

Olecranon anatomy: Use of a novel proximal interlocking screw for intramedullary nailing, a cadaver study

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Abstract

AIM: To define the optimum safe angle of use for an eccentrically aligned proximal interlocking screw (PIS) for intramedullary nailing (IMN).

METHODS: Thirty-six dry cadaver ulnas were split into two equal pieces sagittally. The following points were identified for each ulna: the deepest point of the incisure olecrani (A), the point where perpendicular lines from A and the ideal IMN entry point (D) are intersected (C) and a point at 3.5 mm (2 mm safety distance from articular surface + 1.5 mm radius of PIS) posterior from point A (B). We calculated the angle of screws inserted from point D through to point B in relation to D-C and B-C. In addition, an eccentrically aligned screw was inserted at a standard 20° through the anterior cortex of the ulna in each bone and the articular surface was

observed macroscopically for any damage.

RESULTS: The mean A-C distance was 9.6 mm (mean \pm SD, 9.600 \pm 0.763 mm), A-B distance was 3.5 mm, C-D distance was 12.500 mm (12.500 \pm 1.371 mm) and the mean angle was 25.9° (25.9° \pm 2.0°). Lack of articular damage was confirmed macroscopically in all bones after the 20.0° eccentrically aligned screws were inserted. Intramedullary nail fixation systems have well known biological and biomechanical advantages for osteosynthesis. However, as well as these well-known advantages, IMN fixation of the ulna has some limitations. Some important limitations are related to the proximal interlocking of the ulna nail. The location of the PIS itself limits the indications for which intramedullary systems can be selected as an implant for the ulna. The new PIS design, where the PIS is aligned 20° eccentrically to the nail body, allows fixing of fractures even at the level of the olecranon without disturbing the joint. It also allows the eccentrically aligned screw to be inserted in any direction except through the proximal radio-ulnar joint. Taking into consideration our results, we now use a 20° eccentrically aligned PIS for all ulnas. In our results, the angle required to insert the PIS was less than 20° for only one bone. However, 0.7° difference corresponds to placement of the screw only 0.2 mm closer to the articular surface. As we assume 2.0 mm to be a safe distance, a placement of the screw 0.2 mm closer to the articular surface may not produce any clinical symptoms.

CONCLUSION: The new PIS may give us the opportunity to interlock IMN without articular damage and confirmation by fluoroscopy if the nail is manufactured with a PIS aligned at a 20.0° fixed angle in relation to the IMN.

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Key words: Interlocking screw; Intramedullary nailing; Ulna fracture; Ulna anatomy

Core tip: Limitations of intramedullary nailing (IMN) of the ulna, which make IMN a secondary choice, include problems experienced at the proximal interlocking screw (PIS). A new PIS system may solve most common problems with an eccentrically aligned screw. This new PIS system may be very advantageous if the fluoroscopy time, operation time and the need for additional incision in other systems is considered. However, the screw must be designed at a safe angle to have these advantages. According to our results, a 20.0° is the optimum angle of alignment for this screw.

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INTRODUCTION

Intramedullary nailing (IMN) of the forearm has gained much popularity but still has some technical limitations, especially in relation to IMN of the ulna^[1,2]. The proximal interlocking screw (PIS) is one of the critical steps in IMN of the ulna. Location of the PIS limits the indications for which IMN of the ulna can be used with currently available IM systems. IM systems are useless in fractures where the olecranon is involved. In addition, IM systems may be insufficient in proximal ulna fractures and may require extra caution to avoid damage to the articular surface when placed around the olecranon^[1,2]. Currently available IMN systems of the ulna have the same inherent problems as all IMN, requiring an extra incision for the interlocking screw and prolonged radiation exposure of the surgical team because of the use of fluoroscopy.

A newly developed PIS system^[3] solves these problems with an eccentrically aligned PIS (Figure 1) which is inserted through a hole located at the proximal tip of the nail.

In this *in vitro* study, we aim to identify the optimum angle of the eccentrically aligned PIS to the IMN in relation to the olecranon articular surface.

MATERIALS AND METHODS

Ulna bones of 36 dry bony cadavers were used. The proximal parts of the ulnas were split sagittally into two equal pieces. The deepest point of the incisura olecrani (A) was identified for each ulna. A horizontal line was drawn longitudinally at the middle of the medulla and a vertical line was drawn from point A perpendicular to this line. The point where these lines intersected (C) and the ideal IMN entry point (D) were also identified for each ulna. Then a point (B) was identified, located on the A-C line and 3.5 mm posterior to point A. 3.5 mm is the sum safe distance from the articular surface (2 mm) and the radius of PIS (1.5 mm) (Figure 2). Then, we calcu-



Figure 1 Eccentrically aligned proximal interlocking screw.

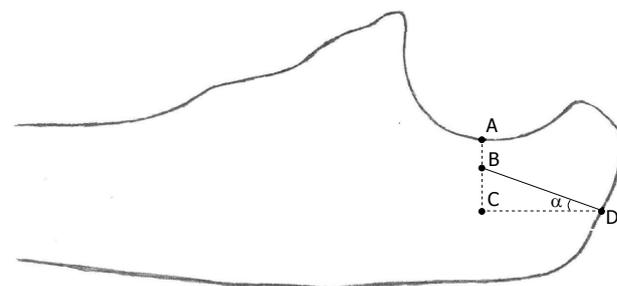


Figure 2 Olecranon anatomy, related to a novel proximal interlocking screw for intramedullary nailing. A: Deepest point of the incisura olecrani; B: The point, which is 3.5 mm posterior to A point and targeted during insertion of the proximal interlocking screw; C: The point where the line from the middle of the medulla and the line perpendicular to point A intersect; D: Ideal entry point for intramedullary nail.

lated the angles of the screws when inserted from point D through to point B using the following formula: $\tan \alpha = B-C/C-D$ (Figure 2).

In addition, taking into consideration the measured angles, a screw aligned eccentrically in relation to the IMN was inserted at a standard 20° through the anterior cortex of the ulna in each bone as a PIS and the articular surface was observed macroscopically for any damage.

RESULTS

The mean A-C distance was 9.600 mm (range 8.500-11.000 mm, SD = 0.763 mm). The mean A-B distance was 3.5 mm for each ulna. The mean C-D distance was 12.500 mm (range 10.000-14.600 mm, SD = 1.371 mm). The mean angle was 25.9° (range 19.3°-29.2°, SD = 2.0°) (Table 1). Lack of articular damage was observed macroscopically for each bone after the 20.0° eccentrically aligned screws were inserted.

DISCUSSION

Intramedullary nail fixation systems have well known biological and biomechanical advantages for osteosynthesis. However, in addition to these well-known advantages, intramedullary nail fixation of the ulna has some limitations^[1,2]. Some important limitations are related to the PI of the ulna nail. The location of the PIS itself limits the indications for which intramedullary systems can be selected as an implant for the ulna.

Table 1 The A-C distance, C-D distance and angle for each ulna

Ulna No.	A-C distance (mm)	C-D distance (mm)	Angle (°)
1	9.7	11.2	24.9
2	9.4	13.8	23.1
3	9.0	12.0	24.6
4	8.5	14.3	19.3
5	8.9	13.4	21.9
6	11.0	14.6	27.2
7	10.1	13.6	25.9
8	10.4	12.4	29.1
9	11.0	13.4	29.2
10	11.0	14.6	27.2
11	9.0	11.7	25.2
12	8.7	10.6	26.1
13	10.2	14.0	25.6
14	10.5	13.2	27.9
15	9.3	12.9	24.2
16	9.8	12.4	26.9
17	10.0	14.5	24.1
18	9.5	12.8	25.1
19	9.5	12.7	25.3
20	8.8	10.7	26.3
21	10.1	13.5	26.0
22	11.0	14.5	27.3
23	9.0	10.7	27.2
24	9.6	12.1	26.7
25	9.9	12.5	27.1
26	8.7	11.3	24.7
27	8.9	10.2	27.9
28	10.8	13.6	28.2
29	9.0	11.0	26.6
30	9.0	10.6	27.4
31	8.9	10.1	28.1
32	8.6	12.5	22.2
33	9.3	12.7	24.5
34	10.1	13.1	26.7
35	9.8	12.4	26.9
36	8.7	10.0	27.4
Total, mean ± SD (range)	9,600 ± 0.763 (8.500-11.000)	12,500 ± 1.371 (10.000-14.600)	25.9 ± 2.0 (19.3-29.2)

Intramedullary fixation systems are inadequate for fractures of the proximal ulna especially if the olecranon is involved. There is usually not enough bone stock to put a PIS into proximal fractures even if the fracture is slightly distal to the olecranon^[4]. If the fracture is to the proximal part of the ulna or at the level of the olecranon, the screw should be inserted perpendicular or oblique to the articular surface^[5-7]. This requires the selection of a PIS to avoid disturbing the joint, and this may not provide adequate stability. Moreover, there may be irritation of the ulnar nerve if the PIS is aligned parallel to the articular surface of the olecranon^[5]. Gehr and Friedl developed an intramedullary device for olecranon fractures, although this device cannot be used for segmental fractures, which also involve distal fractures, and they reported ulnar nerve irritation. The new PIS design allows the fixing of fractures even at the level of the olecranon without disturbing the joint when the PIS is aligned 20.0° eccentrically to the nail body. It also allows the eccentrically aligned screw to be inserted in any direction except through the proximal radio-ulnar joint.

Radiation exposure tends to be underestimated by

surgeons^[8,9]. Proximal interlocking always requires fluoroscopic confirmation. Currently available intramedullary nails for the ulna require quite long fluoroscopy time, even up to 150 min^[7]. By contrast, with the new PIS system fluoroscopy usage is optional, provided preoperative measurements are done properly.

The PIS usually requires an additional incision^[6,10,11]. In the new PIS system, the screw is inserted from the proximal tip of the nail. There is no need for an additional incision for PI other than the incision used for insertion of the IM nail, which means no additional soft tissue damage.

An eccentrically aligned PIS with a fixed angle may provide important advantages. The angle between the nail and screw has critical importance to the articular surface of the olecranon.

Taking into consideration our results, we use a 20° eccentrically aligned PIS for all ulnas by. In our results, the angle required to send the PIS was less than 20° (19.3°) for only one bone (No. 4). However, 0.7° difference corresponds to placement of screw only 0.2 mm closer to the articular surface. As we assume 2.0 mm to be a safe distance, a 0.2 mm closer placement of the screw to the articular surface may not produce any clinical symptoms. Moreover, as far as we know, there are no previous studies which have considered the safe distance between the screw and the articular surface of the olecranon. As a result, the lack of macroscopic articular surface damage in case 4, like all others, may be evidence of the safety of this system.

As a result, this new PIS system may be very advantageous if the fluoroscopy time, operation time and the need for additional incision compared to other systems is considered. However, the screw must be positioned at a safe angle to have these advantages. According to our results, a 20° is the optimum angle of alignment for the screw.

COMMENTS

Background

Intramedullary nail fixation systems have well known biological and biomechanical advantages for osteosynthesis. Limitations of intramedullary nailing (IMN) of the ulna, which makes IMN a secondary choice, include problems experienced at the proximal interlocking screw (PIS).

Research frontiers

Location of the PIS limits the indications for use of IMN of the ulna in currently available intramedullary systems. A new PIS system may solve most common problems with an eccentrically aligned screw. The purpose of this *in vitro* study was to define the optimum safe angle of eccentrically aligned PIS for IMN.

Innovations and breakthroughs

Intramedullary systems may be insufficient in proximal ulna fractures and may require extra caution not to damage the articular surface when placed around the olecranon. Currently available IMN systems of the ulna have the same inherent problems as all IMN, requiring an extra incision for the interlocking screw and prolonged radiation exposure of the surgical team because of the use of fluoroscopy. The new PIS may give the authors the opportunity to interlock the IMN without articular damage and confirmation by fluoroscopy if the nail is manufactured with a PIS aligned at a 20° fixed angle in relation to the IMN.

Applications

The new PIS design allows fixing fractures even at the level of the olecranon without articular damage and confirmation of fluoroscopy.

Terminology

Intramedullary nailing: A rod of metal, or other material for fixation of fragments

of fractured bones, in this study for ulna fractures. Interlocking screw: A screw which passes through the IMN perpendicular to its long axis and prevents the nail to migrate or rotate within the bone.

Peer review

This new PIS system may be very advantageous if the fluoroscopy time, operation time and the need for additional incision at other systems is considered. However, it must be designed at a safe angle to have these advantages. According to these results, 20° is the optimum angle of alignment for this screw.

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