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New and Improved Orthopedic Hardware

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New and Improved Orthopedic Hardware for the 21st Century: Part 1, Upper Extremity

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OBJECTIVE. The purpose of this article is to provide a survey of new orthopedic products for use in the upper extremity.

CONCLUSION. Knowledge of the physiologic purpose, orthopedic trends, imaging findings, and complications is important in assessing new orthopedic devices.

Keywords: arthroplasty, musculoskeletal imaging, orthopedic hardware, radiography

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New orthopedic products are constantly being developed for fracture fixation, arthrodesis, and arthroplasty. Eloquent description of orthopedic hardware and of related complications is an essential part of interpreting musculoskeletal radiology studies and is more important than merely reporting the manufacturer name for a particular construct. Keeping up with the latest hardware technology is an important task for radiologists. This article will provide a survey of new orthopedic devices for use in the upper extremity.

Hardware Complications

A solid understanding of common types of hardware complications is necessary before starting this review of newer orthopedic hardware. The hardware can fracture, disengage if there are multiple components, or loosen. Because of differences in stress distribution after hardware fixation, periprosthetic fractures are also possible. Some hardware materials introduce specific complications; for example, polyethylene is associated with asymmetric wear and small-particle disease. Thus, knowledge of component design and material composition of the hardware is important for predicting and understanding complications.

Clavicle, Acromioclavicular Joint, and Shoulder

Traditionally, clavicle fractures have been treated nonoperatively. However, recent studies have shown better functional outcomes with surgical fixation [1]. A blade hook clavicle plate (Fig. 1) is a new hardware option for fracture fixation. Unlike dynamic compression plates and intramedullary rods, the blade hook clavicle plate allows normal biomechanical rotation between the clavicle and the acromion [2]. The plate is anatomically precontoured with a distal hook inserted underneath the acromion and posterior to the acromioclavicular joint. Generally three or four screws are used to fix the plate to the clavicle. Interfragmentary screws are often concomitantly used to improve apposition of fracture fragments; these screws should be perpendicular to the fracture plane. The end of the hook should be within 1–2 mm of the acromion. The main complication of the blade hook clavicle plate is unhooking from the acromion (Fig. 2). Other complications include osteolysis around the hook, medial clavicle fracture, rotator cuff damage, skin sloughing, and acromioclavicular joint osteoarthritis.

New hardware is also available for the treatment of acromioclavicular joint dislocation. The TightRope technique (TightRope Syndesmosis Repair Kit, Arthrex) uses radiolucent FiberWire (Athrex) sutures fixed by EndoButtons (Smith & Nephew) between the coracoid and clavicle [3] (Fig. 3A). The advantage of this technique is that it is minimally invasive and a second surgery is not required. On postoperative imaging, the EndoButtons should be flush against the coracoid and clavicle, and the acromioclavicular and coracoclavicular distances should be stable. Possible complications include loosening of the sutures, seen as increased coracoclavicular or acromioclavicular distance

(Fig. 3D); EndoButton displacement; fracture; or a soft-tissue mass adjacent to the EndoButtons from granulomatous reaction [4].

Biotenodesis screws (Arthrex), composed of bioabsorbable, radiolucent poly-L–lactide acid, are hardware used for tendon transfers or acromioclavicular joint dislocations. Although radiographic findings may be small in these patients, the underlying procedure may have been quite extensive, including transfer of large amounts of muscle or tendon from other sites of the body. Without a clinical history, these screws could raise concern for metastatic or myelomatous lesions because they appear on radiographs as new round, radiolucent defects in previously normal cancellous bone (Fig. 4A). On MRI, the bioabsorbable screws are low signal intensity on all sequences (Fig. 4B).

Partial resurfacing of the humeral head is a new hardware design introduced in the past few years to treat avascular necrosis or asymmetric chondral defects [5] (Fig. 5). The hardware consists of a titanium screw post attached to a cobalt-chromium alloy surface component. Long-term outcome studies at 48 months have shown increased patient range of motion, improved functional and mental scores, and decreased pain [5]. The only reported complication is the presence of an intraarticular loose body.

Elbow

Radial head replacement is performed to treat complex radial head fractures. Traditionally, unipolar radial head replacements have been used. Recently, a bipolar radial head replacement was developed (Fig. 6). The replacement head can appear to have mild angulation on radiographs because it has a 15–35° range of motion in all planes, mimicking native anatomy, whereas the stem will remain parallel to the radial shaft. There is a unique risk of disengagement of the snap-on head-to-stem components of the bipolar prosthesis (Fig. 7) compared with the unipolar type, which is one single unit of hardware. Other possible complications include loosening, periprosthetic fracture, and asymmetric joint alignment from too thick of a radial head, termed "overstuffing." Overstuffing is seen on anteroposterior radiographs as an asymmetrically narrowed medial aspect of the ulnohumeral joint space with gapping of the lateral aspect of the ulnohumeral joint space [6]. Overstuffing can result in osteoarthritis of the radiocapitellar joint space, capitellar erosions, capitellar osteopenia, and decreased range of motion at the elbow.

Capitellar resurfacing has recently been described to treat radiocapitellar osteoarthritis in patients with radial head arthroplasty [7]. The implant consists of a skirted rim attached to a cobalt-chrome peg (Fig. 6). The capitellar implant should be flush against the bone and normally articulating with the radial head. Possible complications include loosening and overstuffing of the radiocapitellar joint.

Headless titanium screws (Acutrak Mini screws, Acumed) (Fig. 8) are an alternative to radial head arthroplasty for complex radial head and capitellar fractures because they do not pose the risks of arthroplasty loosening or overstuffing. These screws are headless and therefore can be inserted through and beneath articular surfaces without blocking or damaging joint function. These titanium screws are cannulated and tapered with a thread pitch that gets narrower to allow compressive function and to improve internal holding power. Additionally, they are self-tapping—meaning that the screw cuts its own threads as it is inserted into the bone over a guidewire [8]. Reported complications include avascular necrosis of the head and neck and fracture nonunion.

Wrist

For many years, fracture fixation has relied on anatomic reduction using a dynamic compression system. Recently, the locking plate technique has been shown to be superior for the treatment of comminuted, unstable, or osteoporotic fractures [9]. In locked plates, the locking screws mate with the threaded plate holds, creating a fixed-angle construct, negating the need for double-cortex fixation (Fig. 9). Although compression plating requires absolute stability for bone healing, locking plates function as internal fixators with multiple anchor points. The locking plates are better for osteoporotic fractures because they decrease the potential for toggling of screws in the cortex and loss of purchase of small bone fragments, thus providing stable fixation required for healing.

Another notable new locking hardware design is the Volar Buttress Pin (TriMed) and Radial Pin Plate (TriMed) (Fig. 10); they are unique in that they act as a three-axis correction of radial length, volar tilt, and radial inclination [10, 11]. There is also decreased soft-tissue irritation. The buttress plate clip allows elevation of impacted fractures for correction of radial length by bending of the pins and movement of the pins along the length of the plate. Unique complications include pin protrusion through the dorsal surface resulting in damage to extensor tendons and nerves.

An even less invasive new hardware for distal radius fracture fixation is a flexible stainless-steel curved intramedullary implant (Wrist Rocket WRx, Sonoma Orthopedic Products) (Fig. 11). It has locking cortical screws and distal and proximal grippers to engage the intramedullary cortex for rigid fixation while a buttress peg supports the subchondral bone. The main advantage of the hardware is less volar soft-tissue disruption, allowing earlier range of motion and less soft tissue being affected by complications [12].

New hardware for arthroplasty and arthrodesis of the wrist is available. At the distal radioulnar joint (DRUJ), a new prosthesis (Scheker prosthesis, Aptis Medical) that has a constrained design allows full supination and pronation at the joint (Fig. 12A). The prosthesis consists of a cobalt-chromium plate attached to the distal radius by a peg and five screws. An ulnar polyethylene polymer ball attaches to the plate through a hemisocket [13]. Possible complications include hardware loosening (Fig. 12B), disarticulation between the radial and ulnar components, particle disease, and periprosthetic fracture.

Alternatively, the DRUJ can be replaced in a nonconstrained design: The Sigmoid Notch (Small Bone Innovations) implant is a polyethylene insert that slides on a metal radial plate and is secured by lock and screw [14] (Fig. 13). With no link between the components, malarticulation and dislocation are additional potential complications.

Established options for midcarpal fusion or arthroplasty include the Spider Plate (Kinetikos Medical), universal total wrist arthroplasty, and arthrodesis plate. A new device is the Xpode Fusion Plate (Stratmed) (Fig. 14), modeled after the Spider Plate. The Xpode Fusion Plate differs from the Spider Plate in that the Xpode plate is composed of polyethylene, thus allowing full visualization of the degree of fusion between the carpal bones.

Hand and Fingers

Multiple methods for first carpometacarpal joint arthroplasty are available, including hematoma interposition, tendon transfer, and cartilage interposition. Among these methods, new hardware currently available include the PyroHemiSphere (Ascension Orthopedics) and saddle carpometacarpal pyrocarbon implant [15] (Fig. 15). Both designs preserve the trapezium as a bridge to future carpometacarpal joint arthroplasty. These prostheses are composed of pyrolytic carbon coating over a graphite core. Pyrocarbon is a material with an elastic modulus similar to that of cortical bone, thus providing bone-stress transfer.

Pyrocarbon implants are also being used instead of silicone for metacarpophalangeal and proximal interphalangeal joint arthroplasty because of the high complication rates of silicone synovitis and silicone implant fracture. Pyrocarbon implants rely on the overlying soft tissues for movement at the joints.

In postoperative evaluation of pyrocarbon implants, visualization of greater than 2 mm of periprosthetic lucency suggests loosening of the implant and can result in changes in range of motion at the joint and subsequent volar or dorsal tilt of the implant (Fig. 16). No complications unique to the pyrocarbon material have been reported to date.

Conclusion

With continued evolution of orthopedic hardware, the radiologist must keep pace with these advancements and understand the indications for, functions of, and potential complications of these devices.

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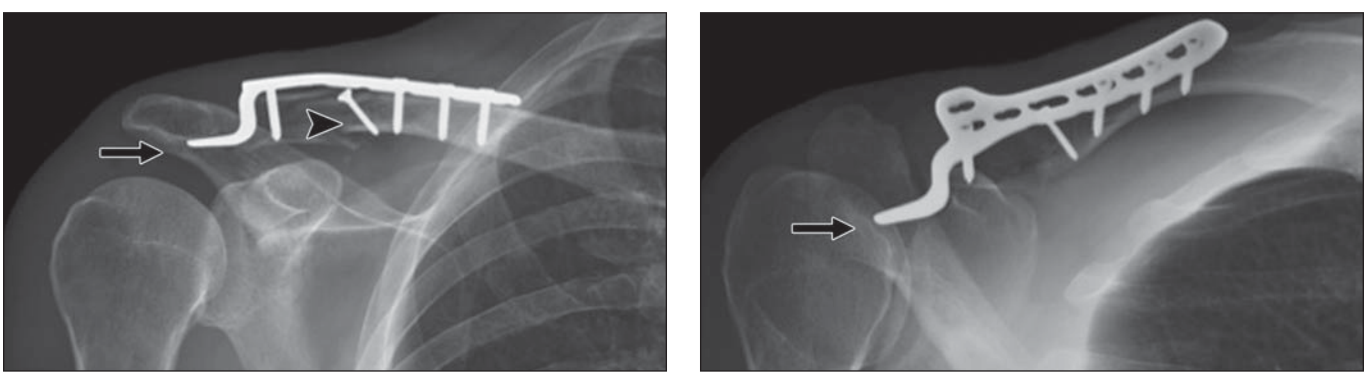


A B

Fig. 1—Use of blade hook clavicle plate to treat distal third shaft right clavicle fracture in 58-year-old woman.
A and **B,** Anteroposterior (**A**) and anteroposterior oblique (**B**) radiographs of distal third shaft right clavicle fracture show blade hook clavicle plate. Hook is within 1–2 mm of undersurface of acromion (*arrow*) and is posterior to acromioclavicular joint, which is normal location. Interfragmentary screw (*arrowhead*, **A**) is also present.

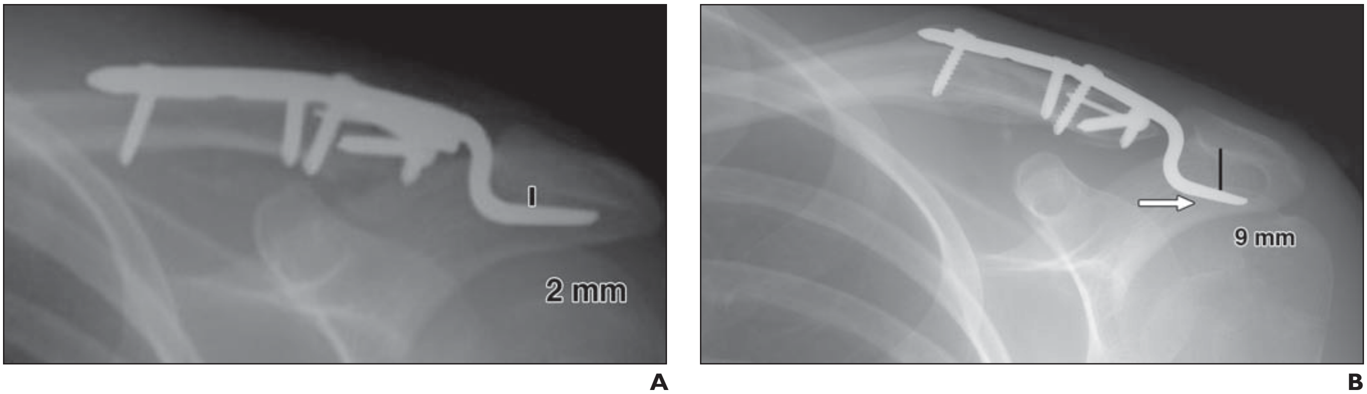


Fig. 2—18-year-old man with left clavicle fracture shows normally positioned blade hook clavicle plate fixating comminuted distal third clavicle shaft fracture.
A, Initial postoperative anteroposterior radiograph of left clavicle shows normally positioned blade hook clavicle plate fixating comminuted distal third clavicle shaft fracture. Black line shows distance between hook and undersurface of acromion.
B, Anteroposterior radiograph obtained 10 months after **A** shows that, although hook of clavicle plate is underneath acromion (*arrow*), new 7-mm gap has developed since initial radiograph; this finding is consistent with progressive unhooking. Black line shows distance between hook and undersurface of acromion.

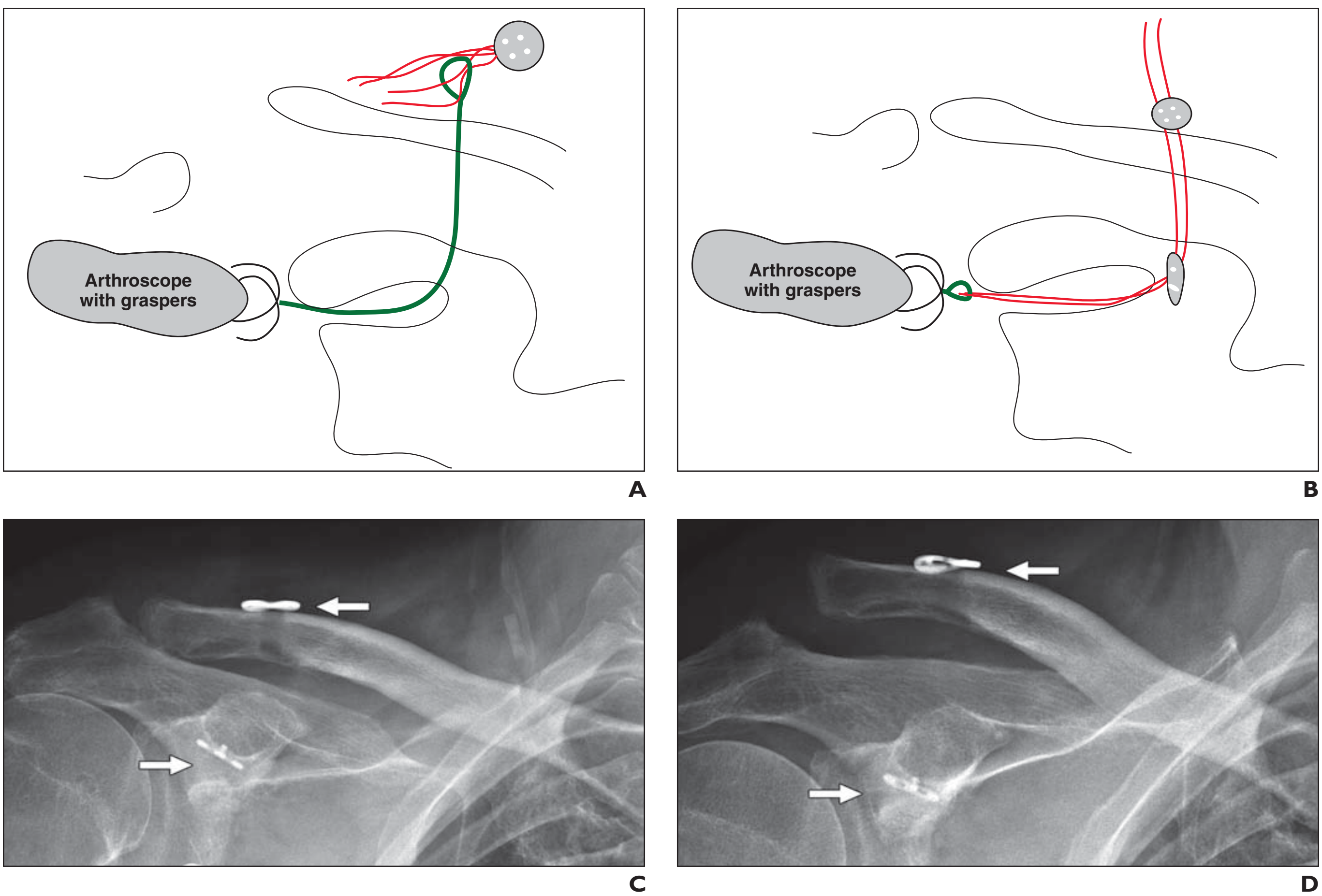
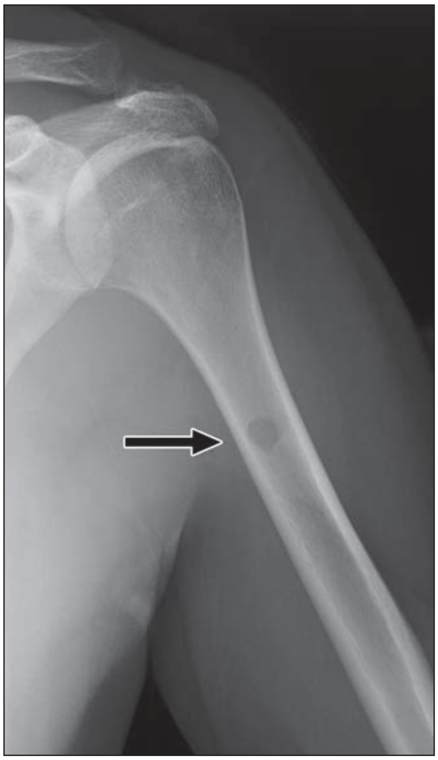
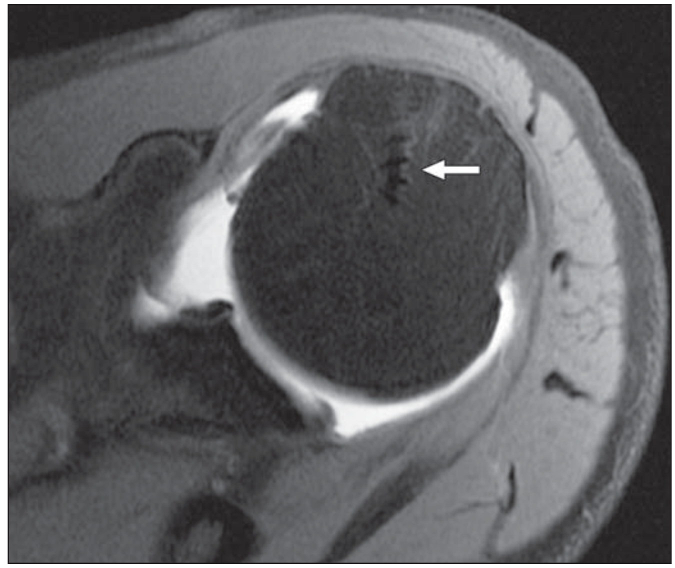


Fig. 3—Use of TightRope Syndesmosis Repair Kit (Arthrex) to treat acromioclavicular joint dislocation.
A, Illustration shows that after holes are drilled through clavicle and coracoid, nitinol suture passing wire (*green*) is passed through drill and grasped by arthroscope. Hook at end of wire grasps two FiberWires (Athrex) (*pink*) that are attached to EndoButtons (Smith & Nephew).
B, Illustration shows nitinol wire (*green*) being pulled by arthroscope, which subsequently pulls FiberWire and EndoButton complex (*pink* [TightRope]) down tract until in end position and acromioclavicular dislocation is reduced.
C, Anteroposterior radiograph of right shoulder in 55-year-old man shows EndoButtons (*arrows*) on superior aspect of clavicle and undersurface of coracoid bridged by radiolucent tract. This is normal radiographic appearance of clavicle TightRope.
D, Anteroposterior radiograph of same patient 1 month after **C** shows failure of TightRope fixation, with abnormal widening of acromioclavicular and coracoclavicular distances (*arrows*).



A

Fig. 4—Bioabsorbable screw in humerus of 46-year-old man.
A, Radiograph of left humerus shows well-circumscribed lucency (*arrow*) in proximal diaphysis of left humerus due to radiolucent bioabsorbable screw (Biotenodesis screw, Arthrex) attaching to biceps tendon.
B, Axial T1 fat-suppressed arthrogram of left shoulder shows screw (*arrow*) in humeral head. On all MR sequences, bioabsorbable screws will be low signal intensity.



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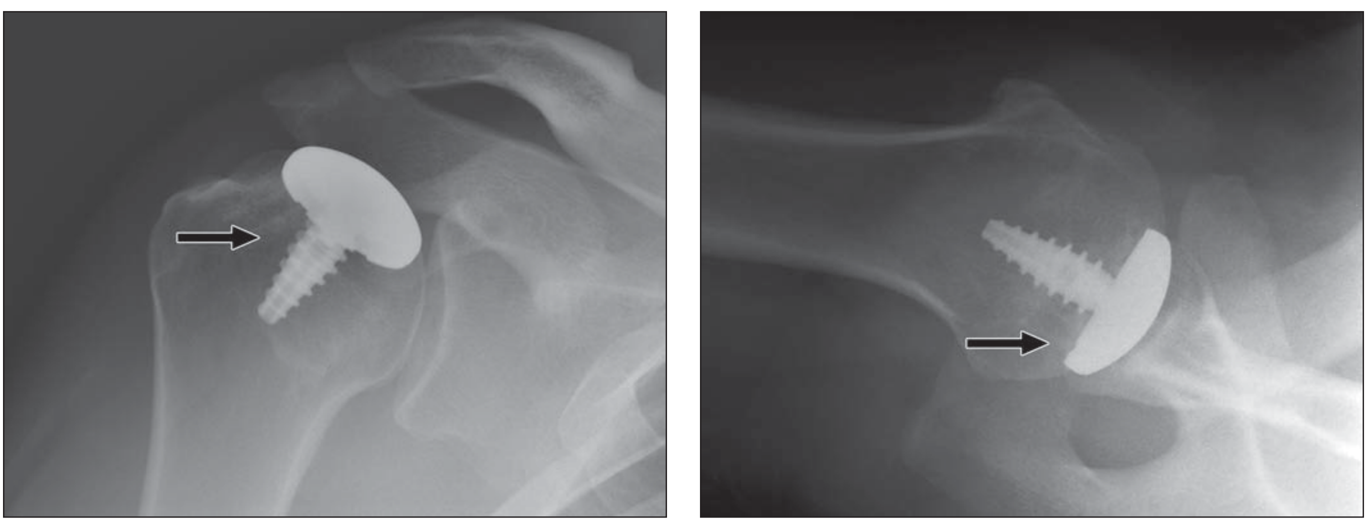
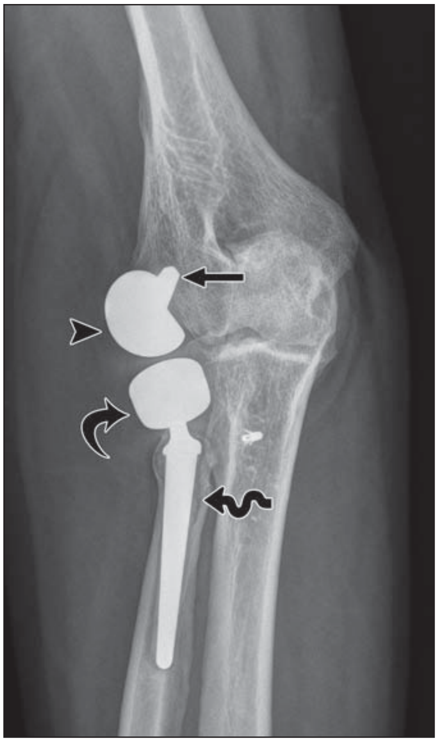


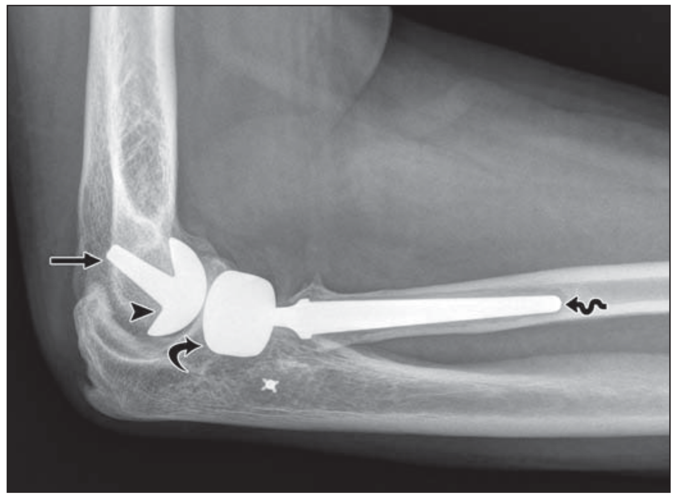
A B

Fig. 5—31-year-old man who underwent arthroplasty of right shoulder for chondral defect related to previous dislocations.
A and **B,** Anteroposterior (**A**) and axillary (**B**) radiographs show partial resurfacing arthroplasty (*arrow*).



A

Fig. 6—42-year-old man with radial head and capitellar arthroplasty.
A and **B,** Anteroposterior (**A**) and lateral (**B**) radiographs show capitellar resurfacing implant and long-stemmed bipolar metal radial head implant. Capitellar implant consists of skirted rim (*short straight arrow*) and peg (*arrowhead*), and bipolar radial head implant consists of head (*curved arrow*) articulating with stem component (*squiggly arrow*).



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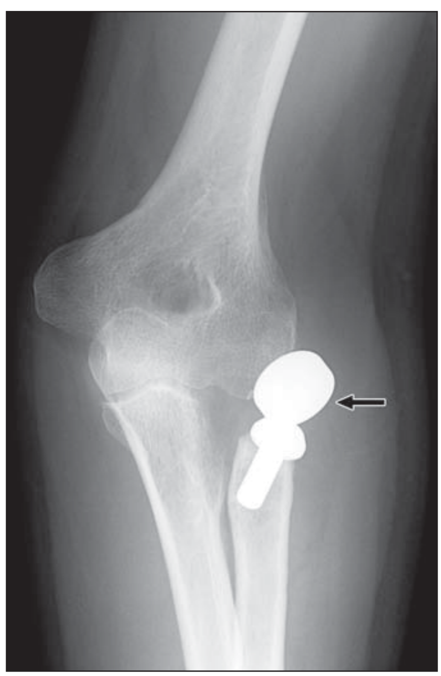
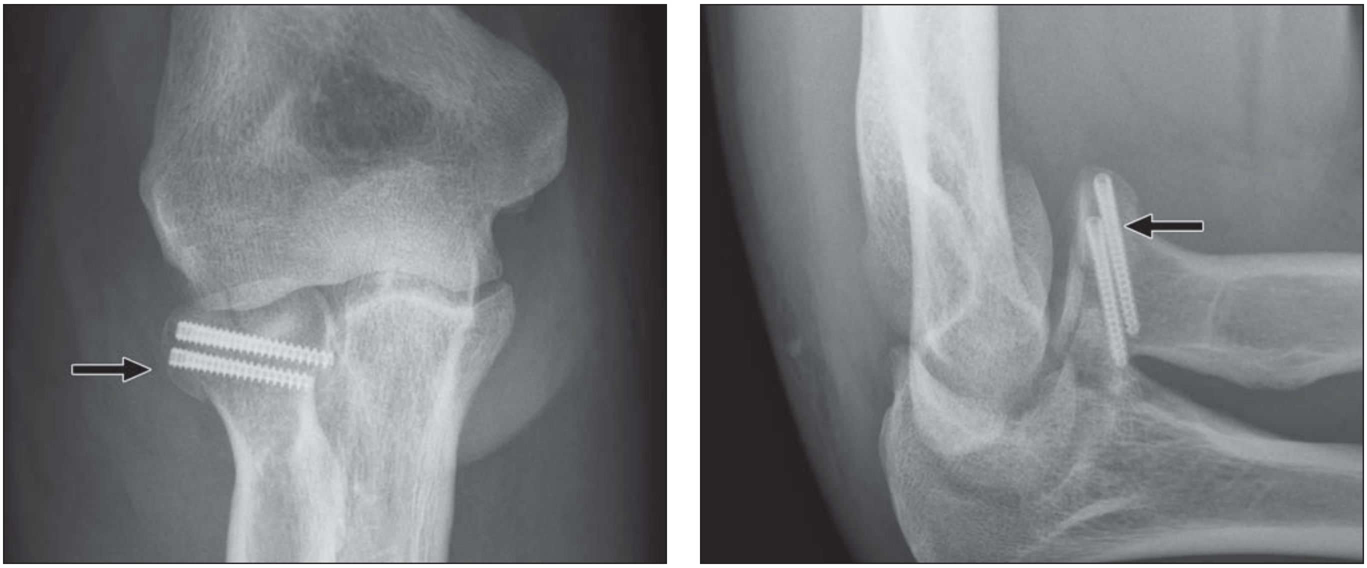
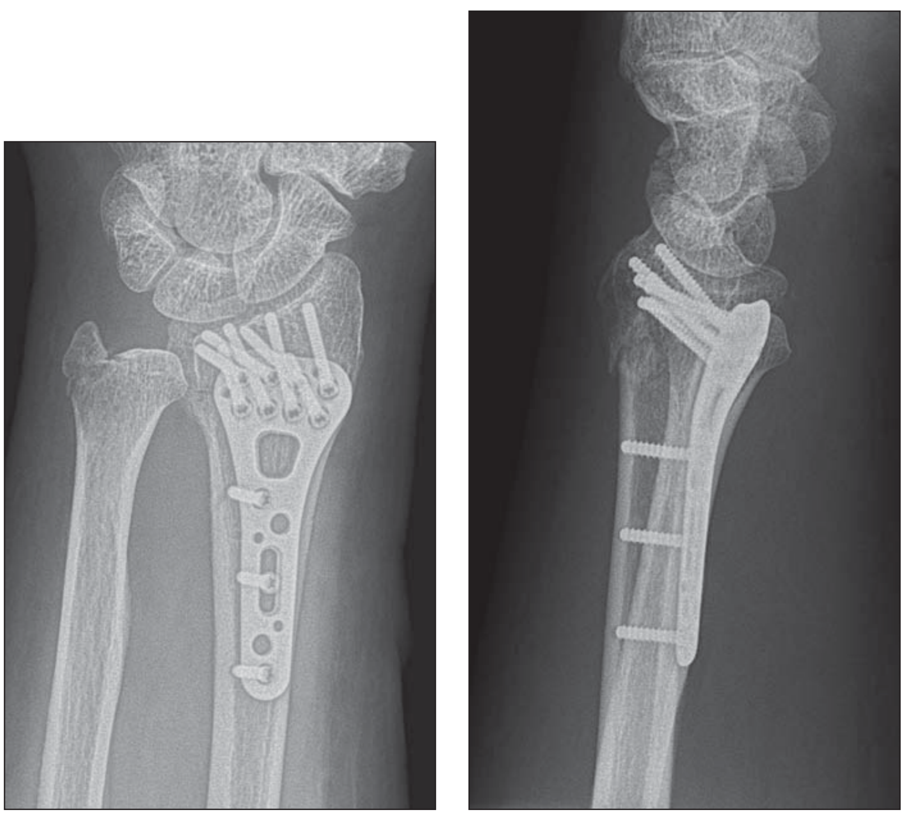


Fig. 7—34-year-old man with radial head arthroplasty for complex radial head fracture. Anteroposterior radiograph shows bipolar radial head implant (*arrow*). Head is at near 90° angle in relation to stem, resulting in disarticulation and disengagement of bipolar components.



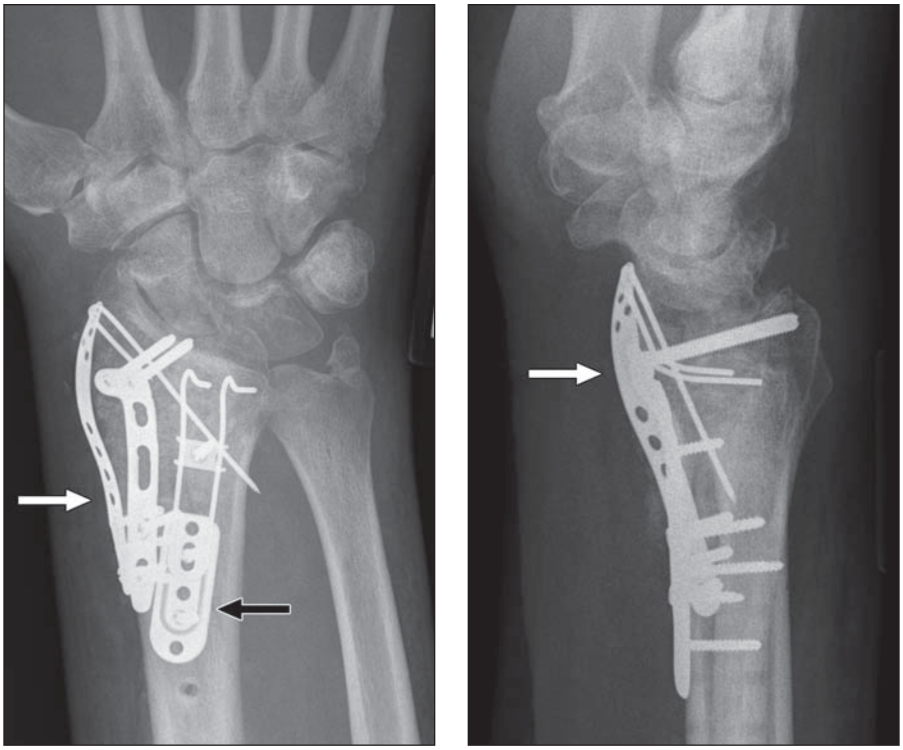
A B

Fig. 8—45-year-old man with radial head fracture.
A and **B,** Anteroposterior (**A**) and lateral (**B**) radiographs show two screws (Acutrak Mini, Acumed) (*arrow*) fixating intraarticular fracture of radial head.



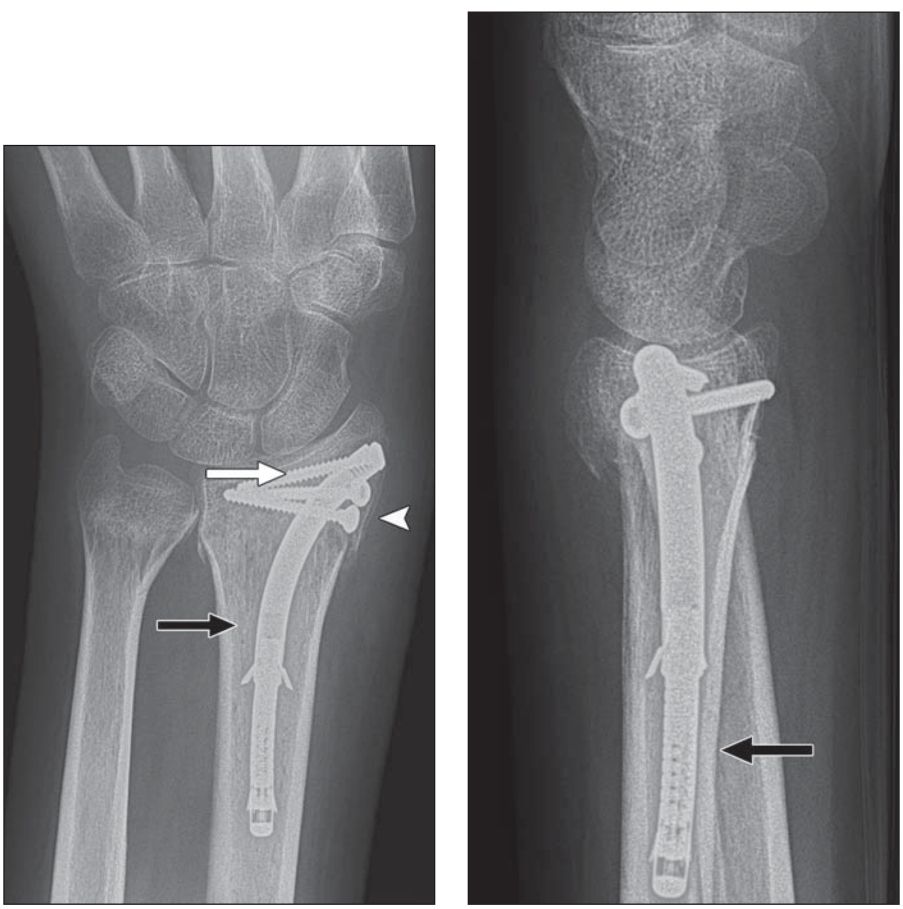
A B

Fig. 9—67-year-old woman with distal radial fracture.
A and **B,** Anteroposterior (**A**) and lateral (**B**) radiographs show plate (TriLock, Medartis) fixating distal radial fracture. Small displaced ulna styloid fracture, incidentally noted, is also present.



A B

Fig. 10—60-year-old man with intraarticular distal radial fracture.
A and **B,** Anteroposterior radiographs show pin (Volar Buttress Pin, TriMed) (*black arrow*, **A**) and pin plate (Radial Pin Plate, TriMed) (*white arrows*) fixating comminuted intraarticular distal radial fracture. Small healing ulna styloid fracture is also present.



A B

Fig. 11—36-year-old woman with distal radial fracture.
A and **B,** Anteroposterior (**A**) and lateral (**B**) radiographs show device (Wrist Rocket WRx, Sonoma Orthopedic Products) (*black arrows*) fixating comminuted distal radial fracture. Two locking screws (*arrowhead*, **A**) and one subchondral buttress peg (*white arrow*, **A**) are placed from lateral approach. Transverse minimally displaced fracture through distal ulna is also present. There is mild diffuse osteopenia, likely due to disuse.

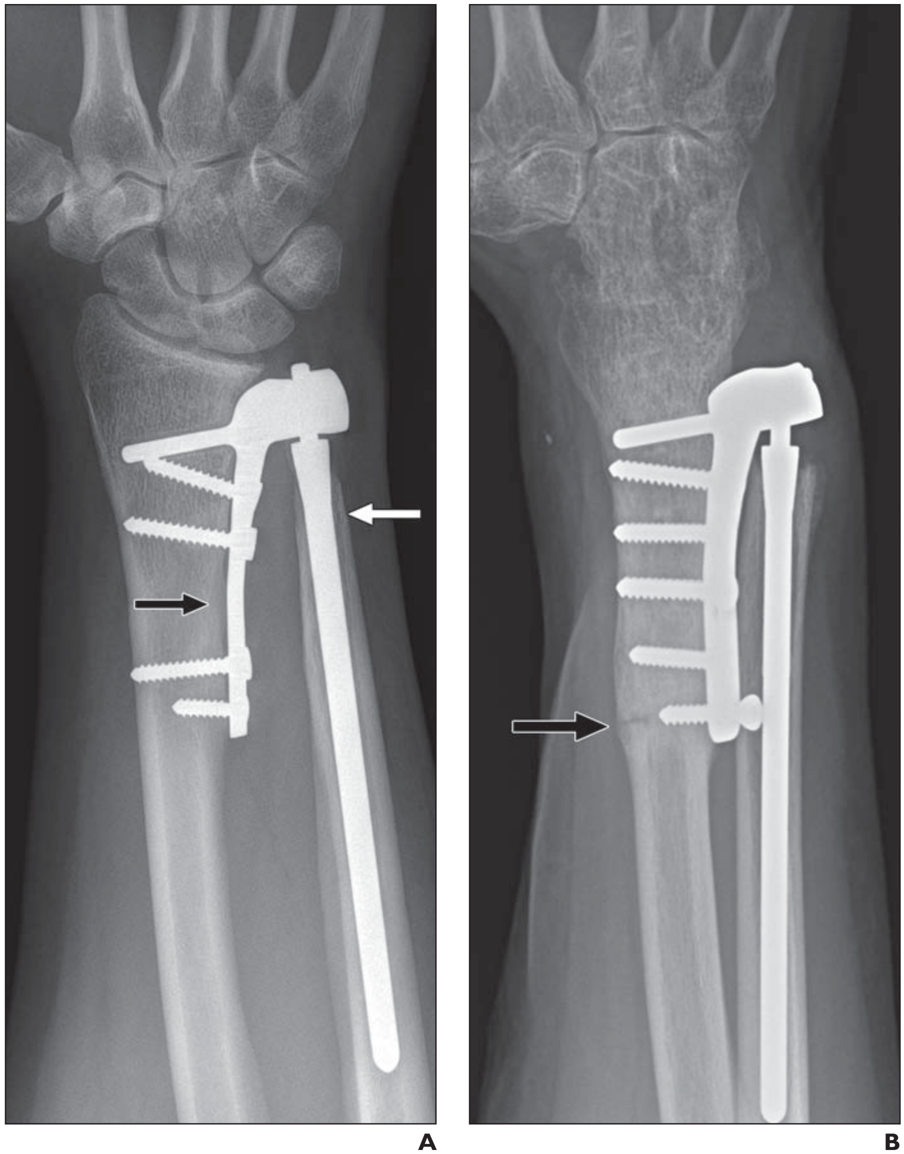


Fig. 12—Distal radioulnar joint (DRUJ) arthroplasty.
A, Anteroposterior radiograph of 28-year-old man shows prosthesis-constrained (Scheker prosthesis, Aptis Medical) total DRUJ arthroplasty with radial plate (*black arrow*) articulating with ulnar stem (*white arrow*) via polyethylene ball. Ball sits in hemisocket and is radiolucent because of its polyethylene composition.
B, Anteroposterior radiograph of 56-year-old woman shows loosening of most distal screw in DRUJ arthroplasty (Scheker prosthesis) with backing out of screw (*arrow*).

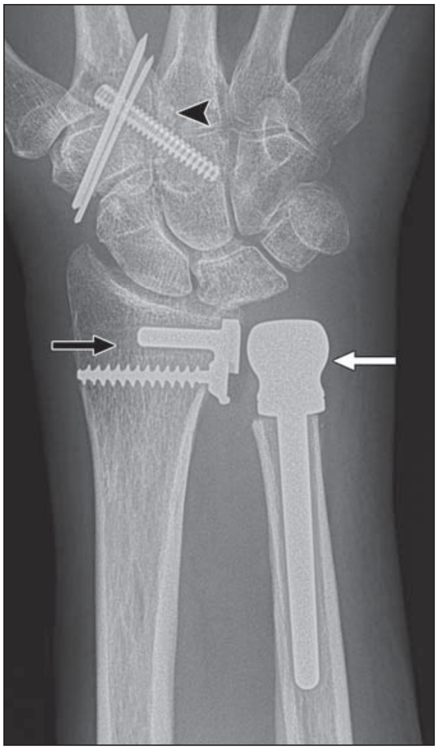
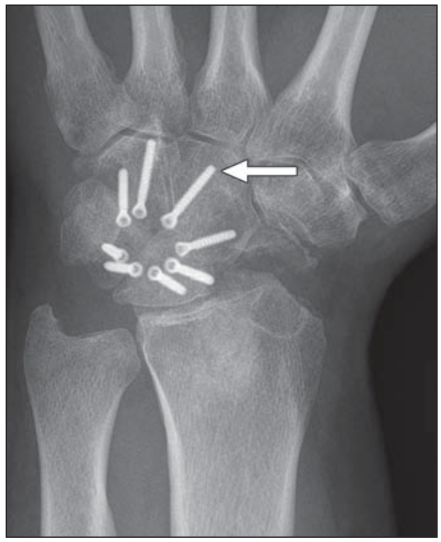


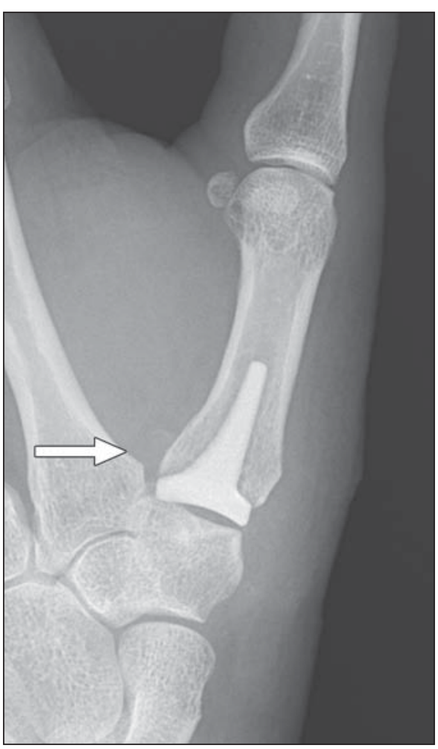
Fig. 13—Anteroposterior radiograph of 75-year-old man shows nonconstrained distal radioulnar joint replacement with ulnar head replacement (*white arrow*) in distal ulna and Sigmoid Notch (Small Bone Innovations) implant (*black arrow*) in distal ulna. Screw (Acutrak, Acumed) (*arrowhead*) and Kirschner wires across second carpometacarpal joint are also noted.



A

B

Fig. 14—54-year-old man with 4-corner arthrodesis.
A and **B,** Anteroposterior (**A**) and lateral (**B**) radiographs of wrist show eight screws (*arrow*, **A**) for midcarpal arthrodesis. Screws are fixated to carpal bones by radiolucent polyethylene plate (Xpode Fusion Plate, Stratmed).



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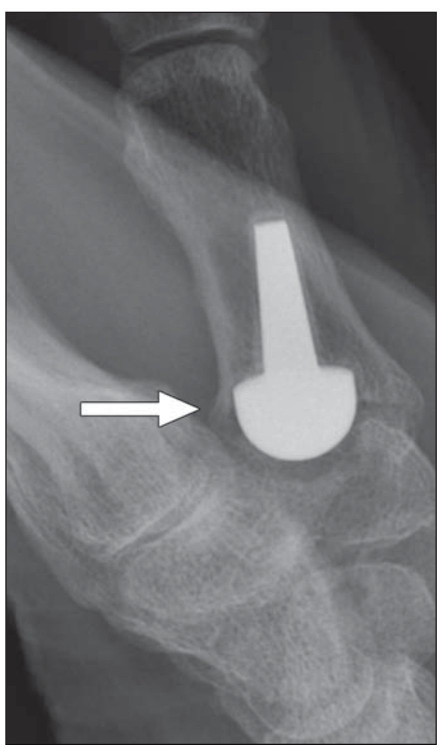

B

Fig. 15—Carpometacarpal hemiarthroplasty.
A, Anteroposterior radiograph of 55-year-old woman shows pyrocarbon saddle carpometacarpal hemiarthroplasty (*arrow*) used to treat mild osteoarthritis. The 1 mm of symmetric lucency surrounding implant is due to radiolucent pyrolytic carbon coating of design. This lucency should not be reported as evidence of loosening.
B, Anteroposterior radiograph of 55-year-old woman shows carpometacarpal hemiarthroplasty (PyroHemiSphere, Ascension Orthopedics) (*arrow*) used to treat moderate osteoarthritis or trapezium erosions.

A

B

Fig. 16—61-year-old woman with interphalangeal joint arthroplasty for osteoarthritis.
A and **B,** Anteroposterior (**A**) and lateral (**B**) radiographs show second proximal interphalangeal joint pyrocarbon arthroplasty (*arrow*, **A**) with subsidence of proximal component and dorsal tilt. Stem is tilted toward and remodeling volar cortex of proximal phalanx (*arrowhead*, **B**).