Prediction of results of treatment of Dupuytren's disease

Although Dupuytren's disease is common it is still not fully understood. A series of patients has been assessed by multiple regression analysis from which "outcome standards" have been formulated. It is anticipated that this method of analysis will further our understanding of the disease when greater numbers of patients are added to the study. As well, the application of an "outcome standard" to a given patient should reduce the number of unexpectedly poor results obtained and expose errors in the primary management of those patients.

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Dupuytren's disease may be unique in being associated with more apparently unrelated diseases than most conditions. It is seen commonly in patients with epilepsy, alcoholism, and diabetes.[1-4] Trauma may play a contributing role.[5, 6] To data a considerable amount of epidemiologic information has not increased our understanding of the disease process. If the many factors associated with Dupuytren's disease and the features of the disease itself could be clearly evaluated, then the cause and pathogenesis of this disease might be better understood.

Multiple regression analysis is a statistical method of evaluating several factors individually while keeping other variables constant.[7] This statistical technique has been applied to a small series of patients. From the analysis of the results of treatment of this group of patients a formula has been created which could serve as a baseline to predict the results of treatment of future patients. If the result in a given patient was better or worse than the "outcome standard" for that patient, the reason for this difference should be apparent. Assessment of these reasons might be helpful in a further understanding of the disease.

The series

Eighty-four patients were chosen who had complete pre- and postoperative documentation and were oper-

ated on by one of us (R. M. M.) by the same type of operation. Therefore the series was selective. Fifty-one patients returned for examination at least 1 year after operation and were examined by J. W. H. L. A total of 69 hands were included in the study.

In each patient a limited dissection was performed in the palm in order to remove the diseased pretendinous and natatory cords. However, in the finger the diseased cords were removed in their entirety and areas of potential recurrence were excised as well.[8] The fascia was exposed through a midline longitudinal incision extending from the distal finger pulp to the proximal palm when a single ray was involved (Fig. 1). When two or more rays were involved the fingers were exposed through a longitudinal incision but the palm was exposed through a transverse incision. The longitudinal incisions were closed with appropriate Z-plasties, whereas the transverse palmar incision was left open after the method of McCash (Fig. 2).[9-11]

Postoperatively the hand was immobilized in a dressing and dorsal splint for 10 days with the affected fingers held in extension. Only those patients with persistent contractures or slow return of flexion or extension received physiotherapy.*

Results

The results were assessed according to the method of Tubiana, Thomine, and Sheldon,[12] in which the preoperative severity, expressed as "global values," was compared with the percentage of correction (Table I). In Tubiana's series the majority of patients with 100% improvement had minimal preoperative involvement, i.e., a global value of 4 or less. Only half of our pa-

*In our present regime, all patients are closely followed up by a hand therapist and they wear a splint for varying periods of time under the direction of the therapist. Supervised postoperative therapy therefore will be another factor to analyze in this ongoing study.

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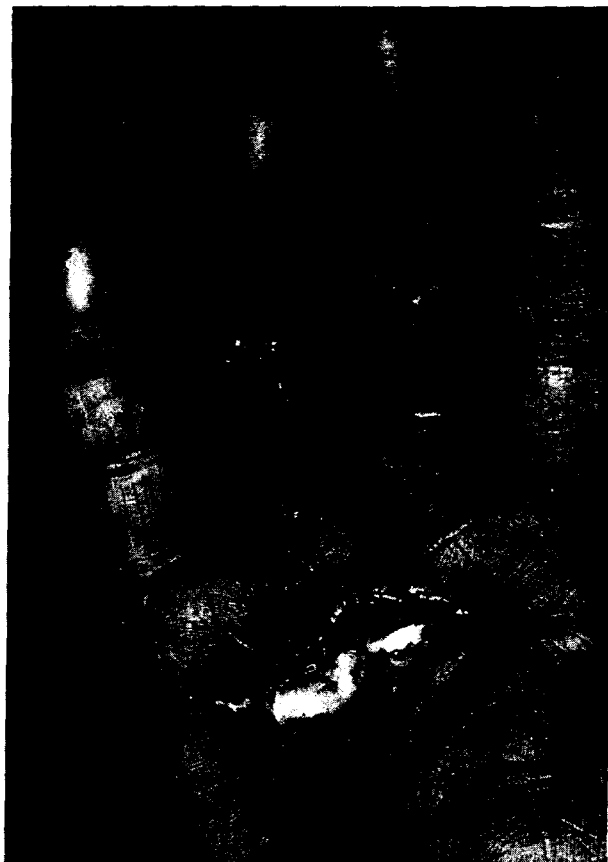Fig. 1. This type of midline longitudinal incision was used for exposure when a single ray was involved.

Fig. 2. These longitudinal and transverse incisions were used when two or more rays were involved. The fingers were closed with appropriate Z-plasties and the palm was left open.

tients in this range had more than 75% improvement, whereas half of the patients with a global value greater than 4 (i.e., severe contractures) improved more than 75%. As with Tubiana's series, the patients who improved less than 50% comprised patients in both high and low global value groups. The reason for these poor results was apparent in only a few cases such as one digital nerve injury with poor recovery, one infected hematoma, and two patients (four hands) with reflex sympathetic dystrophy. Except for these four patients, there were no apparent reasons why some patients with high global values did well and others with low global values did badly.

In an attempt to identify the cause of bad as well as good results, each joint of each finger was assessed individually. The data are recorded in Table II and the significance is established with Student's paired t test. In addition, the individual joint corrections are plotted in Figs. 3 to 5.

It is known that metacarpophalangeal (MP) joint contractures are readily corrected and this is confirmed by the results recorded in Table II and shown in Fig. 3. The average postoperative MP joint contracture of all fingers was less than 3°.

However, the proximal interphalangeal (PIP) joint did not as often regain full extension nor did all digits respond the same, as shown by the wide scatter in Figs. 4 and 5. As shown in Table II, the average residual contracture at the PIP joint varied from 25° in the little finger to 2° in the index finger.

Although there were only seven distal interphalangeal (DIP) joints with loss of extension, only one improved after operation. There were five DIP joints with hyperextension, all of which were corrected by operation.

"**Outcome standards.**" Mushlin, Appel, and Barr[13] described an outcome-based approach to the primary care of patients with upper respiratory tract infections whereby certain results are anticipated. Correctable errors are often exposed when reasons why patients did not attain the expected outcome are sought. This approach is adaptable to many conditions and appears
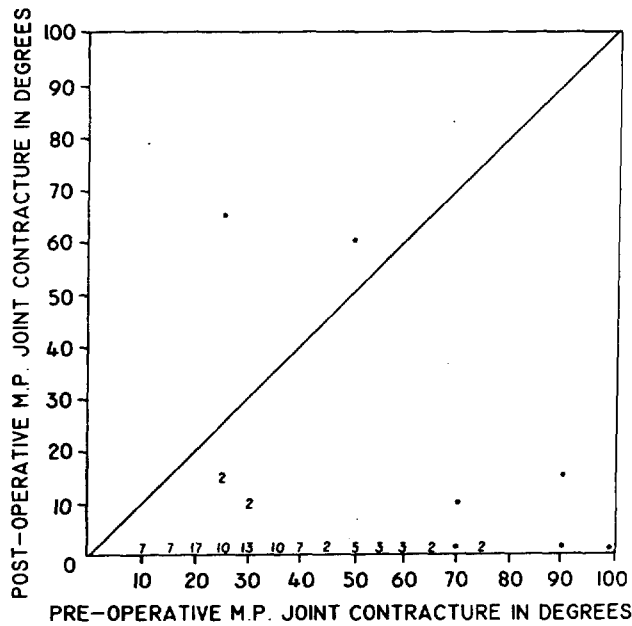
Fig. 3. The pre- and postoperative states of all metacarpophalangeal joints of all fingers. Most joints were fully corrected but in two patients the flexion contracture was worse after operation. Both of these patients were women who developed sympathetic dystrophy postoperatively.
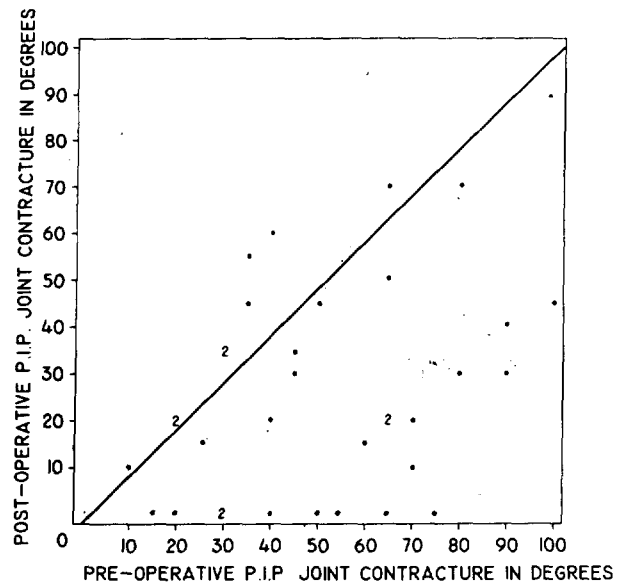

Fig. 4. The pre- and postoperative states of the proximal interphalangeal joints of all the little fingers. There is a wide scatter of results, with relatively few patients regaining full extension postoperatively.

Table I. Comparison of preoperative severity with percentage of correction

Percentage correction	Global value of derformities										Total no. of hands
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	
100	5	4	5	2	—	1	—	—	—	—	17
75-99	—	2	—	5	3	—	1	1	—	—	12
50-74	—	6	6	1	3	—	2	—	—	—	18
25-49	—	—	3	3	—	—	—	—	—	—	6
0-24	2	1	1	3	5	—	—	—	—	1	13
Total	7	13	15	14	11	1	3	1	—	1	66

ideally suited to the assessment and investigation of Dupuytren's disease. In the study of Mushlin the expected outcome was easy to identify, i.e., a full recovery from the infection. In Dupuytren's disease, however, the result depends on many variables so the outcome will be different for each patient. The variables that have been considered in this study are listed in Table III.

Because the MP joint is invariably fully corrected at operation, the "outcome standard" for this joint is 0°. None of the variables listed in Table III affects the outcome of operation upon this joint, so further statistical analysis is unnecessary.

However, there is great variation in the results ob-

tained at operation on the PIP joint, so it is likely that many variables affect the correction of contracture at this joint. For this reason the statistical technique of multiple regression analysis was required. It would have been desirable to construct a formula that considered all the variables listed in Table VI but a large series of patients would be needed. From the analysis of our series the variables that were significant to a P value 0.01 are listed in Table IV and therefore only these appear in the formulas as discussed below. Obviously, the degrees of contracture will affect the extent of correction. The number of rays involved in the disease and the finger and joint involved also had a significant effect on the results of operation. The age and

Table II. Individual assessment of fingers

Joint	No. of patients	Mean preop. (degrees)	S.D. preop (degrees)	Mean postop (degrees)	S.D. postop (degrees)	p value
Little finger:						
MP	28	46	25	3	12	0.001
PIP	34	50	24	25	21	0.001
DIP	6	23	12	15	18	—
Ring finger:						
MP	41	32	16	2	11	0.001
PIP	22	36	22	13	15	0.001
DIP	1	10	0	10	0	—
Long finger:						
MP	26	27	9	1	3	0.001
PIP	12	26	12	11	13	0.01
DIP	0	0	0	0	0	—
Index finger:						
MP	4	21	9	0	0	0.005
PIP	5	32	16	2	14	0.25
DIP	0	0	0	0	0	—

Table III. Variables to be considered

1. Age of patient
2. Sex
3. Family history.
4. Other diseases (diabetes, epilepsy, alcoholism)
5. Other areas of fibromatoses
6. Age at onset of disease
7. Occupation
8. Hand involved
9. No. of rays involved in hand
10. Finger involved
11. Preoperative degrees of contracture at MP joint
12. Preoperative degrees of contracture at PIP joint
13. Preoperative degrees of contracture at DIP joint
14. Type of operation
15. Length of time since operation
16. Experience of surgeon

Table IV. Variables of significance in this series (p < 0.01)

1. No. of rays involved
2. Finger involved
3. Joint involved
4. Preoperative degree of contracture

Fig. 5. The pre- and postoperative states of the proximal interphalangeal joints of all the ring, middle, and index fingers. Most of these patients improved but only about half regained full extension.

sex of the patients, a family history of Dupuytren's disease, and the presence of involvement beyond the volar surface of the hand did not have any predictable effect upon the results ($P > 0.01$). Due to the limited number of patients in the series it was not possible to assess the predictability of some of the other variables listed in Table III.
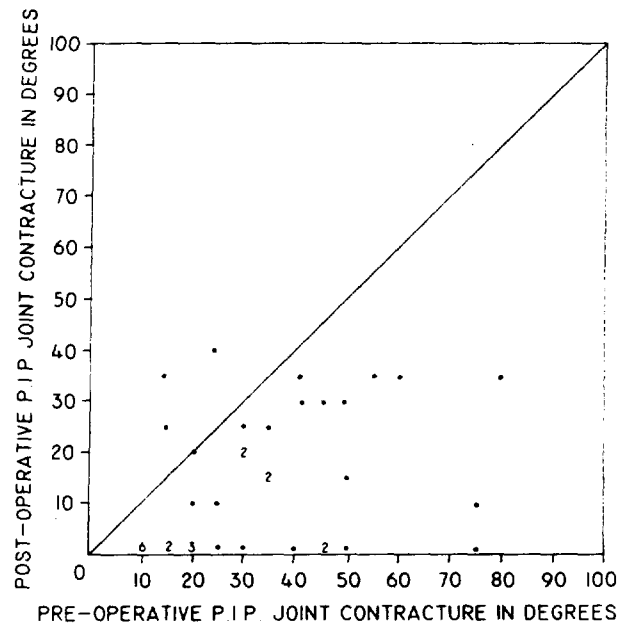
It was interesting to find that the variables shown to be significant in our series (Table IV) had prognostic values for the PIP joint of the little finger different from those for the other three fingers, all of which had the same values. This is indicated by the different "outcome standard" formulas shown below, which were obtained by the multiple regression analysis.

Fig. 6. Pre- (A) and postoperative (B) photographs (case 1) showing the total recovery expected with pure MP joint contractures.

PIP joint of the little finger.

Log$_e$PIP (postop.) = 0.016 MP (preop.) +
$\qquad$ 0.026 PIP (preop.) + 0.275 N + E

where N is equal to the number of rays involved and E is equal to an error factor of random variables that are normally distributed, with zero mean and constant variance. The predictability (R^2) equals 68% which, when further broken down, shows that the MP joint accounts for 3%, the PIP joint for 55%, and the number of rays involved 10%.

PIP joint of the ring, middle, and index fingers.

Log$_e$PIP (postop.) = 0.053 PIP (preop.) + 0.18 N + E

The predictability (R^2) is equal to 53%, of which the PIP joint accounts for 44% and the number of rays involved accounts for 9%.

There were insufficient DIP joints and thumbs to be of value in the study.

Case reports

The following case reports from the series illustrate the use of the formulas and show the effects that the variables in the above formulas have on the results of treatment.

Case 1. A 64-year-old man (C. L.) with Dupuytren's disease, Ledderhose disease, and a family history of Dupuytren's disease had MP contractures of 90° in the little finger,

35° in the ring finger, and 20° in both the long and index fingers. The other joints were uninvolved (Fig. 6, *A*). Because these were pure MP joint contractures a complete return of extension was anticipated and achieved (Fig. 6, *B*).

Case 2. A. N. was a 70-year-old professional man with contractures in the PIP and DIP joints in the left little finger of 75° and 30°, respectively, but with no involvement elsewhere and no family history of the condition (Fig. 7, *A*). His anticipated result was calculated with the use of the formula for the PIP joint of the little finger as follows:

Log$_e$ PIP (postop.) = 0.016(0) + 0.026(75) +
$\qquad$ 0.275(1) + E
$\qquad$ = 0 + 1.950 + 0.275
$\qquad$ = 2.225
$\qquad$ PIP (postop.) = 5° to 10° (from Table V)

The actual result obtained, as shown in Fig. 7, *B*, was a 10° flexion contracture in this PIP joint.

Case 3. E. M. was a 61-year-old man with contractures of the MP joint of 55° and PIP joint of 65° in the little finger (Fig. 8, *A*). The small contracture of the MP joint of the ring finger was secondary to the contracture in the little finger. The MP joint was expected to return to normal and the anticipated PIP joint result was calculated from the formula:

log$_e$ PIP (postop.) = 0.016 (55) + 0.026(65) +
$\qquad$ 0.275(1) + E
$\qquad$ = 0.880 + 1.690 + 0.275
$\qquad$ = 15° to 20°

The MP joint did regain full extension and the PIP joint regained all but 20° of extension (Fig. 8, *B*).

Case 4. J. A., a 53-year-old diabetic man, presented with Dupuytren's disease involving four finger rays but with relatively small contractures in each finger (Fig. 9, *A*). The preoperative loss of extension was:

Finger	MP joint (degrees)	PIP joint (degrees)	DIP joint (degrees)
Little	15	45	0
Ring	25	10	0
Long	25	10	0
Index	25	10	0

The MP joints were expected to return to normal and the expected outcome for the PIP joints were calculated as follows:

Little finger:

$$
\begin{aligned}
\log_e \text{ PIP (postop.)} &= 0.016(15) + 0.026(45) + \\
&\quad 0.275(4) + E \\
&= 0.240 + 1.170 + 1.100 \\
&= 2.510 \\
\text{PIP (postop.)} &= 10° \text{ to } 15°
\end{aligned}
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For the other fingers:

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\begin{aligned}
\log_e \text{ PIP (postop.)} &= 0.053(25) + 0.18(4) + E \\
&= 1.325 + 0.72 \\
&= 2.045 \\
\text{PIP (postop.)} &= 5° \text{ to } 10°
\end{aligned}
$$

At follow-up 8 years after the operation all MP joints had regained full extension, the PIP joint of the little finger had a loss of extension of nearly 20°, and the other PIP joints had lost only 5° of extension (Fig. 9, *B*).

Case 5. G. E., a man 55 years of age, had severe disease affecting three finger rays and causing large contractures, as ·shown in Fig. 10, *A*. The preoperative contractures are tabulated below:

Finger	MP joint (degrees)	PIP joint (degrees)	DIP joint (degrees)
Little	60	80	20
Ring	40	20	0
Long	40	40	0

Even though there were large contractures in the MP joints of this patient we expected full recovery and achieved it (Fig. 10, *B*). The anticipated results of the PIP joints are calculated below:

Little finger:

$$
\begin{aligned}
\log_e \text{ PIP (postop.)} &= 0.016(60) + 0.026(80) + \\
&\quad 0.275(3) + E \\
&= 0.960 + 2.080 + 0.825 \\
&= 3.865 \\
\text{PIP (postop.)} &= 45° \text{ to } 50°
\end{aligned}
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Ring finger:

$$
\begin{aligned}
\log_e \text{ PIP (postop.)} &= 1.060 + 0.540 \\
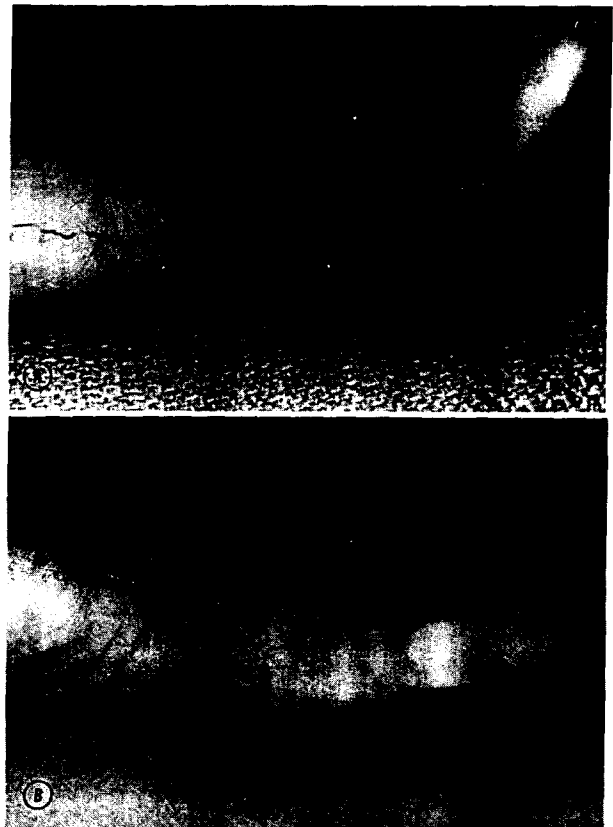&= 1.600 \\
\text{PIP (postop.)} &= 5°
\end{aligned}
$$

Fig. 7. Pre- (**A**) and postoperative (**B**) photographs (case 2) showing the less complete recovery frequently obtained in the PIP joint.

Long finger:

$$
\begin{aligned}
\log_e \text{ PIP (postop.)} &= 0.053(40) + 0.18(3) \\
&= 2.120 + 0.540 \\
&= 2.660 \\
\text{PIP (postop.)} &= 10° \text{ to } 15°
\end{aligned}
$$

As shown in Fig. 10, *B*, the PIP joint of the little finger had a poor result; however, it was not quite so bad as calculated from the formula, having a 35° flexion contracture. As expected, the other PIP joints recovered most of their extension, retaining less than 10° of flexion contracture.

Discussion

This study was an attempt to elucidate reasons for unpredictable results. Many variables were considered. Some factors that have been considered significant did not prove to be so, although the small size of this series may have excluded some important variables. Nevertheless, it is noteworthy that no variables affected correction at the MP joint, whereas the variables that exerted an influence upon the result at the PIP joint were anatomic ones, that is, the number of digits in-
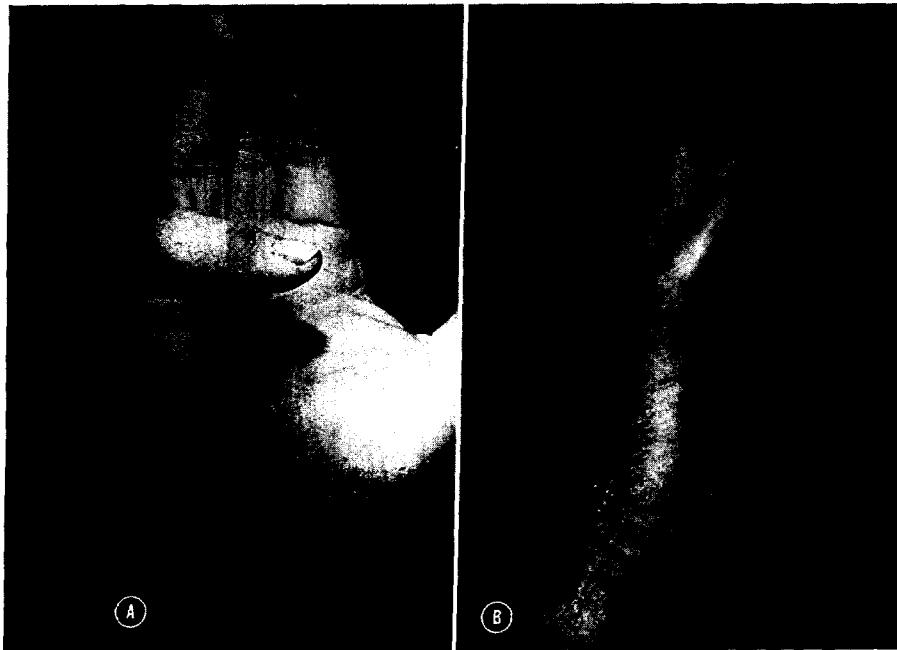
Fig. 8. Pre- (A) and postoperative (B) photographs (case 3) illustrating the adverse effect that the involvement of the MP joint has on the result in the PIP joint. Although this PIP joint contracture was less severe than that in case 2 the result was not as good.

Table V. Exponential tables

X	e^x	X	e^x
<1.6	<5°	4.0	55°
2.3	10°	4.09	60°
2.7	15°	4.17	65°
3.0	20°	4.24	70°
3.21	25°	4.31	75°
3.4	30°	4.38	80°
3.55	35°	4.44	85°
3.68	40°	4.49	90°
3.80	45°	>4.5	>90°
3.91	50°		

volved, the digit involved, and the preoperative state of contracture. Such variables as family history, other diseases, age at onset, and others listed in Table III were not significant.

The evaluation of our results according to Tubiana's system of assessment revealed a number of problems. The basis of Tubiana's classification is a staged numerical determination of the loss of extension in the involved joints. The sum of all the diseased fingers is represented by a "global value." The pre- and postoperative global values are compared to give the percentage of improvement and expressed as in Table I. The consistent return of extension at the MP joint (almost

always to normal) was quite different from the return of extension at the PIP joint. Therefore to combine the measurements of these joints into a single unit for a finger would misrepresent the state of disease and hence the success to be expected. As the computer analysis of our results showed that the PIP joint result in the little finger was dependent on the state of contracture of its MP joint and there was no significant relationship between joints in the other fingers, combination of the finger values into a total hand value or "global value" is not justified.

The method of analysis based on "outcome standards" assesses individual joints and fingers and relates what effect different variables have on them. Previous reports have stated that the most prognostic factor is the degree of the preoperative contracture.[12, 14, 15] A breakdown of the different variables in both of our formulas has shown that the degree of contracture accounts for most of the predictability in the PIP joint (55% and 44% respectively) and it is therefore the most important variable for that joint. However, we have shown that it is not important for the MP joint. This is well illustrated by case 1, in which a man, despite severe disease, involvement beyond the volar surface of the hand, and a family history of Dupuytren's contracture, obtained a perfect result (Fig. 6).

It is logical that the extent of the disease as indicated

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Fig. 9. Pre- (A) and postoperative (B) photographs (case 4) showing that the effect the involvement of a large number of rays has on the PIP joint result is small when the angles are small. All joints regain most of their extension.
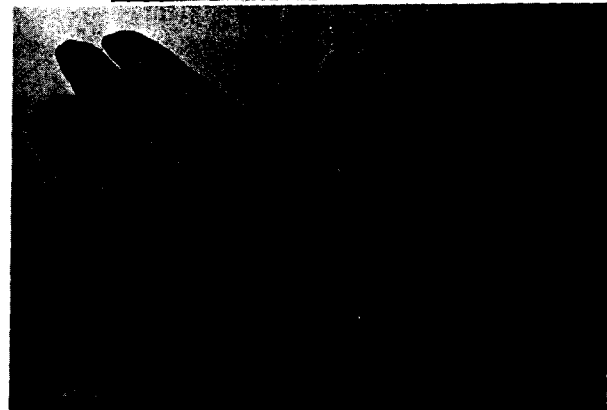

Fig. 10. Pre- (A) and postoperative (B) views (case 5) with extensive involvement and severe contractures. The poor result achieved in the little finger is typical of those in patients with severe and extensive disease.

by the number of rays involved should be important to the result and in this study it was shown to be the second most important variable affecting the PIP joint. This finding is illustrated when the results in the little finger in cases 3 and 5 are compared. The contractures in the joints of the little finger in both patients were severe preoperatively; however, case 5 had more extensive disease (three fingers involved) and this made the outcome considerably worse in this patient.

It is not known why the result of the PIP joint in the little finger is dependent on the state of its MP joint, whereas in the other fingers it is not. Case 3 had a less severe PIP contracture than case 2, but achieved a less perfect result. This difference was due to the involvement of the MP joint in case 3.

The effect that the above-mentioned factors have on the results of the PIP joints accounts for most of the variability in the results of this joint. However, there is still a large error factor (E in the formulas), which accounts for the results that are unexpected and do not

fit our formulas. Some of the variables included in the error factor are unpredictable, such as motivation, but some variables will be predictable if a large enough series of patients is studied.

This method of analysis has many useful applications. It permits an accurate and objective comparison of one series of patients with another but can be used only when accurate pre- and postoperative measurements of all joint angles have been recorded. For instance, we plan to compare results of other procedures with our own because the operative procedures are so different. There seems to be some difference in Dupuytren's disease from one country to another (such as France) and we hope to compare series of patients from different countries. The influence of alcoholism,

epilepsy, diabetes, trauma, and other conditions is uncertain, but an analysis of several series of carefully documented patients should provide useful information. Finally, these "outcome standards" formulas will appeal to some surgeons for their personal use. By recording the predicted result preoperatively, the quality of the actual result is apparent at any time after operation.

Summary

The results of operation, by one surgeon, on 69 hands with Dupuytren's contracture have been subjected to computer analysis. Four factors have been shown to be of predictable prognostic importance. Justification is given for introducing a new method of assessing results based on "outcome standard" formulas and the use of these formulas is illustrated.

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