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.
<table>
<thead>
<tr>
<th>Author</th>
<th>Journal</th>
<th># Patients/ fx</th>
<th>Fix type</th>
<th>Method</th>
<th>Time</th>
<th>Distal locking</th>
<th># Distal Locking</th>
<th>Radiation time</th>
<th>Radiation Exposure</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anastopoulos, et al</td>
<td>CORR 2008</td>
<td>60 patients/ 63 fx</td>
<td>Tibial shaft</td>
<td>Mechanical</td>
<td>47±9.5 min</td>
<td>6.5±2.1 min</td>
<td>2</td>
<td>-</td>
<td>0.85 sec (0.4-1.2 sec)</td>
<td>- 1.4 mGy (0.8-1.9 mGy) Mechanical technique using an extended drill guide 1 targeting device</td>
</tr>
<tr>
<td>Krettek, et al</td>
<td>JOT 1999</td>
<td>Cadaver Oblique tibia</td>
<td>Mechanical</td>
<td>25.4±11.3 min</td>
<td>16.7±8.6 min</td>
<td>-</td>
<td>9±5 sec</td>
<td>0 sec</td>
<td>-</td>
<td>Distal aiming device</td>
</tr>
<tr>
<td>Krettek, et al</td>
<td>JOT 1997</td>
<td>20 patients/ 38 fx</td>
<td>Tibial shaft</td>
<td>Mechanical</td>
<td>108 min (60-180 min)</td>
<td>15.5 min (8-39 min)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Extended drill guide/ targeting device; time for distal lock was for 3 screws. 55% were open is (038 bx)</td>
</tr>
<tr>
<td>Tyropoulos, et al</td>
<td>Injury 2001</td>
<td>40 patients/ 40 fx</td>
<td>Femoral shaft</td>
<td>Mechanical (n=20)</td>
<td>-</td>
<td>-</td>
<td>7.6 (1-10)</td>
<td>56 sec (48-80 min)</td>
<td>4.56 sec (3.6-6.6 sec)</td>
<td>- Image intensifier mounted targeting device; 8 shots was for distal targeting</td>
</tr>
<tr>
<td>Pardwala, et al</td>
<td>Injury 2001</td>
<td>60 fx</td>
<td>Femoral Mechanical (n=30)</td>
<td>19.3±9.8 min</td>
<td>3.8±3.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>AO nail mounted distal locking aiming device</td>
</tr>
<tr>
<td>Suhr, et al</td>
<td>Injury 2004</td>
<td>42 patients/ 44 fx</td>
<td>Femoral and tibia</td>
<td>Computer Guided</td>
<td>17.9±6.5 min</td>
<td>-</td>
<td>-</td>
<td>7.3±6.4 sec</td>
<td>- Computer guided: computational equipment, c-arm, optoeleotronic position detection; additional 40 min required for set-up; distal lock of one screw</td>
<td></td>
</tr>
<tr>
<td>Anastopoulos, et al</td>
<td>Injury 2008</td>
<td>127 patients</td>
<td>Femoral shaft</td>
<td>Mechanical</td>
<td>63.5±18.1 min</td>
<td>6.6±2.6 min</td>
<td>2</td>
<td>17.2±7.4 sec</td>
<td>1.35 sec (8.9-2.2 sec)</td>
<td>- 1.9 mGy (31.2-2.9 mGy) Stryker 02 IM nail distal targeting device; 5 unsuccessful cases</td>
</tr>
<tr>
<td>Suhr, et al</td>
<td>Injury 2001</td>
<td>58 patients/ 60 fx</td>
<td>Tibial</td>
<td>Mechanical</td>
<td>81 min</td>
<td>17.06 min</td>
<td>-</td>
<td>84 sec</td>
<td>15 sec</td>
<td>- Orthofix targeting system</td>
</tr>
<tr>
<td>Arkeitza, et al</td>
<td>Injury 2008</td>
<td>25 patients/ 11 tibia fx and 14 femur fx</td>
<td>-</td>
<td>Mechanical tibia</td>
<td>69 min (65-200 min)</td>
<td>24 min (20-30 min)</td>
<td>-</td>
<td>96</td>
<td>44</td>
<td>- Device mounts to table &amp; patient requires image intensifier; distal locking was for 2 screws</td>
</tr>
<tr>
<td>Chu, et al</td>
<td>Injury 2009</td>
<td>19 patients and fx Tibial</td>
<td>Electrical</td>
<td>49.1±11.7 min</td>
<td>4.121.8 min</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>I M endo detectors; radiation exposure during IWN of femoral fx</td>
</tr>
<tr>
<td>Babis, et al</td>
<td>Arch Orthop Trauma Surg 2007</td>
<td>115 patients/ 120 fx</td>
<td>Tibial</td>
<td>Mechanical (n=103)</td>
<td>38 min (20-55 min)</td>
<td>-</td>
<td>4 (2-6)</td>
<td>-</td>
<td>-</td>
<td>Orthofix distal targeting device; failure rate of 5.2%; required use of Image intensifier on 12 cases</td>
</tr>
<tr>
<td>Krettek, et al</td>
<td>Arch Orthop Trauma Surg 1998</td>
<td>15 cadaver</td>
<td>Femoral</td>
<td>Mechanical</td>
<td>21.2±8.6 min</td>
<td>71±2.4 min</td>
<td>-</td>
<td>28±16.6 sec</td>
<td>-</td>
<td>Extended drill guide/ targeting device; distal locking was for 2 screws</td>
</tr>
<tr>
<td>Sikmczykowski, et al</td>
<td>JOT 2001</td>
<td>10 cadaver</td>
<td>Femoral</td>
<td>Computer Guided</td>
<td>-</td>
<td>1.09±0.17 sec</td>
<td>-</td>
<td>-</td>
<td>1.7±0.14 sec</td>
<td>- Computer guided surgical navigation system based on fluoroscopic images</td>
</tr>
<tr>
<td>Rohilla, et al</td>
<td>Ind J Orthop 2009</td>
<td>70 patients</td>
<td>Femoral shaft</td>
<td>Nail Over</td>
<td>73.4±9.97 min (54-92 min)</td>
<td>23.34±7.51 min (15-55 min)</td>
<td>4.11±6.0 min (2-21)</td>
<td>-</td>
<td>0.14±0.04 min (0.07-0.26)</td>
<td>- Nail over mechanical technique, must open 2 nails</td>
</tr>
<tr>
<td>Abdallah, et al</td>
<td>Injury 2003</td>
<td>10 sawbones</td>
<td>Tibia</td>
<td>Mechanical</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.04 min</td>
<td>- Mechanical technique using an extended drill guide/targeting device</td>
</tr>
<tr>
<td>Levin, et al</td>
<td>JBJS Am 1987</td>
<td>30 patients/25 femur 5 tibia</td>
<td>Femoral and tibia</td>
<td>Mechanical</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>307.2 sec (61.8-462.0 sec)</td>
<td>106.8 sec (28.8-252.0 sec)</td>
<td>12.0 mmr (hand); 8.0 mmr (heck) FHT; addit dosimetry values also given in paper</td>
</tr>
</tbody>
</table>
References

23. Mehlan CT, D'Pasquale TG. Radiation Exposure to the Orthopaedic Surgical Team During Fluoroscopy: “How far away is far enough?”. JOT vol. 11(6), August 1997: 392-398.

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