Learning curves in orthopaedic surgery: a case for super-specialisation?

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ABSTRACT

INTRODUCTION The objective of this study was to assess if there is a significant learning curve in the treatment of developmental dysplasia of the hip.

PATIENTS AND METHODS We followed up cases of developmental dysplasia of the hip treated by a single surgeon over a 12-year period. There were 96 cases, 56 treated by open reduction and 40 treated by closed reduction. Assessment was made of the incidence and degree of avascular necrosis in the treated hips, as a radiological outcome measure.

RESULTS Plotting the cumulative percentage of satisfactory outcomes demonstrated an increasingly high percentage of satisfactory results with increasing number of procedures performed, *i.e.* as the surgeon progressed up the 'learning curve'.

CONCLUSIONS This study demonstrates a learning curve in the treatment of developmental dysplasia of the hip. It may be possible to draw parallels to other treatments, and also support for the growing trend to specialisation.

KEYWORDS

Learning curves – Specialist centres – Developmental dysplasia of the hip – Avascular necrosis

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The proficiency of a surgeon performing a certain procedure potentially affects outcome and there have been suggestions that complications are more likely while the surgeon is learning the procedure,¹ *i.e.* in the early part of 'the learning curve'. This has proved controversial and was highlighted in the Bristol Inquiry.² Ideally, a system would exist whereby a surgeon would learn a procedure without compromising patient safety.³ Recent suggestions have been made of associations between high patient volume and a decreased morbidity thus backing claims for specialist centres.^{4–6}

Developmental dysplasia of the hip is a specialist condition and its surgical treatment usually only occurs at tertiary centres. The development of avascular necrosis after the treatment of a developmental dysplasia of the hip is iatrogenic.^{7,8} It has far reaching consequences^{7,9} and is easily assessed radiographically.¹⁰ One may hypothesise that, if a learning curve existed for the treatment of developmental dysplasia of the hip, the incidence and degree of avascular necrosis would reduce as the surgeon treated more cases.

Patients and Methods

We performed a retrospective audit of the cases of developmental dysplasia of the hip surgically treated by the

senior author (NMPC) over a 12-year period (1988–1999). Teratological dislocations, neurological dislocations and those hips which had received previous treatment by a different surgeon were excluded from the study.

A standard surgical protocol was followed. After a period of traction, surgical reduction was only attempted following the appearance of the capital femoral ossific nucleus, or at the age of 15 months. Under general anaesthetic, an adductor tenotomy and arthrogram were performed. Gentle manipulation was then used in an attempt to achieve a concentric reduction (termed 'closed reduction'); if this failed, a surgical (Salter) approach was made to the hip, which was then reduced ('open reduction'). Following both procedures, the hips were immobilised in a hip spica cast.

The hips were subsequently assessed radiographically for avascular necrosis using the Kalamchi and MacEwen grading system¹⁰ at a minimum of 18 months' post-procedure. It is considered that a Grade I or less can be counted a satisfactory outcome. Assessment of radiographs was made by two individuals (NPMJ and NMPC) with 100% concordance in grading.

The hips were grouped for analysis, initially into closed or open reduction. The two sections were analysed by plotting the cumulative percentage of satisfactory results. This is an adaptation from the cumulative sum method (CUSUM)

Table 1 Cumulative satisfactory outcomes for open reductions

Total number performed	Open number with satisfactory outcome	Percentage satisfactory (%)
1	0	0.00
2	1	50.00
3	2	66.67
4	2	50.00
5	3	60.00
6	4	66.67
7	5	71.43
8	6	75.00
9	7	77.78
10	8	80.00
11	8	72.73
12	8	66.67
13	9	69.23
14	10	71.43
15	10	66.67
16	11	68.75
17	11	64.71
18	11	61.11
19	12	63.16
20	13	65.00
21	14	66.67
22	15	68.18
23	16	69.57
24	17	70.83
25	17	68.00
26	18	69.23
27	18	66.67
28	19	67.86
29	19	65.52
30	20	66.67
31	20	64.52
32	21	65.63
33	22	66.67
34	22	64.71
35	23	65.71
36	24	66.67
37	25	67.57
38	26	68.42
39	27	69.23
40	28	70.00
41	29	70.73
42	30	71.43
43	31	72.09
44	32	72.73
45	32	71.11
46	33	71.74
47	34	72.34
48	35	72.92
49	36	73.47
50	36	72.00
51	37	72.55
52	38	73.08
53	38	71.70
54	39	72.22
55	40	72.73
56	41	73.21

Table 2 Cumulative satisfactory outcomes for closed reductions

Total number performed	Closed number with satisfactory outcome	Percentage satisfactory (%)
1	1	100.00
2	1	50.00
3	2	66.67
4	3	75.00
5	3	60.00
6	4	66.67
7	5	71.43
8	6	75.00
9	7	77.78
10	8	80.00
11	9	81.82
12	10	83.33
13	11	84.62
14	12	85.71
15	13	86.67
16	14	87.50
17	15	88.24
18	16	88.89
19	17	89.47
20	18	90.00
21	19	90.48
22	20	90.91
23	20	86.96
24	21	87.50
25	22	88.00
26	23	88.46
27	24	88.89
28	25	89.29
29	26	89.66
30	27	90.00
31	28	90.32
32	29	90.63
33	30	90.91
34	31	91.18
35	32	91.43
36	33	91.67
37	34	91.89
38	35	92.11
39	36	92.31
40	37	92.50

that was initially used in industry to observe quality control and has been used to describe surgical learning curves.^{11,12}. They were also split in two by sequence, *i.e.* first 28 versus second 28 for open reduction and first and second 20 for closed reduction.

Results

A total of 96 primary procedures were performed, 56 open (Table 1) and 40 closed (Table 2) reductions.

Patients treated with a closed reduction have a lower overall rate of adverse outcome (7.5% > Grade I) than do patients treated via open reduction (26.8% > Grade I), thus the corresponding rates of satisfactory outcome are 92.5% and 73.2%.

There were trends among both open and closed reduction groups that showed a higher percentage of satisfactory outcomes as the number of procedures performed increases (Figs 1 and 2).

Open reductions

The cumulative percentage of satisfactory outcome (Fig. 1) continued to improve during the first 10 procedures. The next 10 procedures (11 to 20) see the cumulative percentage drop before being variable for the next 10 (21 to 30). It is with the subsequent 10 procedures (31 to 40) that there is a gradual increase in the cumulative percentage prior to the achievement of a plateau with the last 16 procedures. Of the first 28 open reductions, 67.8% had a

satisfactory outcome compared to 78.6% of the next 28 open reductions (Table 3).

Closed reductions

The initial 10 procedures demonstrated a variable cumulative percentage of satisfactory outcomes (Fig. 2) before an increase over the next 10 procedures. After this point, the subsequent 20 procedures achieve a plateau. The first 20 closed reductions had a satisfactory outcome rate of 90% compared to the next 20 with a rate of 95% (Table 4). Although the results were not found to be statistically significant, we believe them to be suggestive.

Table 3 Subdivision of open reductions

No. of procedure in sequential order	Unsatisfactory outcomes (n)	Satisfactory outcomes (n)	Satisfactory outcomes (%)
1 to 28	9	19	67.8
29 to 56	6	22	78.6

Table 4 Subdivision of closed reductions

No. of procedure in sequential order	Unsatisfactory outcomes (n)	Satisfactory outcomes (n)	Satisfactory outcomes (%)
1 to 20	2	18	90
20 to 40	1	19	95

Discussion

This study showed that the overall rate of avascular necrosis for open reductions to be greater than that for closed reductions, as suggested in the literature.¹⁵ The incidence of significant avascular necrosis appeared to reduce, both as the number of procedures undertaken increased, and as the surgeons' years of experience increase. Although the results were not statistically significant, they do suggest a learning curve for the treatment of developmental dysplasia of the hip (both for open and closed reductions). This curve can only apply for these procedures, this surgeon and this hospital.

Some published studies would tend to agree that there is improvement in outcome measures with the number of surgical procedures performed,^{14,15} whereas another showed no association between number of procedures performed and mortality, although mortality is not necessarily a good tool for measuring a surgeon's performance.¹⁶

Interestingly, our results showed a noticeable 'dip' in performance in the second subset of 10 operations in the open reductions. This could potentially be explained by a 'comfort zone' with the operation, where familiarity with the procedure could possibly cause a subconscious decline in concentration. It is more likely, however, that the surgeon performed the first 10 procedures on technically straight-forward hips, and subsequently was referred the more complicated cases for which a satisfactory outcome is more difficult to achieve.

If, as our results appear to suggest, a learning curve does exist for surgical procedures, it is our duty as a profession to minimise its gradient. There have been some suggestions to this end such as the role of a surgical mentor,³ practice on cadavers¹⁴ and, most importantly, the training specialist registrars receive under the supervision of experienced consultants (who have reached the plateau on the learning curve); the latter must be of high quality, especially as the new specialist will have a far shorter training than those in the past.

The presence of a learning curve may imply that those rarer procedures should be carried out by a small number

of surgeons, thus increasing their exposure and ensuring improved results.

Conclusion

Our study, when put into context with others that suggest decreased morbidity in specialist centres,⁴⁻⁶ makes the case for specialisation appear compelling.

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