TOTAL REPLACEMENT OF THE KNEE

The response to the publication of a group of papers on this subject in the August 1978 issue of the Journal has been gratifying. It is not my intention to start a regular Correspondence Column, but the observations by Mrs Tew and Professor Waugh are important enough to warrant publication. Mr Aichroth has seen their submission and has replied to it.

It has also been pointed out to me that the original modifications to the Gunston prosthesis, which resulted in the development of the "Manchester Knee", were made by Mr G. Newton, now of Derby, when he was working in Manchester and were presented to a symposium at the Institution of Mechanical Engineers in September 1974. He should be given most of the credit for the basic design although the operations described were done by the late Mr N. E. Shaw.

R. C. F. C.

Sir,

In the August 1978 issue of the Journal Aichroth *et al.* of the British Orthopaedic Association Research Sub-committee drew attention to the need "to compare the results of treatment of the knee. . . . With a large number of prosthetic replacements of the knee now being used throughout the world the problem has become a matter of some importance and urgency." To facilitate such comparisons they produced a standard Knee Function Assessment Chart. This classification was then applied to the clinical assessments of knees before and after replacement with one of the five prostheses—Attenborough, Liverpool, Manchester, Sheehan and Stanmore, as reported by the surgeons who had invented them.

Table I. Average age

Series	Number of knees	Age (years)
Attenborough	(245)	68
Liverpool (e)	(62)	62
Manchester (e)	(51)	59
Sheehan	(135)	59.5
Stanmore	Not recorded	
All	(493)	64.7

($P>0.05$)

(e) estimated; see footnote in text

The outcome of operations in different series can be compared only if the knees in each had similar characteristics before operation, or, in the technical language of statistics, if they can be regarded as samples from the same basic population of damaged knees. The essential first step, therefore, is to bring together and analyse the data describing the condition of knees in the five series before operation.

*Throughout, the overall average (always weighted) is calculated in terms of knees; it is assumed, though perhaps incorrectly, that the distribution by knees is in the same proportion as the distribution by person, where only the latter is given. Statistical significance is determined by the chi-squared test.

In all centres, the indications for knee replacement are an unacceptable degree of pain or physical deformity, or both, resulting in serious impairment of mobility. The underlying disease in nearly every case is either osteoarthritis or rheumatoid arthritis.

The average age in each series (except Stanmore, which did not report it) did not differ significantly ($P>0.05$) from their overall weighted average* of sixty-four years (Table I). In every other respect, differences between the five series were highly significant ($P<0.001$).

The average male to female ratio as a whole was 19:81, but it ranged widely between series—from 12:88 to 29:71. For diagnosis, the average ratio of rheumatoid arthritis to osteoarthritis was 67:33, but that also ranged widely—from 51:49 to 94:6 (Table II). These highly significant statistical differences may reflect either real differences in the condition of patients referred to surgeons or selected by them for operation, or both, or real differences in diagnostic practice; for example, the knees of some patients with generalised rheumatoid arthritis may show osteoarthritic changes, and be classified as rheumatoid arthritis in one centre and as osteoarthritis in another.

Table II. Percentage distribution by sex and diagnosis

Series	Number	Male : Female	RA : OA
Attenborough	(245)	12 : 88	51 : 49
Liverpool (e)	(62)	29 : 71	76 : 24
Manchester (e)	(50)	18 : 82	94 : 6
Sheehan (e)	(135)	28 : 72	82 : 18
Stanmore	(96)	17 : 83	68 : 32
All	(588)	19 : 81	67 : 33

($P<0.001$)

(e) estimated as in Table I

The primary indication, severity of pain, was measured on the Knee Function Assessment Chart according to a simple four-grade scale, of which grades 1 (severe) and 2 (moderate) could be considered unacceptable, justifying knee replacement. Overall 44 per cent of knees were classified as grade 1, ranging from 64 per cent to 20 per cent, and 48 per cent as grade 2, ranging from 80 per cent to 30 per cent, with 8 per cent in grades 3 and 4, ranging from 21 per cent and 19 per cent to zero. The differences in distribution were highly significant ($P<0.001$) (Table III).

Allocation to a grade depends on subjective judgements by the patient and by the recorder; this may render any division between grades 1 and 2 unreliable. However, even if they are amalgamated to give a more realistic picture, it is clear that, unlike in the other series, unacceptable pain was not the indication for one-fifth of the Sheehan and Stanmore operations.

Table III. Percentage distribution by grade of pain

Series	Number	Grade 1	Grade 2	Grade 3	Grade 4
Attenborough	(245)	64	35	1	0
Liverpool	(62)	24	76	0	0
Manchester	(51)	20	80	0	0
Sheehan	(131)	22	59	14	5
Stanmore	(96)	49	30	18	3
All	(585)	44	48	6	2

(P<0.001)

Deformity was measured in four aspects, each according to a four-grade scale. Overall 15 per cent of knees had a flexion contracture greater than 30 degrees, ranging from 25 per cent to 4 per cent, while at the other extreme, 38 per cent of knees had a contracture less than 10 degrees, ranging from 60 per cent to 31 per cent (Table IV). Overall 16 per cent of knees had a maximal flexion of less than 60 degrees, ranging from 26 per cent to 5 per cent; while 31 per cent had a maximal flexion greater than 100 degrees, ranging from 49 per cent to 21 per cent (Table V). With the tibia stressed laterally, 11 per cent of knees had a valgus deformity of more than 20 degrees (grades 1 and 2), ranging from 14 per cent to zero; while 70 per cent had minimal deformity (less than 10 degrees) ranging from

100 per cent to 52 per cent. With the tibia stressed medially, 8 per cent had a varus deformity greater than 20 degrees, ranging from 24 per cent to 1 per cent; while 76 per cent had a varus deformity of less than 10 degrees, ranging from 92 per cent to 36 per cent. Though nearly half the Liverpool knees had a valgus deformity over 10 degrees, none of the Manchester knees had; and though nearly two-thirds of the Liverpool knees had a varus deformity over 10 degrees, few of the Sheehan or Stanmore knees had (Tables VI and VII).

In these four aspects of deformity, as also in extension lag and gait (Tables VIII and IX), differences in distribution between series were highly significant ($P<0.001$). Though clinical measurements in degrees are in a sense objective, precise readings are sometimes difficult. They are doubtless subject to a certain degree of observer variation; but, as the measurements in each series were probably made by several different individuals, it is unlikely that the series as a whole was substantially biased in a particular direction. If there is no bias, then the statistical differences must be accepted as reflecting real differences in the distribution of deformity among knees replaced in different centres.

Pain and deformity in the knee impair mobility, but mobility depends on many factors besides disorder of the knee and it is virtually impossible to standardise for these, in order to isolate the contribution of the knee. Nevertheless, four indices of mobility were assessed, but grading was fraught with inaccuracies and ambiguities.

The patient was asked how far or for how long he could walk. Very few could be expected to respond spontaneously

Table IV. Percentage distribution by flexion contracture

Series	Number	Grade 1 (>30°)	Grade 2 (21°-30°)	Grade 3 (10°-20°)	Grade 4 (<10°)
Attenborough	(245)	14	13	42	31
Liverpool	(62)	15	15	30	40
Manchester	(51)	4	18	18	60
Sheehan	(126)	25	17	25	33
Stanmore	(96)	10	17	23	50
All	(580)	15	15	32	38

(P<0.001)

Table V. Percentage distribution by maximal flexion

Series	Number	Grade 1 (<60°)	Grade 2 (61°-80°)	Grade 3 (81°-100°)	Grade 4 (>100°)
Attenborough	(245)	19	12	42	27
Liverpool	(62)	17	30	30	23
Manchester	(51)	12	20	36	32
Sheehan	(126)	5	14	32	49
Stanmore	(96)	26	9	44	21
All	(580)	16	14	38	31

(P<0.001)

Table VI. Percentage distribution by valgus deformity

Series	Number	Grade 1 (>30°)	Grade 2 (<30°)*	Grade 3 (<20°)*	Grade 4 (0°-10°)
Attenborough		Not recorded			
Liverpool	(62)	6	3	39	52
Manchester	(51)	0	0	0	100
Sheehan	(126)	3	11	21	65
Stanmore	(96)	3	10	13	74
All	(335)	3	8	19	70

(P<0.001)

*Assessment Chart labels which do not prescribe complete and mutually exclusive grades

Table VII. Percentage distribution by varus deformity

Series	Number	Grade 1 (>30°)	Grade 2 (<30°)*	Grade 3 (<20°)*	Grade 4 (0°-10°)
Attenborough		Not recorded			
Liverpool	(62)	6	10	48	36
Manchester	(51)	12	12	18	58
Sheehan	(126)	0	3	7	90
Stanmore	(96)	0	1	7	92
All	(335)	3	5	16	76

(P<0.001)

Table VIII. Percentage distribution by extension lag

Series	Number	Grade 1 ($>20^\circ$)	Grade 2 ($<20^\circ$)*	Grade 3 ($<10^\circ$)*	Grade 4 (0°)
Attenborough	Not recorded				
Sheehan					
Liverpool	(62)	32	21	42	5
Manchester	(51)	0	2	8	90
Stanmore	(96)	0	3	97	0
All	(209)	10	8	59	23

 $(P<0.001)$

*Assessment Chart labels (see Table VI)

Table IX. Percentage distribution by gait

Series	Number	Grades				
		1	2	3	4	5
Attenborough	Not recorded					
Stanmore						
Liverpool	(62)	23	11	60	6	0
Manchester	(51)	0	0	0	95	5
Sheehan	(131)	0	61	27	8	4
All	(244)	6	36	30	26	3

 $P<0.001$ **Table X.** Percentage distribution by distance or time walked

Series	Number	Grades				
		0	1	2	3	4
Attenborough	(245)	20	38	30	12	0
Liverpool (e)	(62)	19	31	40	10	0
Manchester	(51)	0	16	68	16	0
Sheehan	(131)	8	30	37	25	0
Stanmore	Not recorded					
All	(469)	14	33	37	16	0

 $(P<0.001)$

(e) estimated as in Table I

Table XI. Percentage distribution by walking aid

Series	Number	Grades				
		0	1	2	3	4
Attenborough	Not recorded					
Stanmore						
Liverpool (e)	(62)	19	38	36	2	5
Manchester	(51)	0	6	22	25	47
Sheehan	(131)	9	24	26	23	18
All	(244)	9	22	27	20	22

 $(P<0.001)$

(e) estimated as in Table I

with a precise, accurate answer. Sometimes the quoted figures might represent an average, sometimes a maximum achievement. The Knee Function Assessment Chart added to the confusion by giving overlapping limits: for example, ten minutes could be either grade 2 or grade 3. To some patients "indoors" might include the minimum distance to reach a car; other patients could describe this as "five minutes outdoors". "Unable" could mean literally bedridden or chairbound, or it could include the painful staggering of minimum distances necessary for daily living ("unable" by normal standards), which other recorders graded as "indoors". Differences between series in distribution by grade were highly significant

$(P<0.001)$. Overall, 14 per cent of knees fell into the "unable" grade, ranging from 20 per cent to zero; and 33 per cent into the "indoors" grade, ranging from 38 per cent to 16 per cent (Table X).

Likewise, in the other three indices—walking aid, ability to get out of chair and to climb stairs—variations between series were highly significant $(P<0.001)$. There was probably no uniformity in specifying the circumstances when the aid was used, the height of the chair seat or of the stair riser (Tables XI, XII and XIII). These statistical differences may reflect real differences in mobility of patients before operation; but even if they do, they provide no indication of how much such

Table XII. Percentage distribution by ability to get out of chair

Series	Number	Grade 1	Grade 2	Grade 3	Grade 4
Attenborough	Not recorded				
Stanmore					
Liverpool (e)	(62)	33	43	24	0
Manchester	(51)	0	46	50	4
Sheehan	(130)	11	80		9
All	(243)	14	80		5

 $(P<0.001)$

(e) estimated as in Table I

Table XIII. Percentage distribution by ability to climb stairs

Series	Number	Grade 1	Grade 2	Grade 3	Grade 4
Attenborough	Not recorded				
Sheehan					
Stanmore					
Liverpool (e)	(62)	52	24	24	0
Manchester	(51)	0	37	63	0
All	(113)	28	30	42	0

 $(P<0.001)$

(e) estimated as in Table I

differences are due to the affected knee. It is indeed more probable that they reflect the difficulties of taking measurements which have real value in interpreting the clinical conditions.

The distribution of characteristics of the knees before operation in the reported series is found, on analysis, to be different at a very high level of significance. The only possible conclusion is that each series cannot be regarded as a sample from the same basic population of knees damaged by rheumatoid arthritis or osteoarthritis. Of course, they never purported to be *random* samples. It would be eminently reasonable if each surgeon selected for arthroplasty those knees which he considered most likely to benefit from his particular prosthesis, though he might choose to include knees for which he was less confident of the outcome. But, for whatever reason, it is clear that the samples are selected on different criteria—certainly as regards recorded characteristics. It may well be, however, that these do not fully describe the factors taken into consideration: indefinable "clinical

judgement" may play an overriding role and human judgement is very variable and seldom replicable. The practical consequence of having initial study populations so dissimilar is that simple comparisons of the outcome after operation in each series cannot be made. Conclusions, however valid for separate series, are not capable of general application.

The highly significant differences in the clinical assessments before operation found to exist between the separate series may reflect real differences in the knees selected for operation, or extreme diversity in applying standards, or indeed the inadequacy of the characteristics recorded to define criteria of selection. Certainly they rule out simple comparisons of like with like, if proper evaluation of results is to be made, and point to the need for further research into defining what information is material to successful arthroplasty and how it can be precisely elicited.

Yours truly,

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Sir,

Mrs Tew and Professor Waugh point out in their critique of our Knee Function Assessment Chart that further research is required in defining the information *required* for assessing a successful replacement of the knee and in the recording of this information. We are entirely in agreement and again wish to point out that the chart we have produced is an attempt to keep the assessment brief and simple enough to be realistic. Many major knee assessment forms are in existence but we have attempted to record those symptoms and signs which are fundamental to the comparison of one group of results with another. Certainly the collection of this data will vary with different interviewers but the grades are simple enough to obviate large errors. Certainly adjustments will be made, but until it is shown that there is a better and more simple system we feel the chart should be left in its present form. We wish to stress again that the chart attempts to record only basic measurements and so would appear to provide a reasonable start in trying to compare one group of records with another.

Our response to some of the specific points they raise is as follows:

Comparison of the figures in the group of papers in the August 1978 issue of the *Journal* shows striking variations. For instance, the ratio of rheumatoid arthritis to osteoarthritis varies widely and this must surely be due to differences of referral in various centres rather than to any difficulty in establishing a diagnosis.

The assessment of pain is always very difficult. Grades 1

and 4 are easily separated but grades 2 and 3 are certainly more difficult to define. Mrs Tew and Professor Waugh point out that measurement of deformity and movement is difficult and we have therefore used blocks rather than the recording of actual numbers of degree of angulation. Any grading is certainly fraught with inaccuracies and ambiguities but a start has to be made somewhere.

It is very difficult to assess the ability to walk from the history and it is certainly not practical actually to measure the walking distance. The grades 0 to 5 are a simple but reasonable way of attempting to assess this function. If the patient is bedridden or chairbound he is considered "unable to walk" and therefore graded 0. "Painful staggering of minimal distances" would be graded 1. Walking up to ten minutes in time or 100 metres distance is graded 2 and any ability to walk further is classified 3 or more.

The clinical judgements of the observers taking the history and examining the patient must vary and so will the records. We feel, however, that our assessment form provides a simple and expedient record which can be easily stored and presented and which allows one set of results to be compared with another without too much difficulty.

Yours truly,

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