CHAPTER VIII

REPRODUCIBILITY OF DIRECTIONS, POSITIONS AND PATTERN OF HELICAL AXIS BY STEPWISE TIBIAL LATEROROTATION

Some impression of the reproducibility was gained by repeating one experiment. With one preparation, number 3, the entire experiment was carried out twice. After completion of the first experiment - the preparation then occupied a position in the cage corresponding to 35° tibial laterorotation - the tibia was turned back to the zero position as indicated on the disc of the step mechanism of the cage. Then, from this 'new' zero position, the experiment was carried out once more.

From the data obtained during the first and the second experiment, the two bundles of the relative talocalcaneal helical axes were computed for step sizes 5° and 10°.

In Figure 8-1, the projections of these two bundles on the XY-plane have been drawn, the drawing on the left representing the first, that on the right the second experiment, step size 10°.

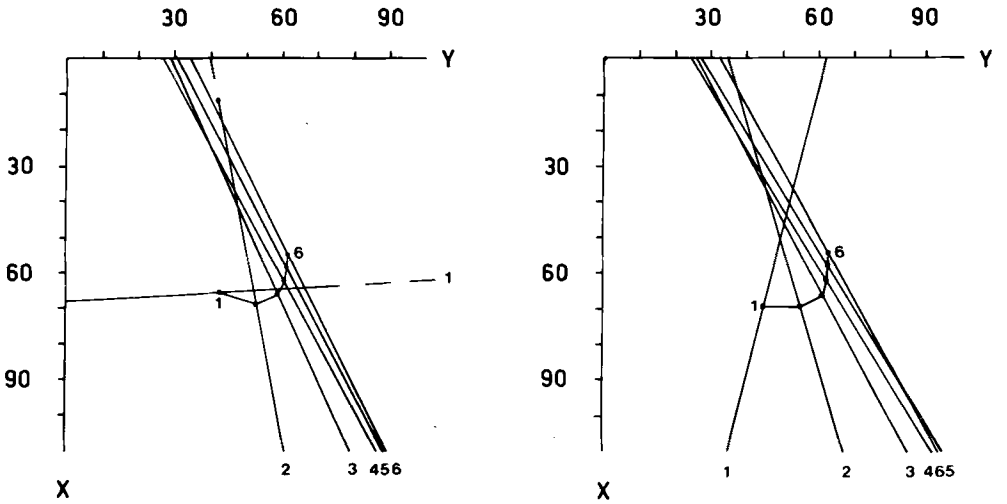

Figure 8-1. Projections TACA helical axis on XY-plane and centres of intersection; left first experiment, right second experiment, stepsize 10°.

The results show that the positions and directions of the axes are virtually equal except for axes nrs 1 and 2; the axes nrs 3, 4, 5 and 6 project over the calcaneal area (see Chapter 9) emerging anteromedially and posterolaterally. The pattern of displacement of the points of intersection of the helical axes with a horizontal plane through the tarsal canal is quite similar in the two series from the third point of intersection (transition 10° - 20° tibial laterorotation). Admittedly, the position of the second point of intersection is only slightly different, but it *is* situated anterolaterally relative to the third point. There appears to exist a gradually decreasing difference for the first three points of intersection. For the first point of intersection, this difference is large, for the second it is smaller and for the third it has grown very small.

In explanation of this difference, a number of factors may be indicated:

1) the relatively large sensitivity to errors in the relative TA-CA helical axis computation for the first few phases with step size 10°, because the angle of rotation α was very narrow (<5°);
2) the articular play or laxity in the talocrural joint (in the initial position and after a change of position);
3) the mechanical play in the transmissions of the propulsion mechanism of the cage;
4) the torsion of the tibia.

sub 1)

It has been demonstrated in the above that the accuracy of the computation of the axis depends on the measure of the rotation angle (Chapter Analysis of Errors; 7.3). We also drawned for the 5° step size calculations the projections of two bundles on the XY plane; the left representing the first and the right the second experiment. (Figure 8-2)

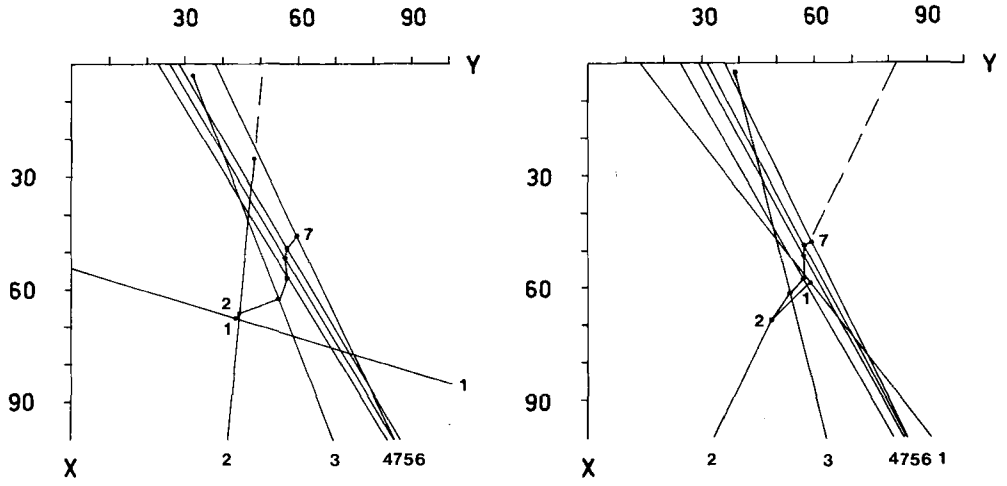

Figure 8-2. Projections TACA helical axis on XY-plane and centres of intersection; left first experiment, right second experiment, stepsize 5°.

Table 8-1 lists the XY-coordinates of the points of intersection of the relative TA-CA helical axes with a horizontal plane (z = 63) through the tarsal canal for the first (X_{1st}, Y_{1st}) and for the second (X_{2nd}, Y_{2nd}) experiment, with the differences between the two experiments for the 5° step size. Also, the table lists the α TACA for both experiments as α $(TA\text{-}CA)_{1st}$ and α $(TA\text{-}CA)_{2nd}$.
This table shows the great difference in phase 1 and phase 2 between the computer coordinates of the first and the second experiment. It also shows that precisely in those first two phases the subtalar rotations were very small, with 0.1° and 1.4°, respectively for the first and 0.3° and 0.7°, respectively, for the second experiment. In the phases 3 to 7 the values for α not only increase markedly, but also show smaller differences between the first and the second experiment.

Table 8-1. Centres of intersection (points) rel. TACA helical axes with horizontal plane. Z = 63 Spec. no. 3 (Right), step size 5°.

		First experiment		Second experiment		mm. abs. diff.	mm. abs. diff.	First exp.	Second exp.
		X_1	Y_1	X_2	Y_2	X_1-X_2	Y_1-Y_2	α	α
Phase									
1	0- 5°	67.85	44.46	58.88	59.21	18.97	14.75	0.1°	0.3°
2	5-10°	66.60	44.65	68.65	48.58	2.05	3.93	1.4°	0.7°
3	10-15°	62.71	55.23	61.60	53.10	1.11	2.13	4.5°	4.0°
4	15-20°	56.61	57.64	57.07	56.95	0.46	0.73	7.8°	7.8°
5	20-25°	51.33	56.67	50.63	56.80	0.70	0.13	6.4°	6.0°
6	25-30°	48.61	57.23	48.59	57.11	0.02	0.12	4.8°	5.0°
7	30-35°	45.61	59.87	47.60	58.98	1.99	0.89	3.0°	3.2°

Table 8-2. Centres of intersection (points) rel. TACA helical axes with horizontal plane. Z = 63 spec. no. 3 (Right), step size 10°.

		First experiment		Second experiment		mm. abs. diff.	mm. abs. diff.	First exp.	Second exp.
		X_1	Y_1	X_2	Y_2	X_1-X_2	Y_1-Y_2	α	α
Phase									
1	0-10°	65.39	45.32	65.16	48.77	0.23	3.45	1.5°	0.5°
2	5-15°	63.58	52.71	63.14	52.18	0.44	0.53	5.9°	4.6°
3	10-20°	58.65	56.81	58.25	55.68	0.40	1.13	12.2°	11.7°
4	15-25°	54.16	57.05	54.20	56.69	0.04	0.36	14.2°	13.8°
5	20-30°	50.10	56.82	49.66	56.90	0.44	0.08	11.1°	11.0°
6	25-35°	47.38	58.17	48.14	57.83	0.76	0.34	7.8°	8.3°

Table 8-2 contains the same data but now for the 10° step size. We now find only in the first phase a great difference between the coordinates of the points of intersection of both experiments, and then only for the Y-coordinate. It is only in the first phase that the α TACA is still found to be small (1.5° and 0.5°, respectively, in the first and the second experiment). In this single repeat experiment, there appears to be good reproducibility for the 10° step size data except for phase 1. This phase 1 will be considered a little further, see sub 2, 3 and 4.

sub 2, 3, 4)
The data concerning phase 1 are computed from the spatial coordinates of the

Table 8-3. Positions tarsal marking balls P1, P2, P3 and P4 in tibia, talus and calcaneus; first and second position, in first and second experiment.

		TIBIAPOSITIONS			TALUSPOSITIONS			CALCANEUS-POSITIONS		
		Exp. 1st	mm diff.	Exp. 2nd	Exp. 1st	mm diff.	Exp. 2nd	Exp. 1st	mm diff.	Exp. 2nd.
P1	1st X_1	71.2	0.5	70.7	87.1	0.0	87.1	85.2	0.4	84.8
	2nd X_2	73.3	0.5	72.8	87.3	0.1	87.4	85.3	0.3	85.0
	1st Y_1	74.4	0.4	74.0	70.0	1.2	68.8	40.1	0.9	39.2
	2nd Y_2	74.0	0.4	73.6	69.8	0.7	69.1	40.1	0.7	39.4
	1st Z_1	86.3	-0.1	86.4	83.2	-0.2	83.4	66.0	0.3	65.7
	2nd Z_2	86.2	0.1	86.1	83.0	0.0	83.0	65.9	0.4	65.5
P2	1st X_1	62.2	0.5	61.7	77.2	-0.1	77.3	75.3	0.4	74.9
	2nd X_2	65.0	0.4	64.6	77.4	-0.1	77.5	75.3	0.3	75.0
	1st Y_1	83.1	0.4	82.7	65.7	0.9	64.8	38.7	0.5	38.2
	2nd Y_2	83.4	0.4	83.0	65.6	0.6	65.0	38.7	0.4	38.3
	1st Z_1	99.3	-0.2	99.5	68.8	-0.1	68.9	50.9	0.3	50.6
	2nd Z_2	99.3	0.0	99.3	68.6	0.0	68.6	50.8	0.3	50.5
P3	1st X_1	76.2	0.4	75.8	84.2	-0.3	84.5	72.2	0.4	71.8
	2nd X_2	78.8	0.4	78.4	84.5	-0.2	84.7	72.2	0.2	72.0
	1st Y_1	82.2	0.5	81.7	76.4	1.1	75.3	37.9	0.6	37.3
	2nd Y_2	81.3	0.4	80.9	76.3	0.8	75.5	37.9	0.5	37.4
	1st Z_1	95.7	0.0	95.7	76.4	-0.2	76.6	61.7	0.3	61.4
	2nd Z_2	95.6	0.2	95.4	76.2	0.0	76.2	61.6	0.3	61.3
P4	1st X_1	61.7	0.4	61.3	67.9	-0.1	68.0	69.8	0.5	69.3
	2nd X_2	63.9	0.4	63.5	68.1	-0.1	68.2	69.8	0.4	69.4
	1st Y_1	75.6	0.5	75.1	68.7	0.6	68.1	31.8	0.3	31.5
	2nd Y_2	75.9	0.4	75.5	68.7	0.4	68.3	31.8	0.2	31.6
	1st Z_1	103.9	-0.1	104.0	73.3	1.0	73.3	44.8	0.4	44.4
	2nd Z_2	103.8	0.2	103.6	73.2	0.1	73.1	44.8	0.5	44.3

bones in their initial position and the position after 5° tibial laterorotation. Table 8-3 lists these coordinates for the marking balls of tibia, talus and calcaneus in both experiments. The differences between the corresponding coordinates in the two experiments are also listed. It is interesting to note the relatively small differences in the computed coordinates of the tibial balls: these differences always equalled or were smaller than 0.5°. For the coordinates of the talar balls much greater differences were found in the initial position, especially in the Y-coordinates. These Y-coordinates were always larger for the first than for the second experiment. This means that in the first experiment the talus in the initial position was slightly more in adduction than in the second experiment.
For most coordinates of the calcaneal balls, the differences in the initial positions of the first and the second experiment were comparable to those of the tibia (exception: the Y-coordinate P_1, with a difference of 0.9 mm).
This deviating Y-coordinate was longer in the first than in the second experiment. Here, again, a greater or lesser degree of abduction of the calcaneus may have played a part. This might justify the conclusion that of the causes, listed under 2, 3 and 4, of the differences in the coordinates of the initial position after the repeat experiment, the major contribution is made by the articular 'play' of the talus in the talocrural joint (osseous and ligamentous).

For the second position of the bones, the differences between the first and the second experiment were either smaller (21 times) or equal (9 times) to the differences in the initial position (6 times slightly more). Here, again, the differences in the Y-coordinates of the talar marking balls and those of one calcaneal marking ball, although admittedly decreased, were still greater than those for the other bones. In the second position, a minor 'talar play' might still be involved.