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Distal Targeting System

Distal targeting clinical review

Introduction

Screw targeting during intramedullary nailing of long bone fractures is a laborious, exact process that can often be the most time-consuming step for reduction. Numerous techniques have been implemented within the past several decades to aid in screw placement. The traditional free hand approach of attaining 'perfect-circles' with the assistance of a C-arm has been universally established as the standard of care, but is still characterized by a moderate learning curve and the potential for screw malalignment. Additionally, many studies have examined surgeon and patient risks that are associated with image intensifiers, both in terms of radiation time and exposure, and allude to deleterious findings.

Because of these reasons, there have been many attempts at experimentally generating an improved methodology of screw targeting. Targeting prototypes span the spectrum from drill guide extensions, nail-mounted apparatuses, computationally guided surgical navigation systems, optoelectronic detectors, table clamp mechanisms, transilluminating emitters, and even 'nail-over' procedures that require opening two intramedullary nails. Data from the literature unanimously supports a decrease in radiation time and exposure with each of these instrumented medical devices. Many authors also cite decreases in procedure time, which can save in operating room costs, and which can indirectly lead to an improved quality of life for the surgeon.

The free hand approach to screw targeting is used as a comparative baseline in many of these studies, but bridging the gap between trusted conventional clinical practice and recent advancements is limited by certain constraints. First, outcome parameters of many studies are biased towards surgeons highly experienced with distal targeting, and in many cases even familiar with the new aiming apparatus. Furthermore, study protocols outline the use of either simulated foam bone models, cadaveric specimens, live patients, or some mixture of the three. Fracture types and anatomical region into which the screw is placed are just as inconsistent; simple fractures are grouped with more complex open ones. Lastly, the definition of study variables such as total operative time, distal locking time, number of targeted screws, and the measurement of radiation exposure are rarely defined.

The lack of systematic categorization in the literature, coupled with technological changes in the 30+ years of investigation of screw targeting helps explain the inconsistency within medical device subgroups, but why one surgeon can distally lock using a free hand approach in 13 minutes (Suhm 2004) and it takes another 41 minutes (Rohilla 2009) is more difficult to comprehend. This discrepancy is even further confounded considering many new aiming propositions require additional OR set-up time prior to surgical intervention. With this in mind, medical literature was searched for publications that included a reference to distal targeting during intramedullary fracture fixation. Only lower extremity, weight-bearing anatomical regions were included. Likewise, any publications that did not specifically pertain to orthopaedic traumatology were excluded. Included articles were categorized based upon fracture type, targeting method, operative and distal locking time, number of C-arm shots, procedural and distal locking radiation time, and procedural and distal locking radiation exposure calculations.

Results

The results of our findings are given in Table 1. By far the most cited technique utilized was some version of a mechanically mounted extended distal targeting device. Fractures of the tibia and femur were evenly cited, although specifics concerning fracture location and type were rarely reported. When reported, the free hand technique was used for comparison, and in all but one instance the proposed new device fared superiorly when compared to this baseline. The total operative time across all instances of intramedullary surgical intervention ranged from a low of 20 minutes (tibial fixation, Babis 2007) to a high of 270 minutes (femoral fixation, Arlettaz 2008). As a subset of this, distal locking ranged from below 4 minutes (Chu 2009) up to an hour (Arlettaz, 2008). The number of fluoroscopic shots needed during distal targeting ranged from 1 (Rohilla 2009) to 81 (Rohilla 2009), and distal locking radiation time was measured to be anywhere from 0 seconds (Krettek 1998) to 15 minutes (Levin 1987). Radiation exposure was rarely reported except in the cases of specific dosimetry studies.

Conclusion

Consistent distal targeting parameters among the medical literature are not well documented. When results are given, the range of experimental values are broad, such that inter-study comparisons are difficult. Thus, guidelines for clinical practice decision making based on such complex multifaceted results may not always be plausibly ascertained from the literature. Researchers and clinicians should evaluate each situation in order to provide the best solution to decreasing distal targeting time and radiation exposure while increasing the quality of life for the surgeon.

Author	Journal	# Patients/ # fxs	Fx type	Method	Time		# Distal shots	Radiation time		Radiation exposure		Comments
					Operative	Distal locking		Procedure	Distal locking	Procedure	Distal locking	
Anastopoulos, et al	CORR 2008	60 patients/ 63 fxs	Tibial shaft	Mechanical	47±9.5 min	6.5±2.1 min	2	-	0.85 sec (0.4-1.2 sec)	-	1.4 mGy (0.8-1.9 mGy)	Mechanical technique using an extended drill guide 1 targeting device
Krettek, et al	JOT 1998	Cadaver	Oblique tibia	Mechanical	25.4±11.3 min	16.7±8.6 min	-	9±5 sec	0 sec	-	-	Distal aiming device
				FHT	30.9±14.3 min	21.9±10.5 min	-	93±34 sec	88±37 sec	-	-	
Krettek, et al	JOT 1997	20 patients/ 38 fx	Tibial shaft	Mechanical	108 min (60-180 min)	15.5 min (8-39 min)	-	-	-	-	-	Extended drill guide/ targeting device; time for distal lock was for 3 screws; 55% were open Is (03B fx)
Tyropoulos, et al	Injury 2001	40 patients/ 40 fx	Femoral shaft	Mechanical (n=20)	-	-	7.6 (6-10)	56 sec (48 80.4 sec)	4 56 sec (3.6-6.6sec)	-	-	Image intensifier mounted targeting device; # shots was for distal targeting
				FHT (n=20)	-	-	43.7 (24-63)	73.8 sec (55.8-105 sec)	31.2 sec (16.8-43.2 sec)	-	-	
Pardiwala, et al.	Injury 2001	60 fx	Femoral	Mechanical (n=30)	-	19.3±9.8 min	3.8±3.5	-	-	-	-	AO nail mounted distal locking aiming device
				FHT (n=30)	-	35.8±18.6 min	11.5±3.4	-	-	-	-	
Suhm, et al.	Injury 2004	42 patients/ 44 fx	Femoral and tibial	Computer Guided	-	17.9±6.5 min	-	-	7.3±6.4 sec	-	-	Computer guided: computational equipment, c-arm, optoeleotronic position detection; additional 40 min required for set-up; distal lock of one screw
				FHT	-	13.7±4.7 min	-	-	108±61 sec	-	-	
Anastopoulos, et al	Injury 2008	127 patients	Femoral shaft	Mechanical	63.5±18.1 min	6.6±2.6 min	2	17.2 ± 7.4 sec	1.35 sec (0.9-2.2 sec)	-	1.9 mGy (1.1-2.9 mGy)	Stryker 02 IM nail distal targeting device; 5 unsuccessful cases
		-	-	-	-	-	-	-	-	331±21 mGy	-	Tsalafoutas-radiation exposure during IMN of femoral fx
Gugala, et al.	Injury 2001	58 patients/ 60 fxs	Tibial	Mechanical	81 min	17.06 min	-	84 sec	15 sec	-	-	Orthofix targeting system
				FHT	85 min	19.08 min	-	117 sec	36 sec	-	-	
Arlettaz, et al.	Injury 2008	25 patients/ 11 tibia fx and 14 femur fx	-	Mechanical tibia	89 min (65-200 min)	24 min (20-30 min)	-	96	44	-	-	Device mounts to table & patient-requires image intensifier; distal locking was for 2 screws
				Mechanical femur	154 min (80-270 min)	31 min (20-60 min)	-	128	55	-	-	
Chu, et al.	Injury 2009	19 patients and fxs	Tibial	Electrical	49.1±11.7 min	4.121.8 min	-	-	-	-	-	IM endotransilluminating device (iMET); no fluoro or repetitive drilling; distal locking was For 1 screw; must dim lights in OR
Babis, et al.	Arch Orthop Trauma Surg 2007	115 patients and fxs	Tibial	Mechanical (n=103	38 min (20-55 min)	-	4 (2-6)	-	-	-	-	Orthofix distal targeting device; failure rate of 5.2%, required use of image intensifier on 12 cases
				FHT (n .12)		-	-	-	5 sec (3-8 sec)	-	-	
Krettek, et al	Arch Orthop Trauma Surg1998	15 cadaver	Femoral	Mechanical	21.2±8.6 min	7.1±2.4 min	-	28.1±16.6 sec	-	-	-	Extended drill guide / targeting device; distal locking was for 2 screws
Slomczykowski, et al	JOT 2001	10 cadaver	Femoral	Computer Guided	-	1.09 ± 0.17 sec	-	-	1.7 ± 0.14 sec	-	-	Computer guided surgical navigation system based on fluoroscopic images
Rohllla, et al.	Intl Orthop 2009	70 patients	Femoral shaft	Nail Over (n=35)	73.40±9.97 min (54-92 min)	23.34±7.51 min(15-55 min)	4.11±6.0 (1-21)	-	0.14±0.04 min (0.07-0.26 min)	-	-	Nail over mechanical technique; must open 2 nails
				FHT (n=35)	70.97±9.91 min (50-97 min)	24.34±6.04 min(15-41 min)	13.07 (11-81)	-	0.25±0.08 min (0.13-0.52 min)	-	-	
Abdlslam, et al.	Injury 2003	10 sawbones	Tibia	Mechanical	-	-	-	-	0.04 min	-	-	Mechanical technique using an extended drill guide/targeting device
Levin, et al.	JBJS Am 1987	30 patients/25 femur 5 tibia	Femoral and tibial	FHT-femur distal lock (n=5)	-	-	-	307.2 sec (61.8-462.0 sec)	106.8 sec (28.8 252.0 sec)	-	12.0 mrem (hand): 8.0 mrem (neck)	FHT; addl dosimetry values also given in paper
				FHT-Femur static lock (n=13)	-	-	-	756 sec (186-1896 sec)	307.2 sec (60.6 900.0 sec)	-		
				FHT-tibia distal lock (n= 1)	-	-	-	325.8 sec	61.8 sec	-		
				FHT-tibia static look n=31	-	-	-	358.8 sec (144-732 sec)	162.0 sec (36.0 396.0 sec)	-		

Table 1

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