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ORIGINAL STUDY

Femoral anteversion measurement : evaluation of inter- and intraobserver reliability

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The aim of this study was to evaluate the inter- and intraobserver reliability of a CT-based femoral anteversion measurement.
17 CT scans showing an abnormal anteversion on one side were presented to 6. Three measurements of all scans were obtained : two bilateral measurements and a third measurement with a flipped CT scan.
Interobserver correlation results using the spearman test for left, right and anteversion difference had a mean of respectively : 0.918, 0.760 and 0.757. Intraobserver correlation had a maximum of respectively : 0,99, 0,89 and 0,94. Correlation coefficients were consistently higher for the second measurement. The lower correlation boarder of 0,8 was often exceeded. Intraobserver correlation was higher than interobserver correlation.
As we evaluated a high variance in interobserver reliability, we recommend an accurate and objective measurement of the anteversion angle. A personal measurement and comparison to the radiological protocol is necessary.

Keywords : anteversion angle ; interobserver ; intraobserver ; reliability ; CT scan.

INTRODUCTION

Femoral neck anteversion is defined as the angle between an imaginary transverse line that runs medially to laterally through the knee joint and an imaginary transverse line passing through the centre of the femoral head and neck (Fig. 1). We speak of femoral anteversion when this angle exceeds 20° *(4)*. Intramedullary nailing is often used in trauma, in which a peroperative variation of the anteversion angle can occur *(3,5,9)*. An elevated anteversion can be the result of certain pathologies, e.g. cerebral palsy, developmental hip dysplasia, Perthes disease or idiopathic excessive antetorsion *(8,9)*.

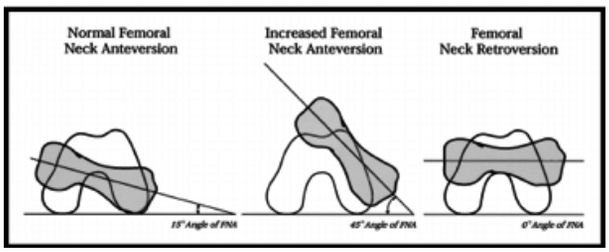

Figure 1. — Defenition of femoral neck anteversion, retroversion an a normal neck anteversion.

Different methods measuring femoral anteversion have been described in the literature. Taking in regard the age of the patients, certain methods are

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used preferentially. MRI and ultrasound are more popular in childhood, in contrast to CT –scan and plain X-rays. The inter reliability of MRI and ultrasound have already been described *(7,8,10,12)*.

Clinically we can see that many patients tolerate abnormal antetorsion *(3)*.

This study deepens on the inter- and intraobserver reliability of femoral anteversion measurement using 2D CT scan method. Special interest is the difference between left and right, because of its importance in case of planning a correction.

A second point of interest is whether the orthopaedic surgeons can determine the correction angle, using the angles measured by the radiologists.

Is one measurement of femoral version enough when surgical correction is planned or is it preferable that the measurement is performed by different observers?

METHODS

Seventeen CT scans were selected. Six observers, of which 2 orthopaedic surgeons, 2 musculoskeletal radiologists, an orthopaedic resident and a radiologic resident, performed three measurements.

The first two were obtained with an interval of three to five weeks, the third after a longer period. To obtain an objective measurement, the patient information was removed from the CT scan. The scanner used was General electrics ep 64 and the thickness of the slices was 3mm. The CT scans were chosen in retrospect for this study.

Nine CT scans were taken after femoral facture for measurement of the femoral torsion after nailing, osteosynthesis and malunion. Two other scans included were done for the measurement of torsional variance after hip prostheses and periprosthetic fracture. Recurrent patellar luxation, congenital hip luxation, clinical endorotation of a leg or preoperative planning of an acetabular reconstruction were the other reasons to perform a CT scan

The protocol for measurement to minimise variation was the same for every observer. The CT scan was opened and the observer himself selected the slices for femoral version measurement, no preselected slices were given. Then the angle between the femoral neck and a horizontal line and the posterior condylar line and a horizontal line were measured in PACS. It was not possible to project multiple CT slices on each other. The difference between the angles was calculated to achieve the version. The observers also had to indicate if there was anteversion or retroversion of the hip. Both sides were measured, with the difference calculated in Excel afterwards. Obtaining the third measurement the procedure was adjusted. The CT scan was flipped and the left and right anteversion angles were measured at the left side of the patient. This was decided due to the better results of reliability during the first and second measurement, when the anteversion angle was measured at the left side.

As mentioned the difference was calculated. This difference is usually important when a surgical correction is planned.

The Kolgomorov-Smirnov test, a statistic test defining the normality of a group, was obtained. The decision was made to work with non parametric tests, because of lack of normality in the groups.

The Spearman test measures the correlation between two observers in non parametric data. This test was used to define the inter- and intraobserver reliability.

RESULTS

For every patient the anteversion angle was measured bilateral on CT scan and the right side was flipped to left for the third measurement. A total of seventeen anteversion angles for the left and right side were collected and the mean angle was measured. The standard deviation with upper and lower border, taking in consideration the 95% confidential interval made it possible to identify the outliers. Table I summarizes the results concerning the left anteversion angle (Table I). These measurements show a low degree of outliers, who didn't exceed the ten cases per patient. In contrast the number of outliers per patient for the right anteversion angle, described in table II, ranged from eight to eighteen (Table II).

Considering the correction angle, the absolute value of the difference between the left and the right anteversion angle measurement, the same descriptive

Table 1. — Per patient the mean angle was determined , as well as standard deviation and minimum and maximum values. The outliners are the angles exceeding the lower and upper border of the standard deviation.

LEFT ANGLE

	Min	Max	mean	standard deviation	outliners
patiënt1	10,3	25,6	16,367	3,2583	4
patiënt2	10	35,2	24,778	5,9351	4
patiënt3	-8	21	-2,34	6,454	1
patiënt4	9,1	20,9	14,906	3,3231	5
patiënt5	2,6	17,5	11,244	4,2704	5
patiënt6	58	70	63,983	3,1407	7
patiënt7	-20	12,2	-15,511	7,4329	1
patiënt8	-10	3	-5,889	3,9534	5
patiënt9	23	34,3	28,561	3,7318	10
patiënt10	-14	10,8	-7,306	5,4627	3
patiënt11	29,4	46,8	36,522	4,1306	4
patiënt12	-30,1	6,7	-4,861	11,2197	4
patiënt13	4,2	15	10,889	2,3968	3
patiënt14	34,2	42,4	38,928	2,5513	5
patiënt15	2,1	27,7	14,306	9,9821	9
patiënt16	6,2	33,3	26,994	6,1666	3
patiënt17	19,3	35	27,061	4,3182	6

Table 2. — Per patient the mean angle was determined , as well as standard deviation and minimum and maximum values. The outliners are the angles exceeding the lower and upper border of the standard deviation.

RIGHT ANGLE

	min	max	mean	standard deviation	outliners
patiënt1	45	56	53,006	2,8784	18
patiënt2	8,4	21,4	15,633	3,5535	16
patiënt3	12	26	19,08	3,842	17
patiënt4	28,4	43,3	33,411	3,2137	18
patiënt5	6,4	16,7	12,661	2,7169	10
patiënt6	14	25,2	21,928	3,101	18
patiënt7	12,9	80	21,156	14,8573	17
patiënt8	-5	25,2	9,544	9,6263	15
patiënt9	-13,7	-1,5	-8,894	3,5984	18
patiënt10	7,6	17,2	12,161	2,7393	17
patiënt11	6	27	12,806	4,4515	18
patiënt12	7,7	29,4	22,661	6,6574	18
patiënt13	13,7	30	20,761	4,7981	18
patiënt14	8	19,1	12,222	2,6419	18
patiënt15	-11,8	11,3	4,617	5,7554	8
patiënt16	2,9	28,8	11,067	5,9791	17
patiënt17	-19,9	31,4	22,894	11,0626	2

statistics were obtained. These results are described in table III (table III). The mean was calculated with an upper and lower boarder. The outliers were in the same range as for the right anteversion angle : the number of outliers ranged from zero to eighteen. The correlation, illustrated in the graphs (Fig. 2&3), was calculated to describe the reproducibility of anteversion measurement between the different observers (interobserver) or oneself over a period of time (intraobserver). The six observers participated for all the three measurements. In the following results no difference in trend was observed between

Table 3. — Per patient the mean angle was determined , as well as standard deviation and minimum and maximum values. The outliners are the angles exceeding the lower and upper border of the standard deviation.

ANTEVERSION DIFFERENCE

	min	max	mean	standard deviation	outliners
patiënt1	29,4	41,9	36,639	3,6743	18
patiënt2	2,5	20,7	9,422	4,8343	17
patiënt3	3	29	21,43	5,768	17
patiënt4	12,1	22,4	18,506	2,926	11
patiënt5	0,6	8,5	3,472	2,2903	16
patiënt6	36,5	51,6	42,056	3,5538	18
patiënt7	6	95,1	36,667	16,5199	18
patiënt8	1	27,7	15,233	8,5706	18
patiënt9	28,1	44,9	37,456	4,8998	15
patiënt10	0,4	29	19,467	6,2397	18
patiënt11	14,9	35	23,717	5,0443	18
patiënt12	18,3	38,3	27,522	5,777	18
patiënt13	1,3	24,3	10,017	5,9139	0
patiënt14	23	33	26,706	2,63	18
patiënt15	1	38,3	10,622	9,6075	7
patiënt16	7,4	30	18,439	5,732	15
patiënt17	0,6	54,9	6,111	12,3858	18

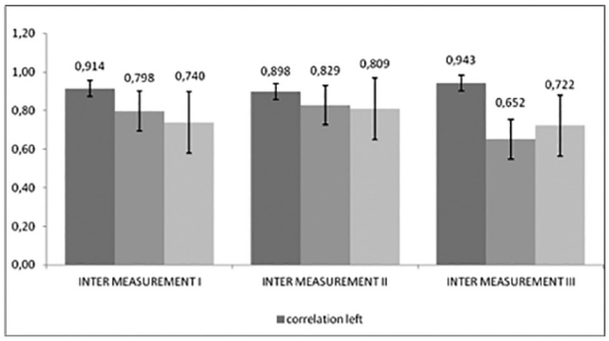

Figure 2. — Mean inter observer reliability illustrated using the Spearman test for correlation.

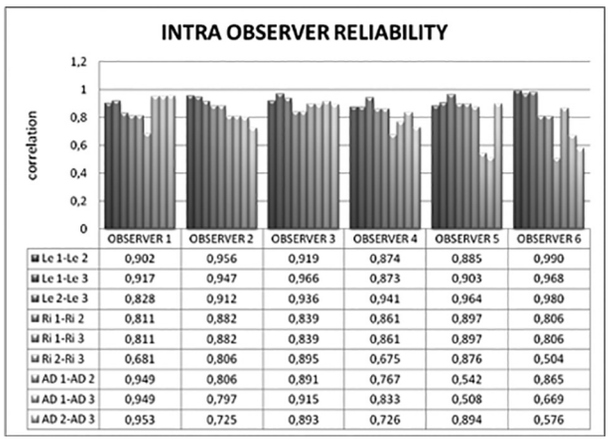

Figure 3. — Intra observer reliability illustrated using the Spearman test for correlation.

the inter- and intraobserver correlation, however the intraobserver correlation had slightly better outcome. The correlation of the left anteversion angle ranged from 0.828 to 0.956, which could be considered as high acceptable to perfect results. If we consider the right anteversion angle we observed correlations ranging from 0.334 to 0.897.

The correlation considering the correction angle gave the following values ranging from 0.407 to 0.953.

The better results for the left anteversion angles were an incidental finding.

DISCUSSION

The purpose of this study was to evaluate the reproducibility of femoral anteversion measurement on CT-scan. The anteversion angle is often measured preoperatively, but can it be used without surgical re-evaluation when surgical correction is planned? Our experience told us that the independent preoperative measurement is not always correct. The major aim was obtaining a critical evaluation of the inter- and intraobserver reliability of femoral anteversion in practice, making us aware of the variable results when measuring femoral anteversion

Certain studies have already evaluated the anteversion measurement on MRI or CT scan as well in human studies as in animal studies. Even older studies already promoted the accuracy of CT scan when measuring the anteversion angle *(12)*. Mostly different research questions were clarified, other than the research question in our study. In general only little literature is available on inter- and intraobserver reliability in femoral anteversion, only emphasising the importance of our study.

Reviewing the literature Botser et al found that anteversion measurement was more reliable on CT scan when compared to MRI. A significant inter-observer correlation difference was observed in favour of the CT scan measurements *(4)*. Souza et al. emphasised the importance of imaging when determining femoral anteversion. Here the physical and radiological (MRI) measurement was compared. The importance of radiological assessment was promoted *(13)*. Ginja et al observed anteversion angle measurement on CT scan in dogs with hip dysplasia. Favourable results were obtained, with an intra-class coefficient exceeding the 90% *(6)*. A cadaveric study of Kuo et al. evaluated the difference in anteversion angle on an anatomical reference compared with the measurement on CT scan. No significant difference in angles was calculated, making CT scan a reliable and accurate technique for measuring femoral anteversion *(11)*. Another factor in anteversion measurement is the femoral alignement in 2D and 3D CT imaging. Davids et al. observed that only a good alignment gave good inter- and intraobserver reliability, as well in 2D measurement as 3D measurement in children with cerebral palsy *(5)*.

The above mentioned studies suggest the improvement of the radiology, especially CT scan, in determining femoral anteversion. Our study is less positive in this matter. We summarised the left and right anteversion angle, with the correction angle measured afterwards. For the left anteversion angle the results were very favourable. Often an inter- and intracorrelation of 0.90 was exceeded. This could be explained by the low number of outliers found in the descriptive statistics.

One must take in account that statistically the mean is a calculation of measured results. The mean measurement in this study can't be interpreted as a gold standard. Interpretation of the high correlation means a minimal difference in measurement but doesn't mean that the measurement was well interpreted.

The correlation of the right anteversion angle was less favourable. Here a high variation of the anteversion angle was found. The same results were found for the correlation considering the difference. As this is a calculated value of measured results, the risk of variation is higher.

Considering the evolution when the measurements were obtained for the second and third time, no clear evolution was obtained. In this study there was no positive learning curve. However, when the mean correlation was calculated (Fig 2), a correlation of 0.70 was the lowest. Nevertheless, correlations lower than 0.70 give a negative outcome of the general correlation. Flipping of the CT scan (third measurement), because of the favourable results after the first and second measurement, didn't give

better correlation, i.e. less variability between the measured angles and thus it has no added value to perform this in the future.

In general favourable correlations were obtained, taking in account certain exceptions. However we suggest that strict control or eventually computerisation of the correlation measurement should be taken in consideration.

The intraobserver reliability was in general higher. Furthermore experience isn't a certainty of higher correlations as we see that the residents achieved as good results as the experienced doctors, as well for inter- as intraobserver reliability.

The reason why the left version has a higher correlation can't be explained by visual interpretation. As mentioned above the correlation of the right version angle didn't increase when the CT scan was flipped. The thickness of the CT scan slices wasn't the same in all patients which can explain the difficulty to measure the version as precise as in other CT scans with less variation and smaller slices.

Also patient factors should not be ignored. The human anatomy is different in every human being and can give difficulties in obtaining the most suitable determination of the version angle.

CONCLUSION

The purpose of this study was to evaluate the reliability and reproducibility of femoral anteversion measurement.

This study shows that the interobserver reliability was not as favourable as accepted. The intraobserver reliability gave good reproducibility. Due to these results we think that a personal measurement is necessary when a surgical correction is planned. A comparison with the results of the radiologist is recommended. A third independent orthopaedic or radiological advice should be considered when a difference greater than 3 degrees is present between the orthopaedic surgeons and the radiologists measurement.

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