freedom®, Remotion®, Maestro®) were conceived following the same design: a one-block radial component and a carpal component consisting of a central body and two lateral screws.

Some authors have shown recently that the survival rate of total wrist implants would drop to 69% on a 10-year follow-up [4]. The main reasons for the implant failure would be the axial defect of the radial component and the stress-shielding forces around the carpal component. The consequences of these features would be the loosening around the radial component and around the fixation screws of the carpal component [5].

The aim of this study was to describe a new total wrist replacement implant (Prosthelast®) designed to reduce the risk of distal migration of the carpal component, to describe the operative technique, to report the short-term clinical results of the first five cases.

Description of the total wrist replacement implant Prosthelast®

The total wrist replacement implant Prosthelast® (Argomedical™, Cham, Switzerland) consists of a radial and a carpal component (Fig. 1).

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Fig. 1 Components of the total wrist replacement implant Prosthelast®. On the left, the radial component, on the right the carpal component

The radial component consists of a one-block implant replacing the radial metaphysis and the articular surface on one side and on the other side a centromedullar elastic radial wire. The one-block radial implant has a titanium and an hydroxyapatite coating and includes horizontal orifices at the junction between the metaphysis and the epiphysis available in case of capsular and ligamentous reinsertion and a vertical orifice for the radial wire which will be fixed by a screw.

The carpal one-block component consists of two distinct segments: a distal titanium segment of which the concave surface is covered in hydroxyapatite and carries the orifices for the screws and a proximal polyethylene segment with a condylar shape.

The primary fixation of the radial component is based on the radial elastic wire in the centromedullar tunnel, whereas the fixation of the carpal component is based on the locking screws. The secondary fixation is based on the osteointegration of the titanium and hydroxyapatite coating.

The tribology is based on the friction coupling of the metal and polyethylene of the implant.

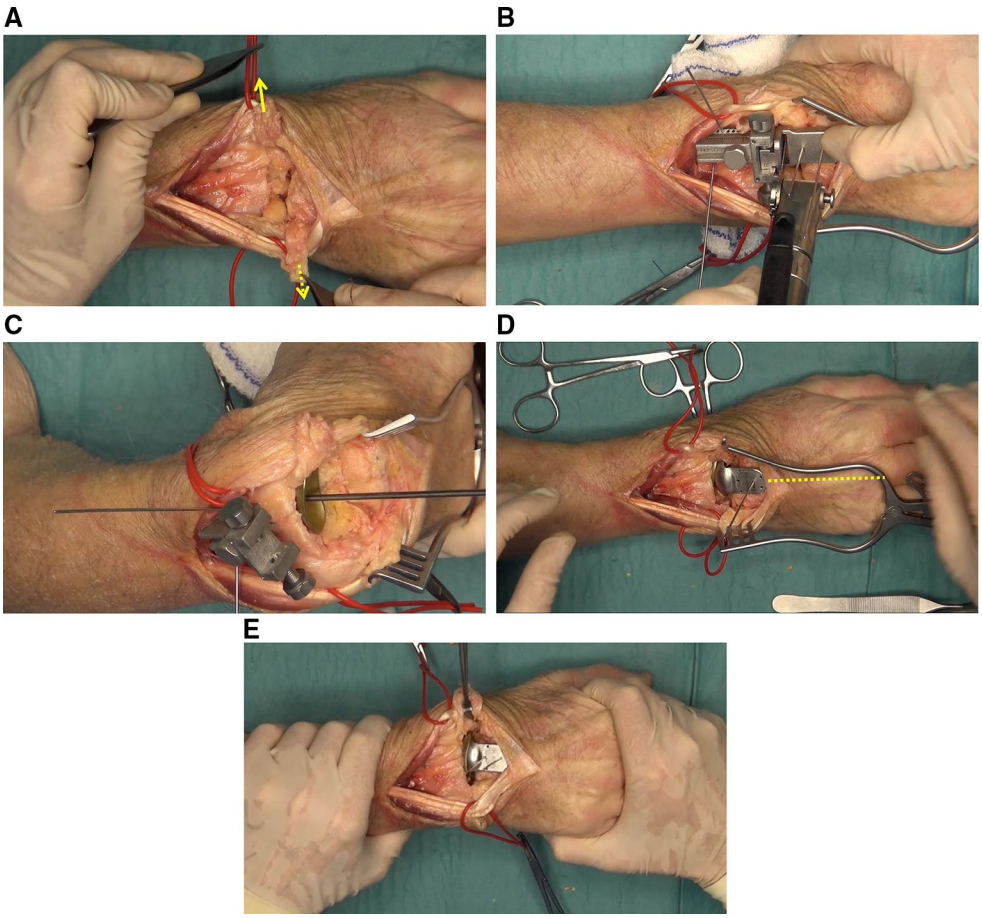

Fig. 2 Total wrist replacement procedure with Prosthelast® on an anatomical specimen. **a** Dorsal approach to the wrist. The tendons of the extensor pollicis longus (above), extensor digitalis communis and extensor indicis proprius (below) are isolated with a vessel loop. The two capsular flaps are raised to expose the radiocarpal joint: The proximal flap is medially based (solid arrow), and the distal flap is laterally based (dotted arrow). **b** With an oscillating saw we drilled through the carpal guide orifice which is fixed to the main guide to perform the proximal row carpectomy through the capitate head. **c** The trial cannulated radial implant is introduced through a 2.5-mm-diameter nail and pushed through the distal radius. **d** The trial carpal implant is applied to the dorsal aspect of the capitate and fixed through a 1.5-mm-diameter nail through its central orifice. The longitudinal axis of the implant has to correspond with the axis of the third metacarpal bone (dotted line on the right). **e** After reduction, the ligament balance is tested manually, here on the frontal plane

The modularity is based on the availability of two sizes: standard and small for both radial and carpal components. The ligament balance is achieved adjusting the position of the carpal component on the carpus, more distally to distend the soft tissues, more proximally to stretch them out.

Operative technique

The total wrist replacement procedure using Prosthelast® (Argomedical™, Cham, Switzerland) is usually carried out as a day case, under regional anaesthesia and arm tourniquet with the patient in a supine position. The technique consists of six steps using an adapted surgical ancillary tool (Video 1 as Supplementary material).

During the first step, a dorsal approach to the wrist is carried out, no undermining on the radial side is performed, and all dorsal veins are carefully preserved. An incision though the fourth extensor compartment synovial sheath is made, and the radiocarpal joint is exposed by raising two capsular triangular flaps based, respectively, medially and laterally (Fig. 2a).

The second step is aimed at creating a space for the implant. The main guide is fixed to the dorsal surface of the radius on both sides of the Lister tubercle. A carpal guide, screwed to the main guide, allows the first carpal row osteotomy. Care must be taken to start the osteotomy 1–2 mm away from the capitate head (Fig. 2b). A proximal row carpectomy is then performed to create a space for the implant.

During the third step of the procedure, the radial component is placed. After placing a radial drilling guide, screwed to the main guide, the subchondral bone of the articular surface of the distal radius is drilled, carefully preserving the epiphyseal bone stock. A 2.5-mm-diameter nail is then introduced manually into the radial epiphysis and pushed through the medullary cavity into the subchondral bone of the radial head. A cannulated bone rasp is then introduced on the nail and pushed in the medullary canal with a bone hammer to create a space for the radial implant. A cannulated trial radial implant is introduced on the nail in order to measure the definitive length of the centromedullar nail (Fig. 2c). The definitive size radial implant (Prosthelast®, Argomedical™, Cham, Switzerland) connected to the centromedullar nail and locked with a specific screw is pushed and placed. A fluoroscopy check of the wrist and of the elbow is performed

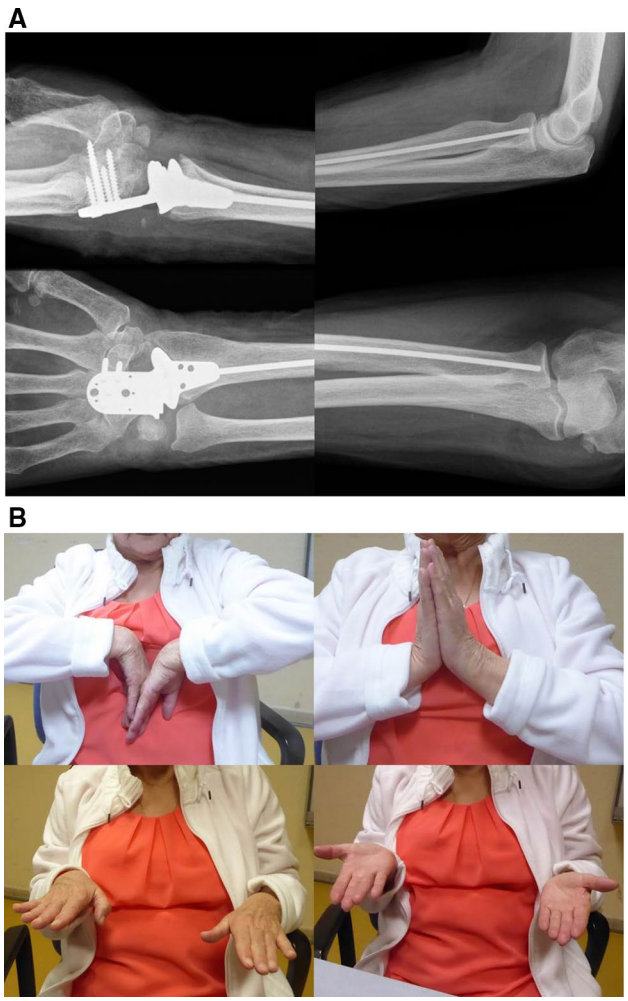

Fig. 3 Total wrist implant Prosthelast® (clinical case no. 2). **a** Postoperative X-ray check. **b** Clinical result 9 month after the surgery

Table 1 A case series of five patients who underwent a total wrist arthroplasty procedure with Prosthelast®

Patient (*n*)	Age (years)	Gender (M/F)	Dominant side (R/L/A)	Affected side (R/L)	Aetiology
1	70	M	R	L	SCAC
2	75	F	L	L	SCAC
3	75	F	R	L	SCAC
4	59	M	A	L	RA
5	60	M	R	R	RA

M male, *F* female, *R* right handed, *L* left handed, *A* ambidextrous, *RP* rheumatoid arthritis, *SCAC* scaphoid chondrocalcinosis advanced collapse

Table 2 Clinical results on a case series of five patients who underwent a total wrist arthroplasty procedure with Prosthelast®

Patient (*n*)	Follow-up (months)	Darrach (Y/N)	Quick DASH (0–100)		Pain score (0–10)		Flexion		Extension		Pronation		Supination		Grasp		Complications	Revision surgery (Y/N)
			Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op		
1	6	N	34.09	29.55	5	8	45	45	25	40	70	75	70	85	3	8	Haematoma/CT	N
2	9	N	90.91	61.36	7	2	40	40	30	45	80	85	80	85	6	8		N
3	11	N	31.82	20.45	5	2	55	25	40	0	70	70	70	80	10	8		N
4	7	O	45.45	54.55	2	5	60	45	30	60		70		45		8		N
5	35	O	70.45	54.55	7	7	55	50	20	40	70	80	50	80	2	12		N
Mean	14		54.54	44.09	5.2	4.8	51	41	39	37	72.5	76	67.5	75	5.25	8.8		

D Darrach, *CT* carpal tunnel

to verify that the radioulnar index is satisfactory and that the centromedullar nail is stable in the subchondral bone of the radial head.

The fourth step is aimed at preparing a space for the placement of the carpal component. A carpal trial implant consisting of a round articular surface and a flat surface for the carpus is applied to the dorsal aspect of the capitate. The carpal component position is adjusted in order to restore the normal carpal height and so that the longitudinal axis of the implant corresponds to the longitudinal axis of the third metacarpal bone. A 1.5-mm-diameter nail is then drilled through the central orifice of the trial carpal implant (Fig. 2d). The trial carpal implant is then removed, and a cannulated disc-shaped rasp is introduced on the nail creating a slight depression which will allow the alignment the superficial aspect of the implant to the dorsal aspect of the capitate. The definitive size carpal implant (Prosthelast®, Argomedical™, Cham, Switzerland) is placed on the nail through its central orifice and applied to the dorsal aspect of the capitate. 2.7-mm-diameter locking screws are secured to the flat surface of the definitive carpal implant. A fluoroscopy check is performed to make sure that the normal height of the carpus is restored and that the longitudinal axis of the implant corresponds to the longitudinal axis of the third metacarpal bone.

The fifth step is the implant reduction. The ligament balance is manually checked (Fig. 2e). In case of excessive ligament tension that could cause on the long term an implant loosening, a revision osteotomy of the capitate is performed in order to lower the carpal implant. If the ligament tension is insufficient, which would cause on the long term an implant dislocation, the capitate defect is filled by a bone graft harvested from the previously resected proximal carpal row to bring the carpal implant higher.

The sixth step includes closure and postoperative care. The two triangular capsular flaps medially and laterally based are sutured to each other, achieving the right tension to avoid joint instability or wrist stiffness. The capsule is not sutured to the radius to avoid any limitations to wrist mobility. The extensor retinaculum and the skin are sutured, and no drains are placed. A volar splint is made, maintaining 30° of wrist extension. The tourniquet is deflated. According to the postoperative continuous analgesia protocol (APC) [6], a perineural catheter delivering ropivacaine 0.75% is placed and removed on the third day after surgery. On the second week after surgery, the volar splint and the sutures are removed and self-physiotherapy is started.

Clinical cases

Five patients underwent total wrist arthroplasty with Prosthelast® (Table 1).

Table 3 Radiological results on a case series of five patients who underwent a total wrist arthroplasty procedure with Prosthelast®

Patient (*n*)	Follow-up (months)	Radius		Carpus		
		Loosening (Y/N)	Migration (Y/N)	Loosening central plot (Y/N)	Loosening screw (Y/N)	Migration (Y/N)
1	6	N	N	N	N	N
2	1	Y	N	N	N	N
3	1	N	N	N	N	N
4	7	N	N	N	Y	N
5	24	Y	N	N	Y	N

Y yes, *N* no

Three male patients and two female patients with an average age of 68 years old presented with severe chondrocalcinosis (in three cases) and rheumatoid arthritis (in two cases). None of the patients had been operated before for a wrist condition.

All patients were operated under regional anaesthesia and on a day surgery regime following the previously described technique (Fig. 3). Regarding the two rheumatoid arthritis cases, a Darrach ulnar osteotomy was performed.

On the average follow-up, all clinical variables have improved postoperatively (quick DASH score, pain, range of motion) except from wrist flexion which was reduced (Table 2). A secondary carpal tunnel syndrome was triggered in one of the patients. All symptoms and signs subsided completely after a carpal tunnel release was performed. Pain score was described as superior or equal to 5 in the two patients presenting rheumatoid arthritis, also due to the contralateral wrist being affected. No revision surgery has been performed so far. Radiological signs of periprosthetic loosening were found in two cases around the radial implant and around two carpal screws, but we did not observe any migration of the radial or carpal component (Table 3).

Discussion

The anatomy and the biomechanics of the wrist are complex. Anatomically the wrist consists of two compartments, a radiocarpal and a mediocarpal one. The radiocarpal compartment is an adaptive condylar joint, and the mediocarpal compartment consists of an arthrodial joint (scapho-trapezio-trapezoid joint or STT), a condylar joint (lunate-capitate joint) and an helicoid joint (triquetro-hamate joint) [7]. From a biomechanics point of view, mechanical stress forces affect both compartments of the wrist through compression, tension, torsion and shear stress [8].

None of the currently available total wrist replacement implants respect neither the anatomy nor the biomechanics of the wrist. All available total wrist implants suppress the proximal carpal row turning the wrist into a condylar joint absorbing all the mechanical stress forces. The three most widely spread types of wrist implants (Freedom®, Remotion®, Maestro®) were conceived following the same design: a one-block radial component and a carpal component consisting of a central body and two lateral screws. In order to compensate for the longitudinal axis defect, some authors suggested to lengthen the nail of the radial component (Cobra®) which tends to settle in the centromedullar canal [9], causing as an inconvenient an increase in the mechanical stress at the prosthesis-diaphysis junction.

The Prosthelast® implant is designed to overcome these limitations. Regarding the radial component, an elastic wire fixed distally to the radial implant is introduced across the centromedullar canal to the subchondral bone of the radial head [10]. The centromedullar wire allows the correction of the longitudinal axis defect and redistributes the mechanical forces across the radial diaphysis. The micromovements caused by the centromedullar wire abide by the isoelasticity concept [11]. Regarding the carpal implant, the screw orientation (horizontal instead of vertical) is aimed at reducing the stress-shielding forces. This orientation of the screws follows the concept of spider plates in mediocarpal arthrodesis [12].

Overall, the preliminary results of our case series show that the new Prosthelast® total wrist implant presents comparable short-term results to those described in the current literature. We will follow up the patients to make sure that long-term results are as satisfactory as the short-term results.

Compliance with ethical standards

Conflict of interest Philippe Liverneaux has conflicts of interest with Newclip Technics, Argomedical, Zimmer Biomet, Biomodex. The remaining authors declare that they have no conflict of interest.

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