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Original Article

Does Tibial Slope Affect Perception of Coronal Alignment on a Standing Anteroposterior Radiograph?

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ABSTRACT

Background: A standing anteroposterior (AP) radiograph is commonly used to evaluate coronal alignment following total knee arthroplasty (TKA). The impact of coronal alignment on TKA outcomes is controversial, perhaps due to variability in imaging and/or measurement technique. We sought to quantify the effect of image rotation and tibial slope on coronal alignment.
Methods: Using a standard extramedullary tibial alignment guide, 3 cadaver legs were cut to accept a tibial tray at 0°, 3°, and 7° of slope. A computed tomography scan of the entire tibia was obtained for each specimen to confirm neutral coronal alignment. Images were then obtained at progressive 10° intervals of internal and external rotation up to 40° maximum in each direction. Images were then randomized and 5 blinded TKA surgeons were asked to determine coronal alignment. Continuous data values were transformed to categorical data (neutral [0], valgus [L], and varus [R]).
Results: Each 10° interval of external rotation of a 7° sloped tibial cut (or relative internal rotation of a tibial component viewed in the AP plane) resulted in perception of an additional 0.75° of varus.
Conclusion: The slope of the proximal tibia bone cut should be taken into account when measuring coronal alignment on a standing AP radiograph.

Standing anteroposterior (AP) radiographs are used to evaluate tibial component alignment following total knee arthroplasty (TKA) [1]. Although the impact of coronal alignment on TKA outcomes is controversial [2–4], a generally accepted objective during primary TKA is to perform a proximal tibial bone cut that is neutral to the tibial mechanical axis [5,6].

Despite this conventional teaching, there is currently no standardized, generally accepted method of measuring the coronal alignment of this bone cut postoperatively. Furthermore, although short-standing AP radiographs have been shown to be less accurate in measuring coronal alignment than other methods [7], we are unaware of any prior studies that examine the relationship of tibial slope to the accuracy of coronal alignment measurement.

Using a cadaveric model, we sought to quantify the combined effect of image rotation and tibial slope on the perception of coronal alignment on a standing AP radiograph.

Materials and Methods

Using a standard extramedullary tibial alignment guide, 3 cadaver legs were cut to accept a primary tibial tray at 0°, 3°, and 7° of slope. The medial third of the tibial tubercle was used as a rotational reference. A computed tomography (CT) scan of the entire tibia was obtained for each specimen to confirm neutral coronal alignment. The cadaver was positioned supine on the scanner gantry table with the leg in a neutral position, similar to the previously described Perth Protocol [8]. The center of the tibial plateau and center of the ankle were used to establish the mechanical axis in the coronal plane, and the tibial cut was evaluated relative to this line to confirm neutrality. To simulate a standing AP radiograph, the legs were then held upright in a cam boot, taken at a standard distance of 10 feet, on a 14-inch by 17-inch

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Table 1
Mean Measurement of Coronal Alignment Among Blinded Surgeons.

Osteotomy Slope (°)	Rotation (°)	Mean (°)[a]	95% Confidence Interval	
0	0	−1.2	−2.6	0.2
0	EXT10	−0.6	−1.4	0.2
0	EXT20	−1	−1.9	−0.1
0	EXT30	−1.6	−2.4	−0.8
0	EXT40	−1.2	−2.2	−0.2
0	INT10	−1	−2.1	0.1
0	INT20	−0.6	−1.8	0.6
0	INT30	−1.4	−2.9	0.1
0	INT40	−1.6	−2.8	−0.4
3	0	0.6	−0.2	1.4
3	EXT10	0.8	0.4	1.2
3	EXT20	1	0.4	1.6
3	EXT30	1	−0.5	2.5
3	EXT40	1	−0.1	2.1
3	INT10	−0.2	−0.9	0.5
3	INT20	0	−0.6	0.6
3	INT30	0	−0.6	0.6
3	INT40	0.6	0.1	1.1
7	0	−0.8	−1.5	−0.1
7	EXT10	1.2	0.8	1.6
7	EXT20	2	0.1	3.9
7	EXT30	2.6	1.6	3.6
7	EXT40	3	2.4	3.6
7	INT10	1	0.4	1.6
7	INT20	−0.4	−1.9	1.1
7	INT30	−1	−2.1	0.1
7	INT40	−1.4	−2.2	−0.6

INT, internal rotation; EXT, external rotation.
[a] Negative value = valgus, positive value = varus.

cassette with alignment of the second toe parallel to the X-ray beam. Using a goniometer taped to the floor, and a Steinman pin rigidly fixed to the anterior tibia for reference, images were then obtained at progressive 10° intervals of internal and external rotation up to 40° maximum in each direction.

Images were then printed in black and white onto standard paper. Blinded labels were assigned to each radiograph, and the images were placed in a random order. Five blinded TKA surgeons were asked to determine coronal alignment. Surgeons were given an appropriately sized goniometer to determine alignment of the proximal tibia cut within 1°. Reviewers were informed that these cuts were performed on cadaveric specimens, but remaining information regarding the study, including study design, number of cadavers, and slope of the cut, was intentionally left out of the instructions.

For each slope (0°, 3°, and 7°), continuous data values were used to calculate intraclass correlation coefficient (ICC). A 2-way mixed model was used to calculate the ICC using SAS version 9.3. Continuous data values were transformed to categorical data (neutral [0], valgus [L], and varus [R]). From the categorical data of each slope, kappa value was calculated for multiple raters.

Results

Mean measurements for all cadaver specimens are listed in Table 1 and shown graphically in Figure 1. Categorical classifications of varus, valgus, or neutral for each cadaver specimen are listed in Table 2.

A clear trend toward varus perception was seen in sloped components imaged with the leg in progressive external rotation, whereas valgus perception was less prominent with progressive internal rotation of the limb (Fig. 1). Nonsloped implants demonstrated no clear trend. Sloped cuts imaged with the limb in external rotation were perceived to be in varus, neutral, and valgus in 77.5%, 22.5%, and 0% of measurements, respectively ($P < .001$).

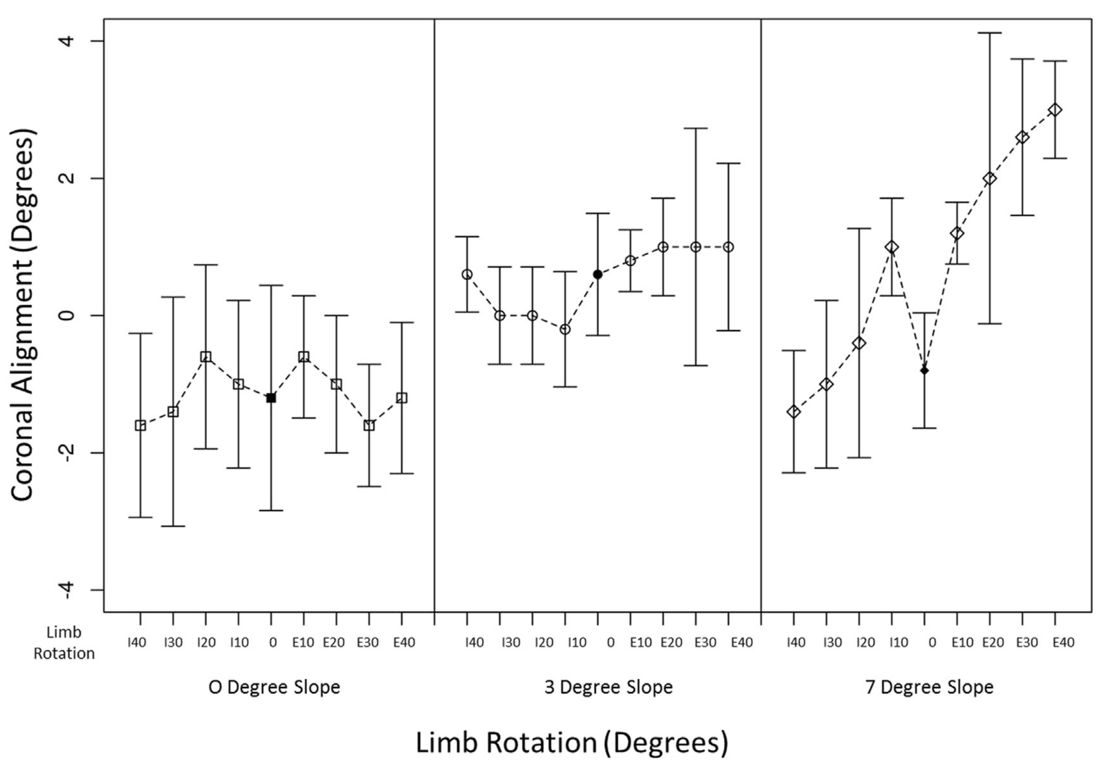

Fig. 1. Mean coronal alignment measurements and 95% confidence intervals for the 3 cadaveric tibial cuts. 0° Slope = mean coronal cut alignment measurement of cadaver with proximal tibia cut at 0° of slope (°), 3° slope = mean coronal cut alignment measurement of cadaver with proximal tibia cut at 3° of slope (°), 7° slope = mean coronal cut alignment measurement of cadaver with proximal tibia cut at 7° of slope (°); for each mean value reported, positive values reflect varus alignment, and negative values reflect valgus alignment. E = externally rotated cadaveric specimen relative to the X-ray beam (°), I = internally rotated cadaveric specimen relative to the X-ray beam (°).