

A NEW LOOK TO AND THROUGH
THE
ABOVE-KNEE SOCKET

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Emphasis has previously been made on the desirability of placing the hip joint in adduction during the socket fitting and alignment of an above-knee prosthesis.^{3,4} This position combined with an appropriately shaped lateral socket wall facilitates increased pelvic stability in the frontal plane during stance phase on the amputated side. With the hip in adduction, the hip abductor muscles act as stabilizers to prevent the compensated Trendelenberg shift of the trunk over the amputated side so characteristic in many above-knee amputees.

The purposes of this paper are:

- (1) to describe an X-ray technique of determining hip position (adduction or abduction) in the fitted prosthesis,
- (2) to apply this method to a series of amputees to demonstrate the "true" position of the hip and femur in the prosthesis,
- (3) to present a series of AK amputees evaluated by this method demonstrating a high incidence of less than optimum hip abduction while wearing prosthesis fitted by conventional techniques,
- (4) to present another series of patients fitted by an altered technique utilizing the X-ray method to assure hip alignment in adduction in the new prosthesis.

Method: An AP X-ray of the pelvis, hips, femora and knee joints is taken on a 14" x 36 cassette with the patient standing. Equal weight is distributed on both the prosthetic and normal side. The heels are placed two inches apart and a standard 72" tube film

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distance is used. Measurements of hip abduction/adduction are made (see attached Figure #1) and the amputated side is compared with the normal side to determine relative hip position in the frontal plane. The amount and distribution of soft tissue relative to the femur and socket wall is also noted.

With the use of this X-ray technique during the alignment of a new prosthesis, the prosthetic knee joint and leg shank can be appropriately out set beneath the socket and also appropriately aligned with the Ischial seat horizontal. When the foot is then brought toward the midline, the femur is adducted, providing sufficient lateral wall contour has been built in to support the femur (Figure #2). Long² in a technical note describes a new method of alignment utilized in the second group of patients reported in this paper. It was found on review of the X-rays of amputees considered to have adequate adduction of the hip as compared to the contralateral side that the femoral head was located approximately over the center of the proximal socket in the medial/lateral dimension. The center of the medial/lateral dimension is then used as a starting point for bench alignment of the prosthesis. A straight line from the center of the socket to the center of the foot should intersect the distal end of the femur remnant in the stump if sufficient adduction of the hip has been achieved in fitting the socket (Figure 3).

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The ischial seat, knee axis and foot should all be at 90 degrees to this line. The prosthetic knee joint must be displaced laterally to allow clearance for the sound knee. A standing X-ray using the described technique is used to confirm hip adduction prior to prosthetic finishing.

CASE MATERIAL

A total of 73 X-ray evaluations involving 51 amputees were performed utilizing the described technique. The first group of 38 patients studied were patients who were wearing prostheses with total contact quadrilateral sockets fitted by standard techniques of fitting and alignment. The prosthesis had been fitted by a variety of prosthetists in different facilities in the United States. With the exception of three patients the X-rays revealed the amputated side hip to be in abduction (26 patients), at zero degrees (4 patients) or in less adduction (5 patients) than the sound side hip (Chart #1, Column A).

A second group of X-ray evaluations were performed on twenty of the above mentioned first group amputees who were fitted with new prostheses, utilizing the revised method of alignment as described. All improved the angles from abduction to adduction as compared to the sound side (Chart #1, Column B). The total change in listed in Column C of Chart #1.

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An additional 13 new amputee had the X-ray method and revised alignment techniques utilized for their initial prosthetic fittings. (Chart #2) Two of these patients had a second socket fitted utilizing this method after shrinkage of the stump. All of the X-ray evaluations on these patients revealed adduction of the hip on the amputated side.

It should be noted that since the X-rays are taken with the patient standing, weight equally distributed and knees straight, any leg length discrepancy will be manifest by unequal height of the femoral heads above the horizontal reference line of the film which is positioned perpendicular to the floor. Eleven prostheses were short by more than .5cm and three prostheses were long by more than .5cm. Shortening of the prosthesis tends to increase the angle of the hip abduction on the amputated side and due to the pelvic tilt increasing the angle of adduction on the sound side. The converse is true if the prosthesis is too long causing a pelvic tilt in the opposite direction and increasing the angle of adduction on the amputated side. Rather than temporarily equalize the leg lengths by lifts while the X-rays were obtained, these discrepancies were accepted on the basis the angles would be similar to those in the patient functioning with the leg length discrepancies.

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DISCUSSION

The concept of X-ray evaluation of amputation stumps in prosthetic sockets is not new. Various authors have utilized X-ray to demonstrate the adequacy of stump-socket interface relative to soft tissue total contact in the socket. Erikson and Urban¹ Utilized X-rays to demonstrate appreciable excursion of the femoral stump within the soft tissues and consequently within the socket relative to stump position. They and other authors did not, however, measure the relative angles of abduction/adduction of the hip joint as described in this paper.

The concept of placing the amputation stump hip in adduction during fitting has long been recognized and taught as necessary to provide pelvic stability during stance phase by placing the hip abductors in an optimum position. Due to varying amounts of stump soft tissue and the tendency for the femur to move laterally during weight bearing on the stump, a clinical evaluation of the amount of hip abduction/adduction is difficult. The described X-ray technique gives a uniform, objective method to determine the true angle of hip adduction/abduction.

The initial group of amputees who had prostheses fitted by a number of different prosthetists across the country demonstrates the current fitting and alignment methods only infrequently puts the hip in adduction. It seems the heel of the prosthetic foot

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is aligned under the ischium without objectively considering the position of the femur within the soft tissues in the socket in current methods of alignment. The described techniques emphasize placing the hip in adduction translating the knee laterally and out setting the foot so that as it is brought toward the midline in walking the hip is brought into adduction.

Amputees who have prostheses fitted with the revised alignment technique and check by X-ray describe an increased sense of stability and balance while walking and standing in the amputated side. This study does not propose to show objective data that the adducted hip alignment in amputees conserves energy for the amputee; however, observation of gait in the majority of these amputees does show some decrease in the compensated Trendelenberg gait of the typical AK amputee.

In summary the described X-ray technique is an objective method of determining hip adduction and femur position in the socket of the AK amputee. The technique may be applied to prosthetic alignment in order to provide increased pelvic stability in the frontal plane during stance phase.

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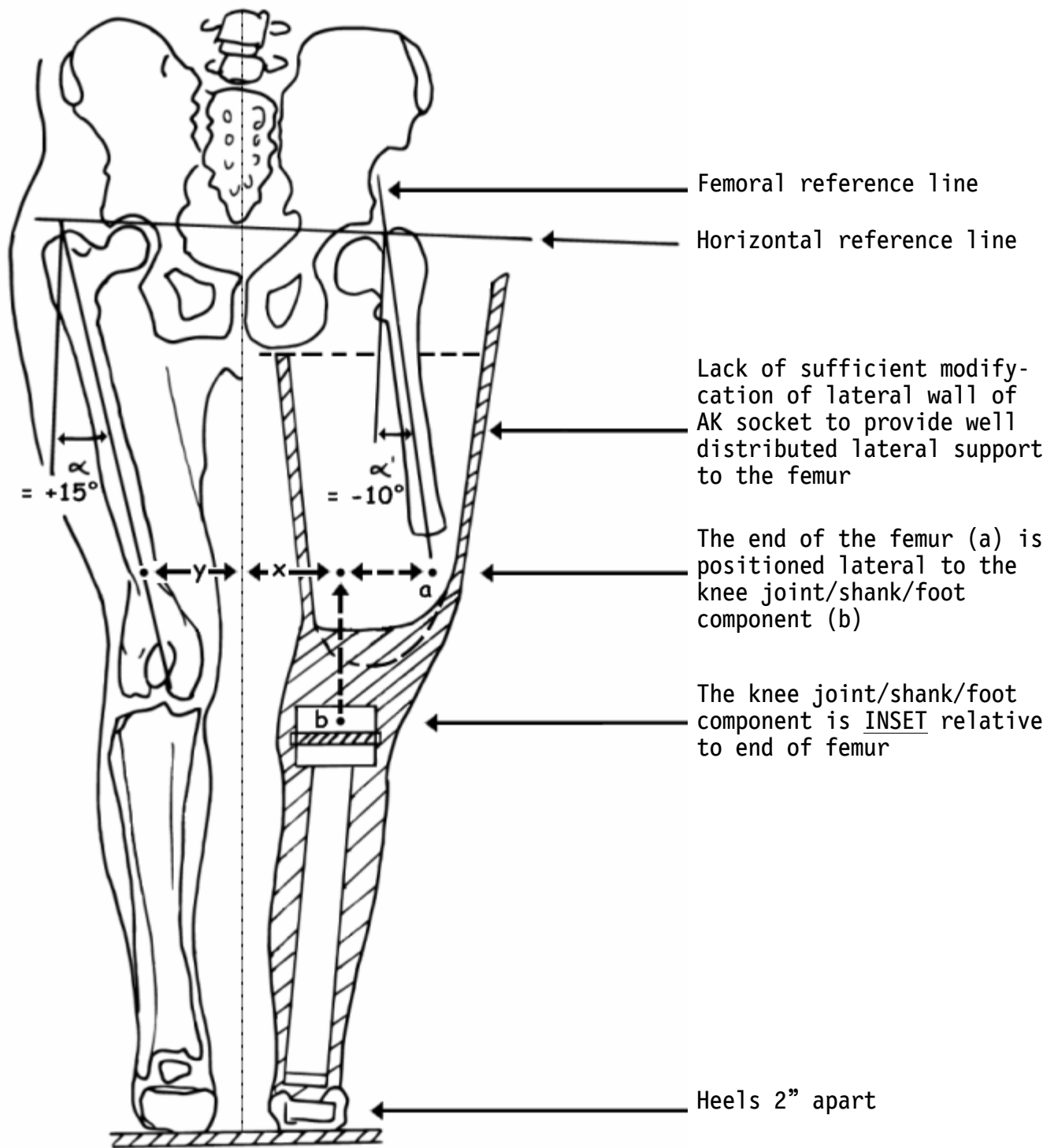


Figure 1
Prosthetic Fit #1

X-ray measurements of relative hip adduction and abduction are made as follows. A horizontal reference line is constructed across the tops of the femoral head shadows and a perpendicular is constructed at the point the femoral reference line crosses the horizontal reference line. In this poorly fitted prosthesis, the amputated hip is in abduction of 10° (α'). The sound side hip is in 15° adduction (α). The heels are maintained 2" apart while the X-ray is taken.

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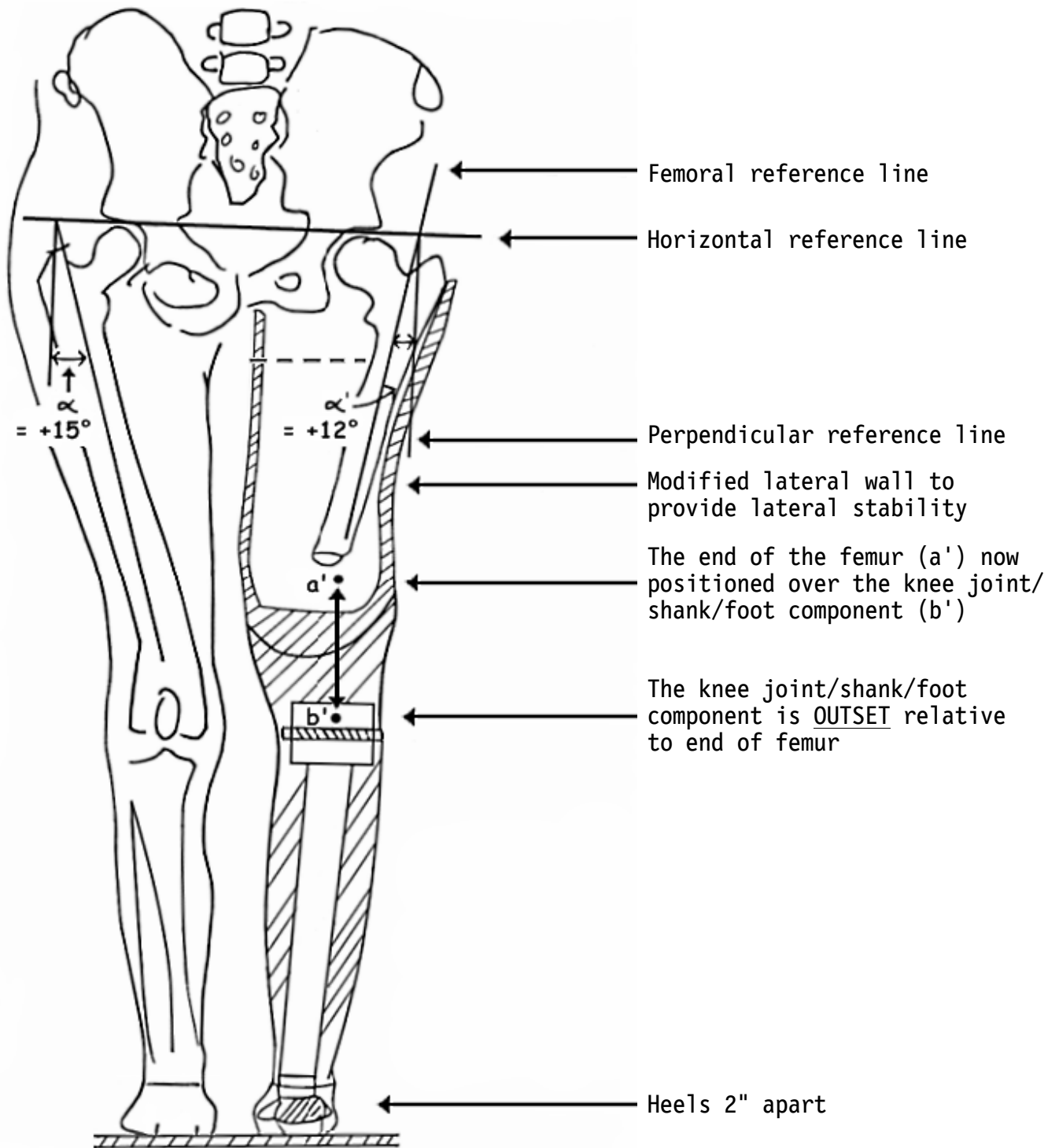


Figure 2
Prosthetic Fit #2

X-ray shows alignment of hip in adduction ($\alpha' = 12^\circ$) with modified alignment technique of positioning end of femur over the knee joint by a relative outset of the knee joint/shank/foot component. The lateral wall has been appropriately shaped to provide lateral stability as demonstrated by the X-ray. The heels are maintained 2" apart as in Figure 1.

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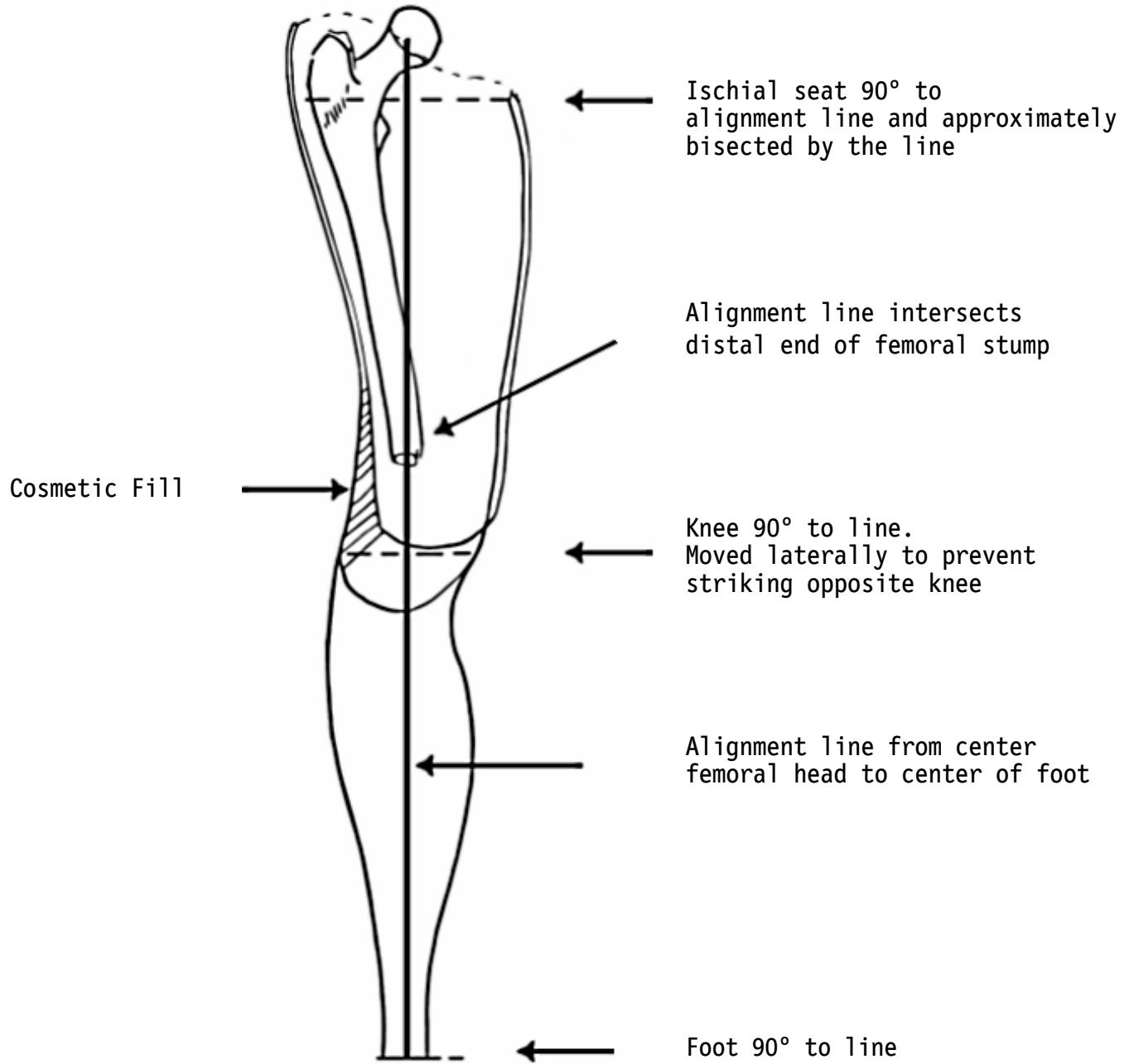


Figure #3

X-ray check of alignment criteria.

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CHART #1

X-rays of prosthesis with standard alignment in the left hand columns and revised alignment in the right hand columns. Numbers are degrees of deviation from a perpendicular to the horizontal reference line. Adduction is signified by (+) and abduction by (-).

Patient	<u>A</u>		<u>B</u>		<u>C</u>
	Standard Amp Side	Alignment Sound Side	Revised Amp Side	Alignment Sound Side	Total Change To Adduction
1	- 6	+10	0	+11	+ 6
2	- 8	+ 8	+ 5	+ 8	+13
3	+ 2	+10	+11	+10	+ 9
4	- 3	+ 8	+11	+ 8	+14
5	- 1	+12	+10*	+ 7	+11
6	+ 3	+10	+10	+ 8	+ 7
7	- 4	+10	+ 2	+10	+ 6
8	-13	+ 8	- 2	+ 4	+11
9	0	+11	+ 8	+11	+ 8
10	+ 4**	+ 7	+ 5	+ 9	+ 1
11	0	+ 6	+ 4*	+11	+ 4
12	+ 5**	+ 3	+ 5	+ 9	0
13	- 3	+ 9	+ 3	+ 6	+ 6
14	- 1	+ 8	+ 6	+ 8	+ 7
15	- 1	+ 7	+ 5	+ 7	+ 6
16	- 8	+10	+ 8	+ 8	+16
17	0	+ 8	+ 7	+ 7	+ 7
18	- 8*	+16	+ 6*	+10	+14
19	- 4*	+13	+ 7	+11	+11
20	- 9*	+11	+ 8	+10	+17

Only Survey X-ray taken and no revision on the following group:

21	+ 2*	+ 8
22(AK,BK)	- 3*	+12
23	- 5*	+ 8
24	- 5*	+15
25	- 4	+ 9
26	0*	+12
27	+ 4	+11
28	+ 8	+ 7
29	- 2	+ 9
30	- 5	+ 5
31	- 9	+ 8
32	-13*	+ 9
33	- 8	+ 7
34	- 9	+10
35	+ 7**	+ 2
36	- 7	+10
37	-21	+ 8
38	-10*	+ 5

* Prosthesis measurement short by more than 0.5 cm.

** Prosthesis measurement long by more than 0.5 cm.

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CHART #2

X-rays of amputees with their first prosthesis utilizing revised alignment method.

<u>Patient</u>	<u>Amputated Side</u>	<u>Sound Side</u>
39	+ 5	+ 7
40	+ 5**	+ 2
41	+ 7	+ 9
42	+ 8	+ 7
43	+13	+ 8
44	+ 4	+ 7
45	+ 3	+ 7
46	+17**	+ 3
47	+ 5*	+11
48	+ 6*	+14
49	+ 8	+ 8
50	+ 2	+ 7
51	+ 5	+ 5

Above patients who received a second fitting:

45	+ 2*	+ 9
43	+ 8	+ 9

- * Prostheses short by more than 0.5 cm.
- ** Prostheses long by more than 0.5 cm.