Special Report

Observations on Interference Screw Morphologies

Bernard R. Bach, Jr., M.D.

Summary: Interference screws are frequently used for fixation of anterior cruciate ligament grafts. When revision surgery is necessary, it is important for the surgeon to recognize variations in interference screw morphology to reduce the potential difficulties in screw removal. The purpose of this observational study is to review the variety of metallic and nonmetallic absorbable interference screws commonly available and to provide a review of their characteristics, dimensions available, and the type and size of screwdriver that would be required in the event that removal is necessary. **Key Words:** ACL reconstruction—Interference screw fixation—Screw variation.

Arthroscopic-assisted anterior cruciate ligament (ACL) reconstruction is a routinely performed operative technique for restoring stability to the ACL-deficient knee. Interference screws on either the femoral and/or tibial side are regularly used for fixation of patellar tendon autografts and allografts. Recently, the use of interference screws has been advocated for the fixation of free bone-block–hamstring constructs, hamstring graft constructs, and quadriceps tendon grafts. There are numerous commercially available metal and bioabsorbable interference screws. There has been marked improvement in the results of ACL surgery since the early and middle 1980s, and the perception of both patients and physicians is that it is a less morbid operative procedure; hence, increasing numbers of ACL reconstructive procedures are being performed. An estimated 75,000 to 100,000 ACL injuries occur annually. The literature supports a predicted 10% failure rate.[1-3] For these reasons, one can anticipate increasing numbers of ACL revision procedures. One potential problem at the time of revision ACL surgery is hardware removal. The purpose of this article is to review the different types of interference screws that are currently available, specifically with regard to their appearance radiographically and their dimensions, as well as the type of screwdriver that would be necessary for removal. Currently, there are a variety of internal diameters and screwdriver designs that may be necessary for interference screw removal.

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MATERIALS AND METHODS

Products from 7 manufacturers of interference screws were collected for this review: Arthrex, Inc. (Naples, FL), DePuy Orthotech (Warsaw, IN), Innovasive Devices, Inc. (Marlborough, MA), Instrument Makar, Inc. (Okemos, MI), Linvatec (Largo, FL), Smith & Nephew/Acufex/Dyonics (Mansfield, MA), and Stryker Endoscopy (Santa Clara, CA). All manufacturers produce metallic interference screws and all manufacturers except Stryker manufacture bioabsorbable interference screws in the United States.

Table 1 summarizes the dimensions of the metallic interference screws reviewed, and they are shown in Figs 1 and 2. All screws are made of titanium. Available lengths range from 15 to 50 mm in 5-mm increments (Fig 3); screw diameters are 5.75, 6, 7, 8, 9, 10, 11, and 13 mm (Fig 4A). Several manufacturers

TABLE 1. *Metallic Interference Screws*

Product	Diameters (mm)	Lengths (mm)	Guidewire	Screwdriver	Recess Size (mm)	Head Shape	B/ST
Arthrex							
Round Head	6	20,25,30	1.5 mm	Hexagonal	2.5, C	RH	B
	7	20,25,30	2.0 mm	Hexagonal	3.5, C	RH	B
	8,9,10	20,25,30,35	2.0 mm	Hexagonal	3.5, C	RH	B
	9,10	40,50	2.0 mm	Hexagonal	3.5, C	RH	B
Headless	7,8,9,10	20,25,30	2.0 mm	Hexagonal	3.5, C	FH	B
	8	35,40,45,50	2.0 mm	Hexagonal	3.5, C	FH	B
Soft Screw	7	25,30	2.0 mm	Hexagonal Hexagonal	3.5, NC 3.5, C	FH	B/ST
	8	30,35	2.0 mm	Hexagonal Hexagonal	3.5, NC 3.5, C	FH	B/ST
	9,10	35,40	2.0 mm	Hexagonal Hexagonal	3.5, NC 3.5, C	FH	B/ST
	9	50	2.0 mm	Hexagonal Hexagonal	3.5, NC 3.5, C	FH	B/ST
	10	20,25,30,35,40	2.0 mm	Hexagonal Hexagonal	3.5, NC 3.5, C	FH	B/ST
DePuy							
Kurosaka Advantag	7	15,20,25,30,35,40	0.062 in	Hexagonal	3.5, C	FH	B
	9	15,20,25,30,35,40	0.094 in	Hexagonal	4.0, C	FH	B
Profil	7,8	20,25,30	0.062 in	Hexagonal	3.5, C	RH	B
	9	20,25,30	0.094 in	Hexagonal	4.0, C	RH	B
Big Advantage	11,13	20,25,30	0.094 in	Hexagonal	4.0, C	FH	B
Innovasive							
Interference Screw	6	15,20,25	0.042 in	Hexagonal	2.5, C	TH	B
	7,8,9,10	20,25,30	0.062 in	Hexagonal	3.5, C	TH	B
Instrument Makar							
PerFixation	6,7,8,9	25	None	Threaded circular	—, NC	FH	B
PerFixation	6,7,8,9	25	1.0 mm	Hexagonal	3.0, C/NC	FH	B
Linvatec							
Guardsman 7 × 30	7,8,9	20,25,30	0.062 in	Hexagonal	3.5, C	RH	B
Propel	7,8,9	20,25,30	0.062 in	Hexagonal	3.5, C	FH	B
Cannulated Spiral Tip	5.75,7,8,9	20,25,30,35,40	0.062 in	Hexagonal	3.5, C	FH	B
Smith & Nephew							
Soft Silk	7,8,9	20,25,30	1.5 mm	Hexagonal	3.5, C	RH	B/ST
Soft Silk	7,8,9	20,25,30	2.0 mm	Hexagonal	3.5, C	RH	B/ST
RCI	7,8 9	25,40 25	2.0 mm 2.0 mm	Hexagonal Hexagonal	3.5, C 3.5, C	RH RH	B/ST B/ST
Stryker Endoscopy							
Wedge	7,8,9	20,25,30	1.5 mm	Hexagonal	3.5, C	RH	B

Abbreviations: B/ST, recommended for bone (B) or soft tissue (ST) fixation; C, cannulated; NC, noncannulated; RH, round head; TH, tapered head; FH, flat head.

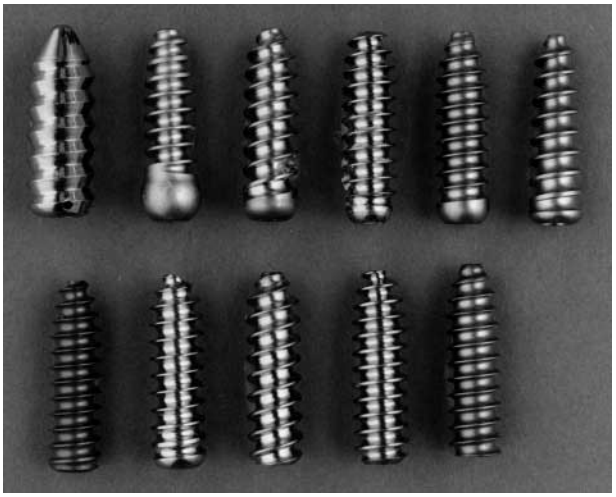

FIGURE 1. Metallic interference screws. Top row, left to right: Instrument Makar noncannulated PerFixation screw, Smith & Nephew RCI screw, Linvatec Guardsman, DePuy Profile, Arthrex, and Stryker Wedge round-head interference screws. Bottom row, left to right: Innovasive Tapered Head interference screw, Smith & Nephew Soft Silk, Linvatec Propel, DePuy Kurosaka Advantage, and Arthrex flat-head screws. All screws in this photograph are 7 × 25 mm, with the exception of the PerFixation screw, which is 9 × 25 mm. Note the characteristic shape of the PerFixation screw, the hemispherical head of the RCI screw, the tapered profile of the Stryker Wedge, and the subtle differences in screw shaft, thread size, and thread pitch of the remaining screws.

have developed round-head femoral screws in an attempt to protect the graft, and 1 manufacturer has developed a tapered head. The Smith & Nephew RCI screw has a unique hemispherical head shape (Figs 1 and 2). Of note is that the RCI screw has a 7- × 25-mm variant that is reverse threaded and used for right knee graft fixation. Most manufacturers produce a flat-head screw used for either femoral or tibial fixation. Radiographic silhouettes show some unique characteristics and some variation in screw shape and thread size and pitch (Fig 2). One manufacturer (Stryker Endoscopy) manufactures a screw that is more tapered in appearance (Fig 4B). Guidewires used for cannulated screw removal varied from 0.042, 0.062, and 0.094 inches to 1.5, 2.0, and 3.5 mm. All metallic screws except the Instrument Makar PerFixation noncannulated screw are used with hexagonal screwdrivers that vary from 2.5, 3.0, 3.5, to 4.0 mm. The Instrument Makar PerFixation noncannulated screw requires a threaded extractor that is threaded into a circular recess. There is a small hole in the side of the head to allow placement of a needle that will allow disengagement of the screwdriver. The peripheral threads are larger in diameter allowing for screw insertion and are oriented clockwise, whereas the deeper threads are of a narrower diameter and are oriented counterclockwise to assist in screw removal. Removal requires a different threaded extractor than that for insertion.

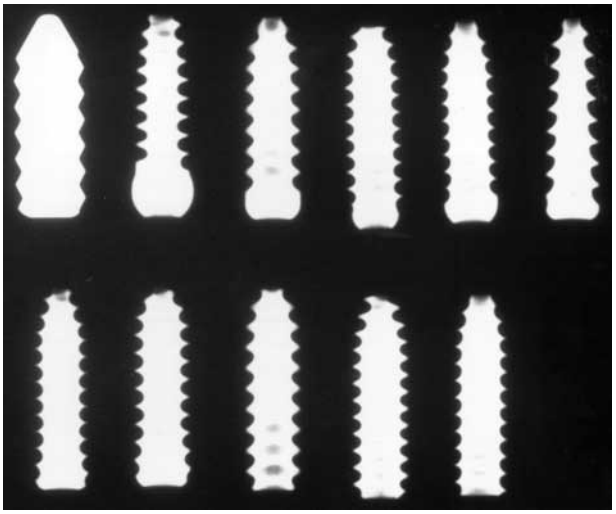

FIGURE 2. The screws in Fig 1 are shown radiographically in the same sequence. Note the 100-mm radiographic reference rule. Note the round-head, tapered-head, and flat-head variations.

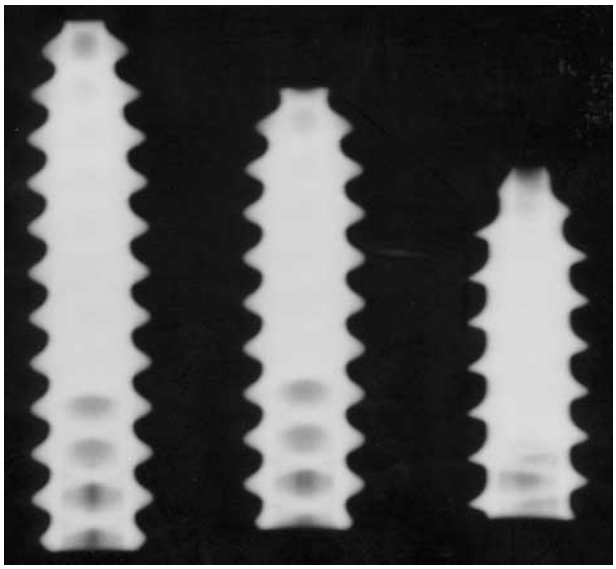

FIGURE 3. Radiographic views of the Linvatec Propel screws, which are 7 mm in diameter and 20, 25, and 30 mm in length.

Table 2 summarizes the dimensions of available nonmetallic bioabsorbable interference screws. Their morphologic appearance is shown in Fig 5 and cross-sections are shown in Fig 6. Examples of nonmetallic interference screws are shown in Figs 5 and 6. Guidewires used for placement and removal range

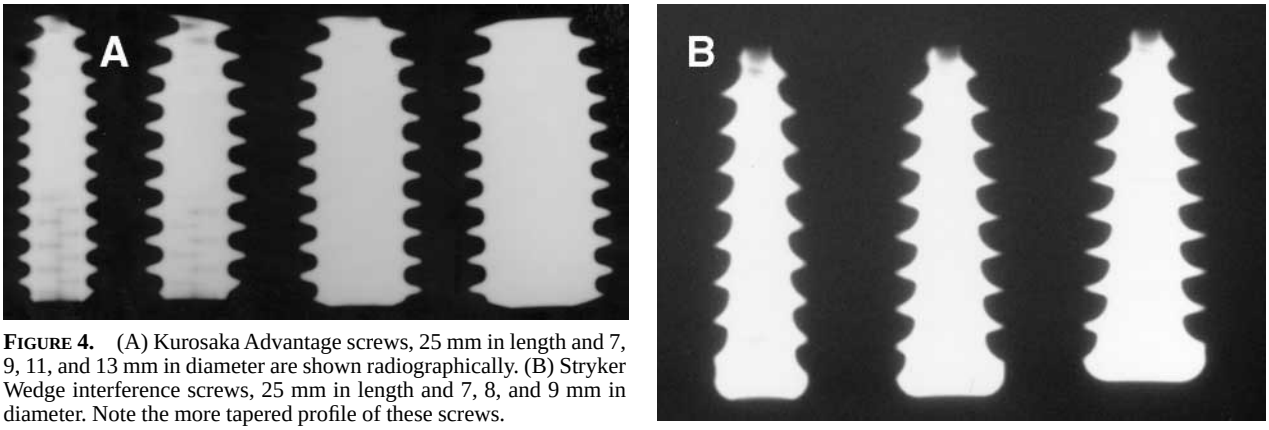

FIGURE 4. (A) Kurosaka Advantage screws, 25 mm in length and 7, 9, 11, and 13 mm in diameter are shown radiographically. (B) Stryker Wedge interference screws, 25 mm in length and 7, 8, and 9 mm in diameter. Note the more tapered profile of these screws.

from 0.045, 0.062, 1.1, to 1.5 mm. Screw diameters range from 7 to 11 mm, and lengths range from 20, 23, 25, 28, to 30 mm. These screws have considerable variation in the screw head recesses (Trilobe, ''Six-star'' torx, quadrangular, and tapered hexagonal). It should be noted that the tapered quadrangular screwdriver used for the DePuy Phantom screw is size specific (i.e., 7, 8, and 9 mm). The Phantom SofThread has 2 different screwdrivers that are size specific for the 7- and 8-mm screws, and the other is used for the 9- and 10-mm screws. Additionally, there is some variation in the biomaterial (poly-L-lactide; poly D-L lactide coglycolide [85%/15%]; polyglycolide cotrimethylene carbonate [67.5%/32.5%], PLLA). These variations in the bioabsorbable material affect rates of resorption. The author prefers to refer to these implants as nonmetallic interference screws. The variable rate of resorption may affect the ability to remove the screw at the time of revision. The recess may be brittle or softened, resulting in screw stripping or fracture. All

TABLE 2. *Nonmetallic Interference Screws*

Product	Diameters (mm)	Lengths (mm)	Guidewire	Screwdriver	Head Shape	B/ST	Composition
Arthrex							
Femoral BioInterference	7,8,9,10	23	1.1 mm	Tapered hexagonal	RH	B/ST	PLLA
Tibial BioInterference	7,8,9,10,11,12	28	1.1 mm	Tapered hexagonal	FH	B/ST	PLLA
Tapered BioInterference	8/10 9/11	35 35	1.1 mm	Tapered hexagonal	FH	B/ST	PLLA
DePuy							
Phantom	7 8,9	20,25,30 20,25,30	0.045 in 0.062 in	7,8,9 mm cannulated drivers	FH	B/ST	PLLA
Phantom SofThread	7,8	25	0.045 in	Quadrangular tapered Quadrangular tapered	RH	ST	PLLA
	9,10	25	0.062 in		RH	ST	PLLA
Innovasive							
Absolute	7,8,9,10	23,30	1.1 mm	Hexagonal 2.8 mm	TH	B/ST	PLLA
Instrument Makar							
Biologically Quiet	9	25	None	Quadrangular	FH	ST	Poly D-L lactide coglycolide (85%/15%)
Linvatec							
BioScrew	7,8,9 10,11	20,25 25	0.045 in	Trilobe	FH	B/ST	PLLA
Guardsman	7,8,9	20,25	0.045 in	Trilobe, fully driven	RH	B/ST	PLLA
Smith & Nephew							
Endo-Fix	7 9	20,25,30 20,25,30	1.5 mm 1.5 mm	''Six-star'' Torx ''Six-star'' Torx	FH FH	B/ST B/ST	PLLA PLLA

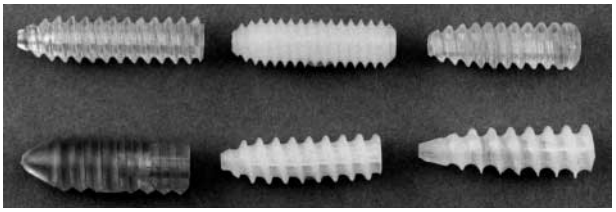

FIGURE 5. Nonmetallic interference screws. Top row, left to right: Arthrex BioInterference, DePuy Phantom, and Innovasive Absolute screws. Bottom row, left to right: Instrument Makar Biologically Quiet, Linvatec BioScrew, and Smith & Nephew Endo-Fix interference screws. Note the variation in shape, thread size, and pitch.

bioabsorbable screws are marketed for soft-tissue fixation and several are approved by the Food and Drug Administration for bone fixation.

DISCUSSION

This variation in internal guidewire diameter and in screwdriver recess diameter and shape underscores the need for the surgeon to have a varied armamentarium of guidewires and screwdrivers when confronted with hardware removal in revision situations. This is slightly less problematic for metallic interference screws because most use hexagonal-shaped screwdrivers; nevertheless, 4 different internal diameters exist.

It should be noted that a narrow-diameter metal interference screw is more likely to require a 2.5-mm diameter hexagonal screwdriver (e.g., Arthrex 4.0, 5.0, and 6.0 mm). Removing a 5.75-mm diameter Linvatec screw and a 6.0-mm diameter Instrument Makar screw requires a 3.0-mm screwdriver. As previously noted, the Instrument Makar screw may require a threaded screwdriver if it is a noncannulated screw. The silhouette of this screw is unique and different from other screws so that a surgeon should be able to readily identify it and recognize that removal may require special instrumentation. At the time of this writing, this specific Instrument Makar interference screw was noncannulated, whereas all other manufacturers produced cannulated screws. All Linvatec, Smith & Nephew, Stryker, and Arthrex screws use a 3.5-mm hexagonal screwdriver with the exception of the 4.0-, 5.0-, and 6.0-mm diameter Arthrex screws (2.5-mm hexagonal screwdriver). The 6.0-mm Innovasive screw requires a 2.5-mm hexagonal screwdriver. All 7.0- and 8.0-mm diameter screws, regardless of manufacturer (with the exception of the cannulated Instrument Makar PerFixation screws, which require a 3.0-mm hexagonal screwdriver), require a 3.5-diameter screwdriver. All 9-mm diameter screws, with the exception of the DePuy Kurosaka screw (4.0-mm screwdriver) and Instrument Makar PerFixation (3.0-mm screwdriver), require a standard 3.5-mm hexagonal screwdriver for removal. The first generation 7-mm DePuy

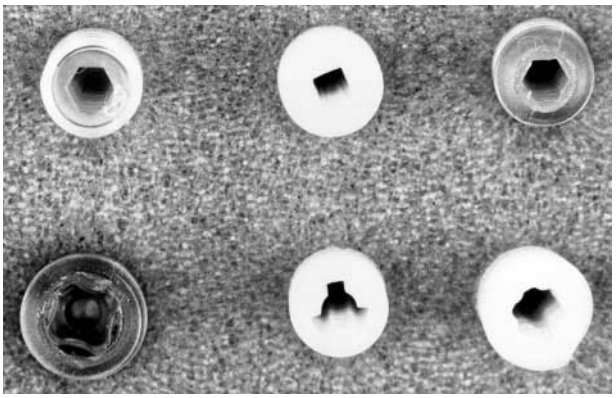

FIGURE 6. Cross-sections of screws shown in Fig 5. The variation in screwdrivers necessary for removal includes a tapered hexagonal, quadrangular tapered, 2.8-mm hexagonal screwdriver, quadrangular, trilobe, and ''Six-star'' torx screwdrivers.

FIGURE 7. Instruments commercially available for screw removal (courtesy of Arthrex).

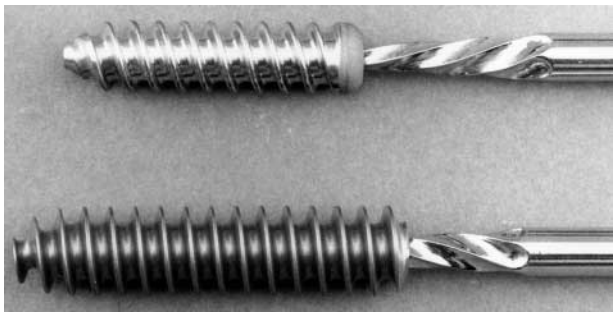

FIGURE 8. The Arthrex ''Easy In'' and ''Easy Out'' extractors are shown with a 7- × 30-mm Linvatec Propel and a 9- × 40-mm DePuy Kurosaka Advantage screw. These devices are used to assist in insertion or removal if the correct screwdriver is not available or the hexagonal recess has been damaged.

FIGURE 9. Postoperative radiograph of endoscopic ACL reconstruction. The femoral screw was bypassed endoscopically with a 7- × 25-mm interference screw. On the tibial side, reorientation of the tibial tunnel obviated the need for removal of the index tibial interference screw.

Kurosaka screw used a 2.5-mm hexagonal screwdriver until 1992/1993, when a transition was made to a 3.5-mm screwdriver. Finally, the largest diameter Big Advantage screws (11 and 13 mm) manufactured by DePuy require a 4.0-mm hexagonal screwdriver (Fig 1).

Surgeons performing revision ACL procedures should be aware that there are commercially available revision screwdriver sets that provide an array of instruments. Arthrex markets a screwdriver instrumentation system with flexible and nonflexible screwdriver shafts, an array of cannulated and noncannulated screwdriver shafts, and tapered ''Easy In'' and ''Easy Out'' screw extractor devices (Figs 7 and 8). At a minimum, 4 different hexagonal screwdrivers, sized 2.5, 3.0, 3.5, and 4.0 mm, should be available to the surgeon. If the surgeon does not have access to one of these revision interference screwdriver sets, one should consider purchasing a metric hexagonal wrench set and threaded extractor from a local hardware store.

It is critical for the surgeon to recognize that there is considerable variability in the types of interference screws that are currently used in ACL surgery. If the correct screwdriver is not available, removal may be difficult because the internal recess of the screw may be damaged, stripped, or, in the case of a nonmetallic screw, fractured. This may make subsequent removal difficult if not impossible. A review of the index operative report can be quite helpful for preoperative planning with regard to screw removal. It is recommended that surgeons include implant specifications into their operative reports, listing the manufacturer and the screw diameter and length, to potentially assist another surgeon in the event of a future revision reconstruction. Before revision surgery, one should also note the relative location of the screw. Depending on the position and orientation of the screw and tunnel, one may be able to perform a revision ACL procedure without removing the interference screws that were placed at the index reconstruction (Fig 9). We recommend having an array of screwdrivers available so that interference screw removal can be performed in an expedited fashion.

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