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FACTORS INFLUENCING RESULTS OF HIGH TIBIAL OSTEOTOMY IN GONARTHROSIS

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Despite the postulated association between knee pain, roentgenological degenerative changes and proven angular deformity (Danielsson & Hernborg 1970), the predictability of progression of subjective inconvenience for a given patient who suffers from gonarthrosis cannot be made with sufficient certainty. Spontaneous decline of subjective complaints in patients with arthrotic knees is an occurrence very well appreciated in daily orthopaedic practice.

High tibia osteotomy (HTO) has become a very common method in the treatment of gonarthrosis, with a relatively constant success rate reported (Appel & Friberg 1972, Bauer 1969, Debeyre & Artigou 1972). Since there is no reliable system for classifying the evolutionary phase of gonarthrosis, it is impossible to reject the hypothesis that reported deterioration may be the result of some self-deteriorating factor acting in gonarthrosis. There are two theoretical explanations for development and progress of gonarthrosis: The theory of biomechanical causes (Pauwels 1965) and the theory of circulation disturbance (Arnoldi 1971). The HTO may act by changing the mechanical axis of the knee, by altering the circulation or by both. Despite this discussion, we believe that very little attention is paid to the causes for the patient's satisfaction or dissatisfaction with HTO.

In our retrospective study we tried to investigate the following: Whether or not the patient's satisfaction after HTO is correlated to the functional state of the operated knee. We were further interested in which other factors influence the patient's assessment of HTO.

MATERIAL AND METHODS

Our series comprises the patients operated on when we began to use HTO in treating gonarthrosis. It comprises 89 patients operated on between 1965 and 1971. The operations were carried out by 10 surgeons with varied operative experience. Of the 89 patients, 86 were available for postoperative examination, one patient was excluded (fully satisfied patient with anchylosis of the knee following infection). Of the remaining 85 patients, 11 of the osteotomies were bilateral, giving a total of 96 knees reexamined. Five patients had a second operation on the same leg (two for delayed healing, three because satisfactory correction had not been obtained). The figures given throughout the paper refer to the definitive state and number of knees and not to the number of operations or patients.

The indication for osteotomy was a combination of deformity with roentgenological signs of arthrosis of the knee and failure to relieve pain by the usual conservative means. There were 79 knees with varus deformity and 17 knees with valgus deformity. The average age was 64 years, ranging from 37 to 80 years. Compared to the sex distribution of the population in our admission area, there was a significant over-representation of women in our series, especially in patients over 60 years. The exact duration of knee pain was impossible to estimate precisely, but was never shorter than 2 years. The follow-up period varied between 15 and 84 months, with an average of 38 months.

Preoperative assessment

Preoperatively the knee were assessed in terms of four basic parameters: pain, stability, range of motion and functional capacity. The degree of deformity was assessed from weightbearing anteroposterior roentgenograms in 62 knees and non-weightbearing roentgenograms in 34 knees.

There were 48 knees with varus deformity of up to 5 degrees, 19 knees with the deformity up to 10 degrees and 12 knees with the deformity over 10 degrees. In 17 knees with valgus deformity, the deformity ranged from 12 to 25 degrees. Of the 79 knees with varus deformity, 72 had an arc of motion exceeding 80 degrees and seven had an arc of motion ranging from 65 to 80 degrees. Fifty-six knees were without contracture, 19 had a contracture ranging from 5 to 15 degrees, and four had a contracture ranging from 16 to 25 degrees. Contracture of more than 25 degrees was considered a contraindication for HTO. In 17 knees with valgus deformity there was one knee with an arc of motion of 60 degrees, two knees with motion ranging from 65 to 80 degrees, and 14 with motion exceeding 80 degrees. Two of them had a contracture of 10 degrees and one a contracture of 25 degrees. Of the 79 knees with varus deformity, there were 22 knees with clinical signs of instability but only 19 knees with roentgenological signs of subluxation. Of the 17 knees with valgus deformity, 10 knees experienced clinical instability and only four knees had roentgenological signs of subluxation. Angular deformity and subluxation were measured on roentgenograms according to the suggestions of Ahlbäck (1968), but no attempt was made to estimate the severity of arthrosis.

Technique of operation and postoperative management

A bone wedge with a lateral or medial base was removed from the upper part of the tibia proximal to the patellar tendon insertion. The size of the wedge was calculated

from the preoperative femorotibial angle. As mentioned above, only two-thirds of the measurements were made on a standing roentgenogram. In the present series, tightening of the ligamentous structures was noticed in operative records of seven knees operated for varus deformity and in one knee operated for valgus deformity. Postoperatively the knee was immobilized in a cylindrical cast for 4–8 weeks and weightbearing was encouraged as early as possible, usually within 1 week after operation.

Method of follow-up study

The goal was to gain a very accurate description of the patient's own assessment of the operative result as a contrast to the objective evaluation of the knee made at the same time by us. All patients were interviewed personally by the authors and as a result of this interview the patient was asked to make his own assessment of the effect of operation using the following grading: a) fully satisfied, b) improved, c) no change, d) worse. "No change" and "worse" are throughout the paper reported as "poor".

In the objective evaluation, which was based on the grading system of Potter (1972), the following features were measured in "demerit points" (DP):

A. Subjective features: pain (0–7 DP), walking support (0–4 DP), walking distance (0–4 DP).

B. Objective features: Restriction of motion (0–6 DP), contracture (0–6 DP), angular deformity in standing position (0–4 DP), instability (0–4 DP), and quadriceps power (0–6 DP). Using the demerit points, the results were grouped as follows: excellent results (0–3 DP), good results (4–7 DP), fair and poor results ($>$ 7 DP).

RESULTS

Summarized results in Table 1 show that the patients tended to overestimate the results in comparison to the results of the objective evaluation. In searching for the influence of age on the results, it was apparent that this tendency to overestimate was more pronounced in patients over 65 years of age. (Subjectively, 49 per cent fully satisfied as compared to only 25 per cent excellent objective results in this age group.) Less demand for mobility in the older people can be accepted as an explanation of this fact, but the patient's devotion to his surgeon should be also considered. (We were careful in our follow-up not to let the operating surgeon interview his own patient.)

The influence of sex: the percentages of excellent objective results were equal in both sexes (43 per cent in women and 45 per cent in men). The percentage share of subjectively fully satisfied patients in the female group was twice as high as in the male group (49 per cent and 27 per cent, respectively). It seems as though the younger men are more critical in considering the state of the knee.

Table 1. Subjective and objective assessment of results in 96 knees with high tibia osteotomy (HTO).

	Deformity		Total
	Valgus	Varus	
Subjective			
Satisfied	36	4	40
Improved	27	5	32
Poor	16	8	24
			96 knees
Objective			
Excellent	41	2	43
Good	20	4	24
Poor	18	11	29
			96 knees

The durability of results

We have related the operative results to the length of the follow-up period. Two groups of knees were compared: in the first group, which comprised 58 knees, less than 3 years have passed since the operation. In the second group, which comprised 36 knees, more than 3 years have passed. We compared the proportion of excellent, good and poor results (according to demerit point scheme) in both groups. It appeared that the results did not differ in the two groups concerned ($0.95>P>0.90$). But the conclusion that improvement, once gained, lasts more than 3 years is not fully justified, for the mean observation time in the groups of fully satisfied and improved patients was only 2.8 years as compared with 3.7 years in the poor group.

The influence of preoperative deformity

a) The type of deformity. The results of HTO done for valgus deformity are strikingly worse both subjectively and objectively as compared with knees with varus deformity (Table 1). Several interrelated factors seem to influence the results of HTO done for valgus deformity: 1) concurrent joint disease, which influences the mechanics of the knee joint, was present in half of these knees (seven cases of hip disease and one case of contralateral knee fusion in 15 patients), 2) the ligament laxity, which is primarily more pronounced in valgus knee, is further accentuated by the operation procedure (Shoji & Insall 1973). The

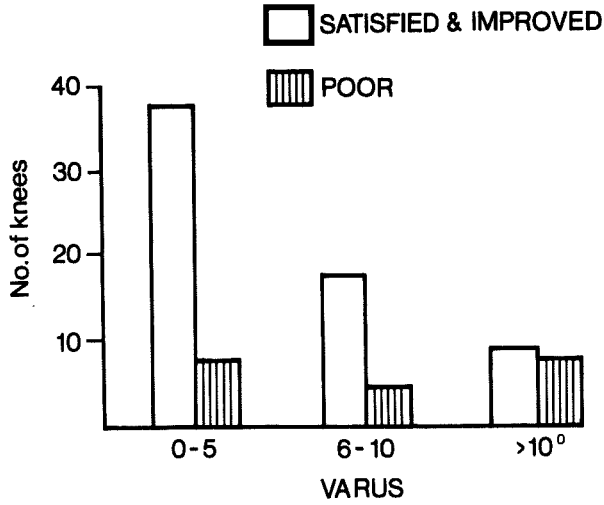

Figure 1. Subjective assessment × initial angle.

close association of instability with progress of gonarthrosis has been demonstrated (Bauer 1969).

b) The grade of preoperative deformity. Figure 1 relates the preoperative deformity in varus knees to the assessment made by the patient. It appears from the Figure that osteotomy is unlikely to satisfy patients with severe varus deformity. Several reasons for failure may be considered: 1) The deformity in these knees coincides with a greater degree of ligament laxity. The difficulty in such cases is in deciding how large a bone wedge should be removed to correct a fixed deformity and what allowance should be made for joint instability. Undercorrection is, in fact, closely correlated to the recurrence of deformity (Figure 5). 2) There exists the possibility that such a great degree of deformity is an expression for a special, more progressive form of gonarthrosis which cannot be stopped by HTO.

c) The success of correcting the deformity. Figure 2 correlates the definitive femorotibial angle with the satisfaction of the patient. It is apparent that the success is dependent on the possibility of correcting the angular deformity and returning the mechanical axis to the centre of the knee joint. One difficulty is in determining which is the value for the "physiological" valgus of the femorotibial angle when correcting the deformity; the other one is in defining this angle in the follow-up study. It is obvious that these two values are entirely different, which makes the comparison of published results difficult. We used Bauer's

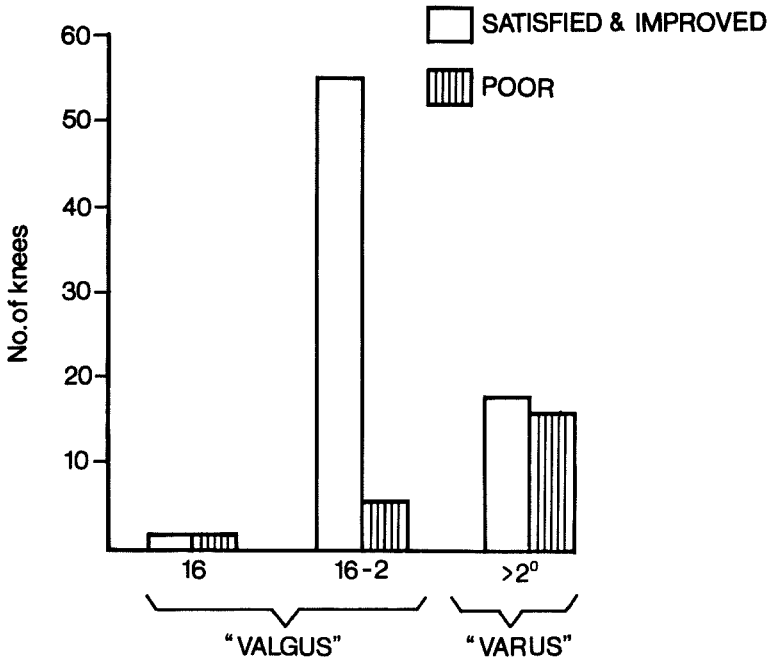

Figure 2. Subjective assessment × definitive angle.

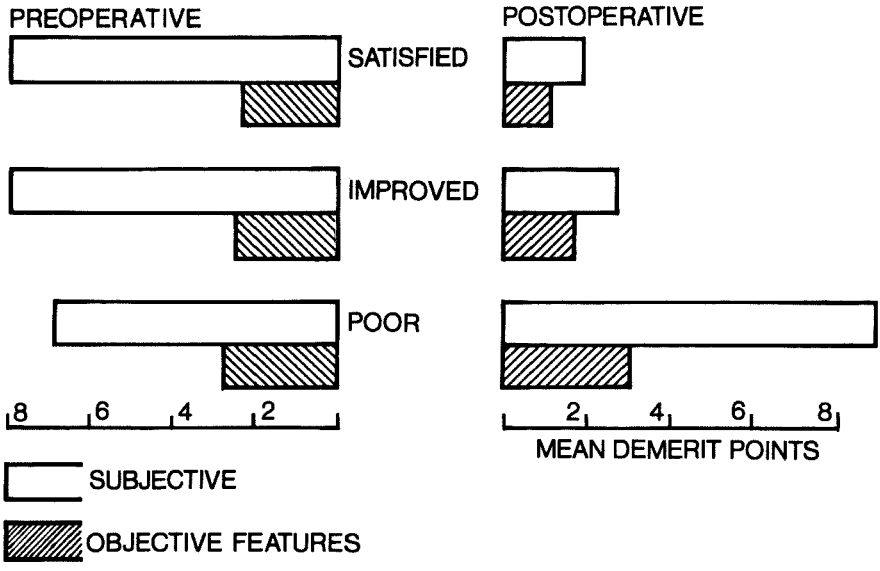

Figure 3. Changes in knee state by operation (expressed in means of demerit points) in three groups of patients.

scheme (1969) defining the angle from 2 to 16 degrees of valgus as "physiological" in our follow-up study. It is obvious that there is a group of satisfied patients in spite of their persistent deformity. The observation time in this patient group is no different from the mean observation time of patients with well corrected deformity, indicating long-lasting osteotomy effects despite undercorrection in this small group.

d) The effect of subluxation. We did not succeed in finding any fully satisfied patients with persistent roentgenological signs of subluxation in the group of patients in whom HTO had been done more than 3 years previously. We consider now that roentgenological subluxation combined with femorotibial angle values exceeding 10 degrees contraindicate HTO and that alternative procedures such as knee fusion or replacement are preferable in these patients.

The influence of preoperative state

Figure 3 relates changes in the state of the knee made by operation to the patient's own assessment. One should notice: The reasons for patient satisfaction were primarily subjective features, and the objective state of the knee is not so much influenced by the operation. We judged the state of the knee on the basis of demerit points and the possibility should be considered that the evaluating scheme was not sensitive enough.

The correlations with roentgenological signs

All roentgenograms both pre- and postoperatively were evaluated in terms of the following parameters: sclerosis and narrowing of medial and lateral and femoropatellar joint space, flattening of femoral condyles, reduction of tibial condyles, and subluxation. No notice was taken of osteophytes. No attempt was made to grade the changes; instead, only pure comparisons were made using the terms unchanged (amalgamated plus ameliorated) and worse. It appeared that there exists some correlation between progression of roentgenological changes and the patient's own satisfaction with the results of HTO. In the group of satisfied and improved knees, roentgenological signs of deterioration were present in 18 per cent, and in the poor group deterioration was noticed in 45 per cent of the knees. There is one exception: the femoropatellar arthrosis progressed equally in both groups. In fact, there was only one patient in the whole series in whom patellectomy

was done, despite the development of osteophytes in the majority of knees, sometimes to a considerable size.

Recurrence of deformity

This was our most frequent complication, observed in a total of 26 knees with primary varus deformity, and in nine knees with primary valgus deformity (overcorrection), making a total of 35 knees with definitive varus deformity. The deformity was slight (up to 2 degrees of varus) in 20 knees, and total recurrence was observed in 11 knees. There was no correlation with age and sex of patients, uncertain correlation with operative method (fibulaosteotomy versus lysis of upper fibulotibial joint). On the contrary there were close correlations to the initial femorotibial angle (Figure 4) and to the degree of correction of the deformity (Figure 5) in the group of knees with primary varus deformity. The relations to the initial angle were discussed above, but the correlation to the correction achieved by operation deserves mention here: We have observed in some patients that there is a loss of correction into varus already during the period of healing. In the normal knee joint, there is a varus stress during the stance phase of gait (Smidt 1973), and it is reasonable to assume that it still was present after the tibial osteotomy in the patients whose deformity was not fully corrected. The unsatisfactory mechanical qualities of the medial tibial condyle in arthrosis (Lereim & Goldie 1973) are further deteriorated by osteotomy. It is difficult, if not impossible, to relieve with a cylindrical cast the varus stress still acting in an undercorrected knee with osteotomy, particularly when the patient is obese. This also explains (in Figure 5) why there are no recurrences of the deformity in primary overcorrected knees. Bilateral operations in seven patients maintained primary correction in both knees, in three patients the correction was lost in both knees, and in only one case was the correction maintained in one knee and lost in the other (this knee was successfully reoperated later). This fact encouraged us to investigate whether there are some anatomical forms of deformity in the tibial head which are coupled with the recurrence of deformity. Two main types of deformity in the tibial head could be discerned in gonarthrosis with varus deformity: a) the type where deformity is caused by reduction of the medial tibial condyle, b) the type where the deformity is caused by increased varus angle between tibial head and the tibial shaft (Figure 6). In the 48 knees in which the primary varus deformity was less than 5 degrees,

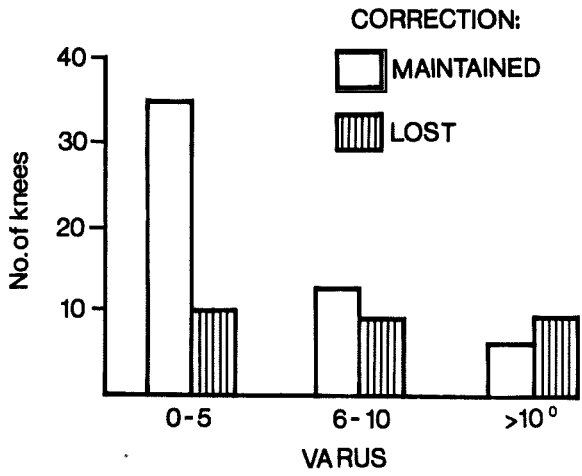

Figure 4. Initial angle × definitive correction. The abscissa gives the degree of preoperative femorotibial angle.

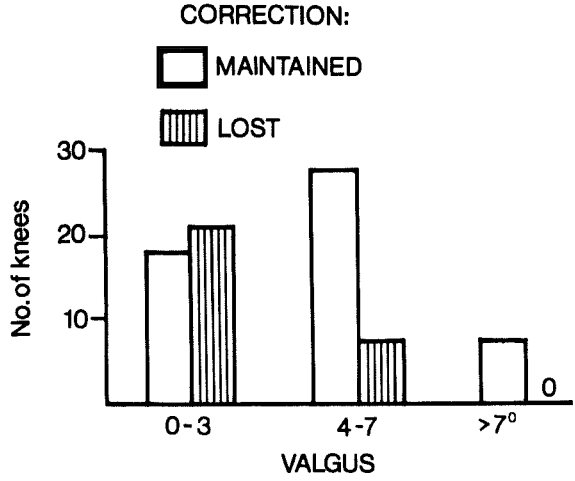

Figure 5. Immediate postoperative correction × final correction. The abscissa gives the degree of immediate postoperative femorotibial angle. Measured on weight-bearing roentgenogram.

there was no noticeable reduction of medial tibial condyle, and the mean angle (α in Figure 6) between tibial head and shaft was 4.7 degrees. In 12 knees in which the deformity exceeded 10 degrees of varus, both reduction of medial tibial condyle and increase of head-shaft angle (mean α angle 9.2 degrees) were seen. This permits the suggestion

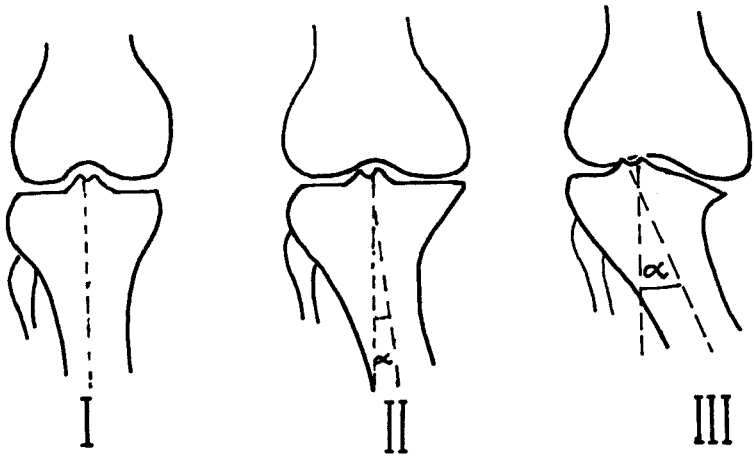

Figure 6. Types of tibial deformity in gonarthrosis: I. the normal knee joint, II. the knee joint where the tibiofemoral deformity is caused by increased angle between tibial head and shaft, III. the deformity is a combination of increased angle head-shaft and reduction of medial tibial condyle.

again that there exist two types of gonarthrosis. The one type is characterized by moderate degree of angle between tibial diaphysis and epiphysis, absence of reduction of medial tibial condyle, absence of signs of subluxation. In these knees the tibiofemoral angle does not exceed 10 degrees and the chances of satisfying the patient by performing an HTO are high. The other type is roentgenologically characterized by combination of reduction of medial tibial condyle (the angle between tibial head and shaft exceeding 9 degrees), presence of roentgenological signs of subluxation, and the femorotibial angle exceeds 10 degrees. The correction of the deformity in these knees is very difficult, recurrence of the deformity is frequent, and the chances of satisfying these patients by doing an HTO are low. We cannot decide if the type with poor prognosis is a special type caused, for example, by osteoporosis (Debrunner 1961) or if it represents only the late development of the former one.

Complications

The only other complication influencing subjective assessment was infection in two knees: this was the supposed cause of recurrence of the formity. This solitary statement was made for knees with valgus deformity by Shoji & Insall (1973), and in a more general form by Coven-assessment.

DISCUSSION AND CONCLUSIONS

HTO is an analgetic operation causing very few changes in the objective state of the knee beyond correcting the tibiofemoral deformity. On reading several reports on this object, one gains the impression that, provided that the right correction is done, good results are achieved in a high proportion of all operated knees.

Only rarely does one meet the suggestion that HTO is not the appropriate operative method in all types of gonarthrosis combined with deformity. This solitary statement was made for knees with valgus deformity by Shoji & Insall (1973), and in a more general form by Coventry (1973). Debeyre & Artigou (1972), on the basis of 260 HTO, stated that the absence of subluxation signs is essential for good results with HTO, while the correction of the deformity is of secondary importance in all types of gonarthrosis. However, the degree of ligamentous instability and subluxation that can be accepted without prejudicing the results of osteotomy is hard to define in these reports. In a recent report on follow-up of knees where HTO was done more than 5 years previously, Insall (1974) observed that knees with more than 10 degrees of varus deformity are poor candidates for HTO. We think that these observations are in accordance with our results, and indicate that there are two forms of gonarthrosis primary which are not suited for HTO: The group of knees with valgus deformity caused by secondary biomechanic changes in other joints (hip, contralateral knee), and the group of knees with varus deformity exceeding 10 degrees and with typical changes in the medial tibial condyle. The subjective assessment is influenced by secondary features such as age and sex, and even modest objective results are accepted as fully satisfying by the female patients in the age group over 65 years of age.

SUMMARY

Based on our results with high tibia osteotomy for gonarthrosis in 96 knees, the type of primary deformity was found to significantly influence the patient's subjective assessment of the results. Knees with valgus deformity secondary to changes in other joints are not suitable for correction by HTO. Knees with varus deformity exceeding 10 degrees and with roentgenological signs of reduction of the medial tibial condyle are seldom corrected by HTO and the results in these knees are poor. There is a clear correlation between patient's satisfaction with

HTO done for gonarthrosis and the correction of femorotibial deformity.

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