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Technical Note

Techniques for predicting and avoiding unintentional biplanar movements during iliosacral screw placement

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ABSTRACT

The technique for placing iliosacral screws typically involves the surgeon using an inlet and outlet view as the primary means for assessing the anteroposterior and craniocaudal position of the guidewire, respectively. However, because these views are rarely, if ever, orthogonal to one another, this technique will inevitably lead to unintentional biplanar movements. These unintentional movements, in turn, require correction, which can increase operating room and fluoroscopic time. Here we calculate the degree and magnitude of these unintentional movements. Additionally, we provide a simple technique for minimizing or eliminating them altogether.

Introduction

Iliosacral screws are a common fixation construct for a wide variety of pelvic ring injuries. The technique for inserting these screws under fluoroscopic guidance has been well-described [1]. Typically, the surgeon uses an inlet and outlet view as the primary means for assessing the anteroposterior and craniocaudal position of the screw, respectively. [1–5]

However, it has been shown that a good inlet and outlet view are rarely, if ever, orthogonal to one another.[6–9] As a result, attempting to change screw position on either view by moving perpendicular to the fluoroscopy beam will inadvertently result in potentially significant movements on the other fluoroscopic view. [6] Correcting these unintentional movements by trial and error can increase fluoroscopic time and decrease operating room efficiency.

Here we calculate the magnitude and direction of these unintentional biplanar movements. Additionally, we provide a practical technique for decreasing or eliminating these movements in the operating room.

Methods

We used trigonometry to determine the magnitude and direction of unintentional biplanar guidewire translations with attempted uniplanar guidewire translations. Linear algebra was used to determine the magnitude and direction of unintentional biplanar guidewire angulations with attempted uniplanar guidewire angulations. All trigonometric and vector figures were generated using Mathcha (2019 Mathcha.io). We assumed that the inlet and outlet views were less than 90 degrees apart from one another, which appears to be universally true based on the available literature on the topic [6–8].

Results

Intentional translation of an iliosacral screw guidewire perpendicular to the current fluoroscopic view results in predictable unintentional translation in the other view. For example, intentional posterior translation of the guidewire perpendicular to the inlet view results in predictable unintentional cranial translation of the guidewire on the outlet view (Fig. 1). Similarly, intentional anterior translation will result in unintentional caudal translation of the guidewire. The magnitude of these unintentional biplanar translations can be calculated as a Sine function of the degree arc difference between the inlet and outlet views:

BC = AB x Sin (90 - θ) where:

BC is the unintentional translation on the other view

AB is the intentional translation on the current view

θ is the degree arc difference between the inlet and outlet views

This formula is represented graphically in Fig. 2. Common degree arc differences and the resultant unintentional biplanar translations are provided in Table 1.

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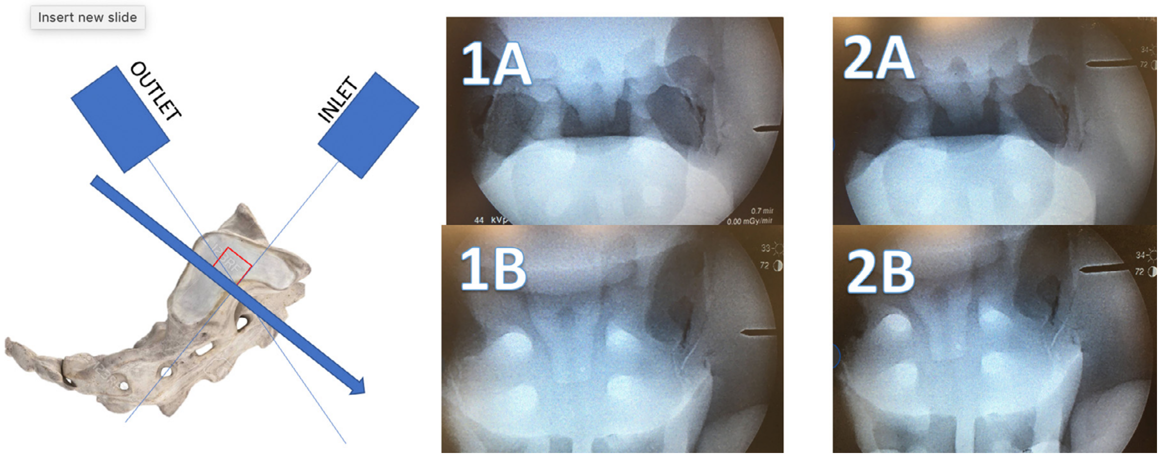
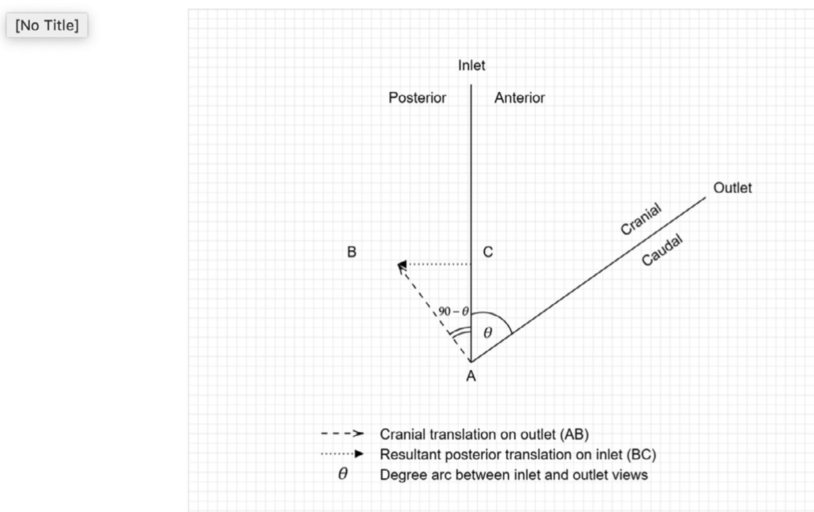


Fig. 1. Fluoroscopic images demonstrating guidewire position change when making anterior (1A/B) to posterior (2A/B) adjustments by moving perpendicularly to the inlet view beam. Images 1A/B demonstrate the initial position of the wire on the inlet (1A) and outlet (1B) views. Images 2A/B demonstrate the final position of the wire on the inlet (2A) and outlet (2B) views. Note that intentional posterior translation (2A) also resulted in unintentional cranial translation (2B).



$$\sin(90-\theta) = \frac{BC}{AB} \qquad \therefore\ BC = AB \times \sin(90-\theta)$$

Fig. 2. Graphical representation of inadvertent posterior translation on the inlet view due to guidewire translation perpendicular to the outlet view.

Table 1
Unintentional biplanar movement when translating guidewire perpendicular to fluoroscopic projections.

Degree arc Between inlet and outlet (0)	1 cm cranilal on outlet will move you (x) cm posterior on inlet	1 cm anterior on the inlet will move you (x) cm distal no the outlet
45	0.71	0.71
50	0.64	0.64
55	0.57	0.57
60	0.50	0.50
65	0.42	0.42
70	0.34	0.34
75	0.26	0.26
80	0.17	0.17
85	0.09	0.09
90	0.00	0.00

For angular changes to the guidewire made perpendicular to a given view, the same relationship holds true. That is, intentional anterior angulation perpendicular to the inlet view will result in unintentional caudal angulation on the outlet view, while intentional posterior angulation will result in unintentional cranial angulation. The magnitude of these unintentional angular changes can be calculated using linear algebra:

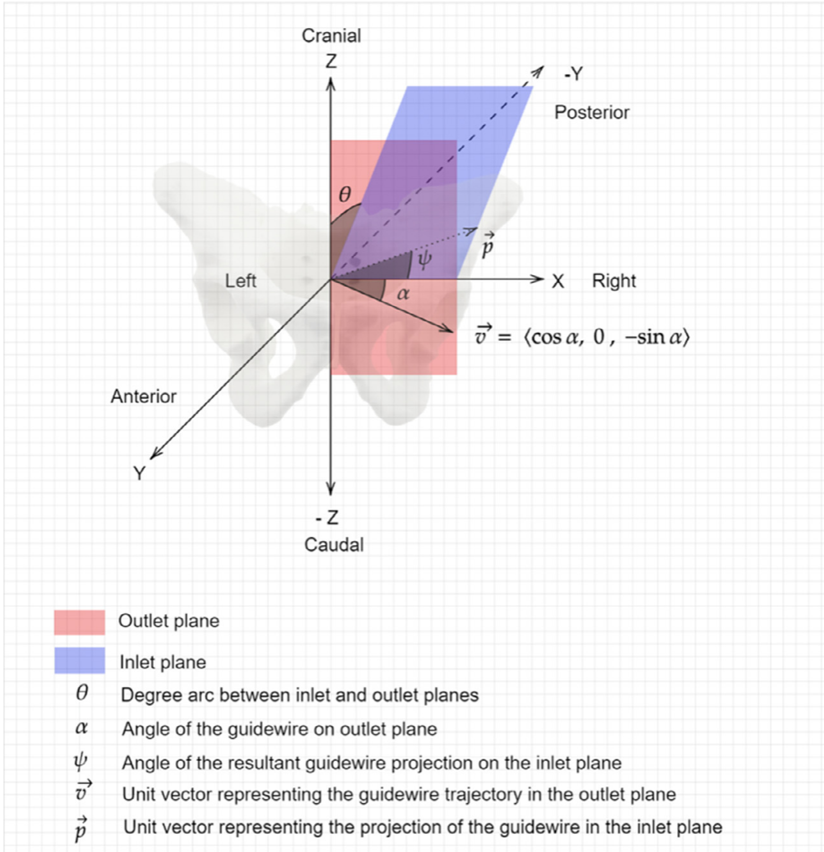
Ψ = Arctan (Cos θ × Tan α) where:

Ψ is the unintentional angular change on other view

α is the intentional angular change on the current view

θ is the degree arc difference between the inlet and outlet views

This formula is represented graphically in Fig. 3. The derivation of this formula is provided in Appendix 1. The above function is fairly linear over angular changes less than 40 degrees and can be simplified to the Cosine function, Ψ (degrees) = α × Cos θ. Thus, knowledge of common Cosine values allows for simple prediction of resultant biplanar angular changes. For example, if the difference between the inlet and outlet views is 60 degrees, then any intentional angular change on the current view will lead to half that angular change in the other view (cos(60) equals 0.5). In other words, a 20 degree intentional angular change in the outlet view would result in a 10 degree unintentional change in the inlet view, and vice-versa.



$$\psi\ (degrees) = \arctan(\cos\theta \times \tan\alpha)$$

Fig. 3. Graphical representation of inadvertent angulation on the inlet view due to guidewire angulation perpendicular to the outlet view.

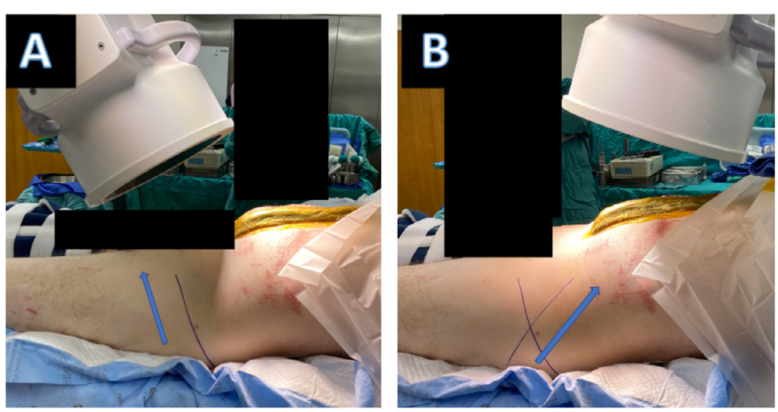


Fig. 4. Practical technique for limiting unintentional biplanar motion. A line is drawn parallel to the outlet view (5A) and inlet view (5B). Moving the guidewire along the line drawn parallel to the outlet view (5A) in the direction of the blue arrow will result in anterior translation only. Moving the guidewire along the line drawn parallel to the inlet view (5B) in the direction of the blue arrow will result in cranial translation only.

Technique for limiting biplanar movements

The unintentional biplanar movements discussed above are the result of attempting to correct anteroposterior position or angulation by moving perpendicularly to the inlet view and craniocaudal position or angulation by moving perpendicularly to the outlet view. To avoid the necessity for biplanar correction we suggest an alternative technique for targeting iliosacral screws. Once the surgeon has obtained satisfactory inlet and outlet views, a line in drawn parallel to the fluoroscopy beam in each position on the side of the patient. These lines will ideally, but not necessarily, cross at or near the start point. (Fig. 4)

To change anteroposterior positioning, the guidewire is moved anteriorly or posteriorly along the line drawn *parallel* to the *outlet view*. To change craniocaudal positioning, the screw is moved cranially or caudally along the line drawn *parallel* to the *inlet view*. Always moving in line with the fluoroscopic beam position for either the inlet or the outlet view will eliminate most unintentional biplanar movements. (Fig. 5).

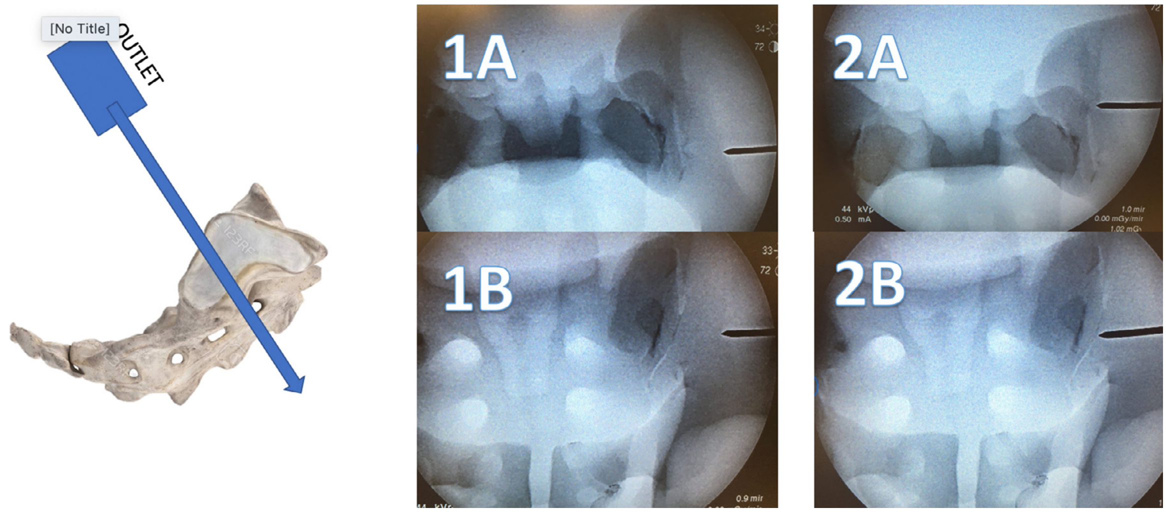


Fig. 5. Fluoroscopic images demonstrating guidewire position change when making anterior (1A/1B) to posterior (2A/2B) adjustments by moving parallel to the outlet view beam. Images 1A/B demonstrate the initial position of the wire on the inlet (1A) and outlet (1B) views. Images 2A/B demonstrate the final position of the wire on the inlet (2A) and outlet (2B) views. Note that intentional posterior translation (2A) resulted in no unintentional cranial translation (2B).

Discussion

While placing iliosacral screws may seem straightforward in theory, in practice it can be technically difficult for a number of reasons. Screw malpositioning remains a problem, and numerous imaging modifications and improvements have been proposed to increase the efficiency and safety of iliosacral screw placement. [10–15]

One particular difficulty with placing iliosacral screws is the simple fact that for most, if not all, patients the inlet and outlet views are not orthogonal to each other. Numerous studies has found that the average inlet view is obtained with approximately 20-25 degrees of tilt while the average outlet view is obtained with 40-45 degrees of tilt [6–9] Graves, et al, noted that the average difference in angle between these views was 67 degrees, with a range of 62-76 degrees [6] As a result, attempts to change the position of the screw or guidewire by moving perpendicularly to the fluoroscopy beam on either view will result in unintentional biplanar motion on the other view. Correcting these biplanar movements may be accomplished by repeatedly switching between the inlet and outlet views after each positional change. Unfortunately, this process has the potential to increase fluoroscopic time and decrease operating room efficiency.

This is the first study formally analyzing the these biplanar movements. Mathematical analysis demonstrates that these movements are predictable in both magnitude and direction. The formulas and tables provided could be used as a corrective tool for surgeons trying to place iliosacral screws. Practically, however, making such calculations and corrections precisely in the operating room would be difficult.

Therefore, we also present a simple technique for avoiding biplanar movements by ensuring that one is always moving parallel to the angle of either the inlet view (to correct craniocaudal position) or outlet view (to correct anteroposterior position). The combination of these corrections and/or our suggested technique will hopefully help surgeons improve the efficiency and accuracy of their iliosacral screw placement.

It should be noted that the directionality of the biplanar movements described in this paper assume that the inlet and outlet views are always less than 90 degrees different from one another. This appears true for most, if not all, patients based on available literature. In the case of a patient with an inlet and outlet view greater than 90 degrees different from one another, the equations provided here would still work, but the directions of translations and angulations would be opposite from those described in the results section. The technique we describe for limiting biplanar movements would also still work in these exceedingly rare scenarios.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.injury.2021.02.086.

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