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Original Article

Mobility of the spine after spinal surgery in acute spinal cord injury

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Study design: Restrospective study of mobility of the spine.
Objectives: To study the relation between mobility of the spine, operation and length of surgical stabilisation.
Setting: The National Spinal Injuries Centre, Stoke Mandeville Hospital, Aylesbury, UK.
Method: Questionnaires were sent to 99 consecutive acute traumatic spinal cord-injured patients (UK residents) admitted in 1990–1994. All had acute spinal surgery. A total of 68 responded. Their replies, medical records and radiographs were reviewed.
Results: (1) In all, 63 patients had surgery in the cervical, thoracolumbar or lumbar spine; 11 of them had more than two functional spinal units (FSUs) stabilised, 10 of these 11 (91%) had less than satisfactory results in terms of metal failure, improper placement of the implant or functional restriction of spinal mobility (FROSM). A total of 35 had 1–2 FSUs stabilised. None of them had metal failure or improper placement of implant, but 14 (40%) had less than satisfactory result due to FROSM; 17 had laminectomy alone, four of these had FROSM. (2) Five patients had surgery in the thoracic spine. Three of these who had 5–7 FSUs stabilised had no FROSM. Two had laminectomy alone, one of whom had FROSM.
Conclusion: (1) Long surgical stabilisation in the cervical, thoracolumbar and lumbar spines was likely to result in either metal failure or FROSM. (2) Long surgical stabilisation of the thoracic spine was not associated with either metal failure or FROSM. (3) A small proportion of patients had laminectomy alone. One of them who had multiple injuries had FROSM.
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Keywords: acute spinal cord injury; spinal surgery; spinal mobility

Introduction

It is important to know how the length of surgical intervention on the spine, particularly surgical stabilisation, affects various sections of the spine in designing the operation and choosing the right type of implant.

Paralysed people are more dependent than the abled on satisfactory functional spinal mobility; for example, wheelchair-dependent tetraplegics rely on rotation of their neck to look behind themselves, and thoracic and lumbar paraplegics require good spinal mobility for optimum functional mobility in transfer and activity of daily living.

This study is not to determine the indications for specific length of surgical stabilisation based on types of vertebral injuries in individual cases or the results of this study. This is an issue of diversified opinions and depends on various factors and situations involved at the time of the operation. The study is concentrating on possible biological and mechanical adverse effects related to long surgical stabilisation alone, regardless if the stabilisation is necessarily or unnecessarily long. It is hoped that the results of the study might be helpful in selecting the appropriate length for surgical stabilisation of the traumatically injured spine in the acute spinal cord-injured persons.

Material and methods

Between 1 January 1990 and 31 December 1994, 158 patients with acute traumatic spinal cord injury admitted to the National Spinal Injuries Centre (NSIC) had spinal surgery. In all, 37 were operated upon in the NSIC; 121 were initially injured and had their spines operated upon in the acute stage in various parts of the world. Questionnaires were sent to the 99 who were UK residents to study the mobility of the spine after spinal surgery (Figures 1a, b and 2a, b). The questionnaires

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were designed by three of the authors (DW, EMKB and MEC). All movements described in the questionnaires are basic ones for a full independent living. There was no quantified answer in the questionnaires in order to avoid difficulty in measuring restriction of movement. A total of 68 patients (68.7%) responded, 57 of them were male and 11 were female patients. Any questionnaire that recorded even a single answer of YES was classified as having functional restriction of spinal mobility (FROSM). Only questionnaires that did not record a single NO are classified as having no FROSM. The age at injury ranged from 16 to 72 years with a mean of 33.5. In all, 36 patients were tetraplegic. The neurology of 13 of them was ASIA Grade A, while that of 23 was B, C and D. A total of 32 patients were paraplegic, 16 of them were ASIA Grade A, while the other 16 were Grade B, C and D. Seven patients had associated injuries. Two patients had chest injury, one of them was severe. Five patients had relatively minor associated injuries such as brain concussion and limb fractures that did not restrict limb movements after healing of fractures. Follow-up is the time from the last operation

Consultant: ________________ Spinal no: ________

(a) Questionnaire for tetraplegics

Return address (please place the address in the window of the stamped envelope):

Dr/Mr/Mrs X
Consultant in spinal cord injury
National Spinal Injuries Centre
Stoke Mandeville Hospital
Aylesbury
Buckinghamshire
HP21 8AL UK

Please tick the appropriate answer in one of the boxes below.

I am willing to answer the following questions to assess the results of rehabilitation of my injury. ☐

I am not willing to answer the following questions to assess the results of rehabilitation of my injury. ☐

Please note that all movements mentioned below are independent without assistance.

Please answer questions only if applicable to you. For example, if you do not have an environmental system then ignore the question and go to the next one.

1. Do you have restriction of movement in your neck which affects your communication with other people (e.g. talking and seeing the person in front of you or alongside of you) while sitting in a chair or wheelchair?

   Yes   No

2. Do you experience difficulty in ducking your head when you move into a car?

   Yes   No

3. Is your driving ability restricted by the difficulty in looking in mirrors?

   Yes   No

Figure 1 (**a**) Questionnaire for tetraplegics. (**b**) Questionnaire for tetraplegics

on the spine to the time of this study that started in January 1996. It ranged from 540 to 2260 days with a mean of 1484 days, a period sufficiently long for the effect of surgical stabilisation to be established. None of these patients recorded any restricted movement in the extremities, particularly the hip joint that could have contributed to the functional restriction of mobility included in the questionnaires. The results of questionnaires were considered in conjunction with medical records and radiographs to identify the relation between surgical intervention, particularly the length of surgical stabilisation, and the functional mobility of the spine. Two lengths were calculated. One was the total length of surgical stabilisation and the other the length of surgical stabilisation beyond the injured region. The region was considered beyond injury when there was no injury in either the vertebrae or the supporting tissues recorded in either clinical notes, referral documents, radiological images and reports or operative notes that may have caused instability. The length of spine was measured by the number of functional spinal units.[1]

The outcome was considered satisfactory when both mechanical stabilisation of the spine had been achieved without metal failure or improper placement of the fixation device and the patient had no FROSM. Otherwise, it was classified as less than satisfactory.

Consultant: ________________ Spinal no: ________

(b) Questionnaire for tetraplegics (continued)

4. Do you have difficulty in assessing your environmental control system switches by the limitation of your head/neck movement?

   Yes ☐ No ☐

5. Are you using a long straw when you drink?

   Yes ☐ No ☐

6. Do you experience difficulty in using a mouth stick because of head/neck movement?

   Yes ☐ No ☐

7. Do you experience difficulty in operating head/chin control of your powered wheelchair?

   Yes ☐ No ☐

Further comments, if any:

Name in block letters: ______________________________

Signature: __________________________________ Date: __________

Figure 1 (*continued*)

Consultant: ______________ Spinal no: ________

(a) Questionnaire for paraplegics

Return address (please place the address in the window of the stamped envelope):

Dr/Mr/Mrs X
Consultant in spinal cord injury
National Spinal Injuries Centre
Stoke Mandeville Hospital
Aylesbury
Buckinghamshire
HP21 8AL UK

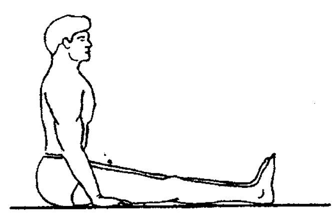
Please tick the appropriate answer in one of the boxes below.

I am willing to answer the following questions to assess the results of rehabilitation of my injury. ☐

I am not willing to answer the following questions to assess the results of rehabilitation of my injury. ☐

Please note that all movements mentioned below are independent without assistance.

1. Can you maintain the upright sitting position in bed without being propped up behind your back?



Yes ☐

No ☐

If the answer is yes, please go straight to Question 3.

2. Why do you need propping up?

a. My back is stiff ☐

b. Other (please specify) ☐

Figure 2 (**a**) Questionnaire for paraplegics. (**b**) Questionnaire for paraplegics

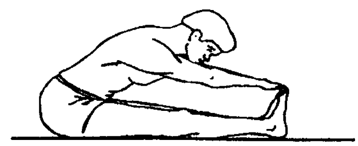
Results

The type of operation and length of surgical stabilisation in these patients are shown in Table 1. Patients with fixation and fusion with bone grafting are classified as a single group. The number of FSU fixed beyond the injured region was 1–8 with a mean of 3.56. In 54 patients, the number of FSU fixed beyond injured region was less than 2, while in seven it was two and more. Four patients had multiple level of vertebral injuries. In three of them, operation was carried out on the major unstable level, while the minor stable one was dealt with conservatively. In one patient, the injured vertebrae were T5–9 and L1. A continuous long-fixation device from T2 to L3 (13 FSUs) was implanted. In all, 10 patients had a second operation. The reasons for and type of second operation are listed in Tables 2 and 3. No patient had a second operation because of insufficient length of surgical stabilisation. All spines became stabilised after second operation.

Consultant: _______________ Spinal no: ________

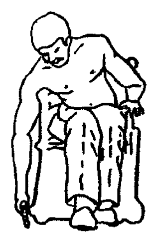
(b) Questionnaire for paraplegics (continued)

3. Can you reach your feet in bed with legs straight out in front of you?



Yes **No**

4. Can you pick up things off floor from the side sitting in chair or wheelchair without lifting your bottom?



Yes

No

5. Can you pull off your T-shirt with two hands together?

Yes

No

Name in block letters: ____________________________

Signature: _______________________________ Date: __________

Figure 2 (*continued*)

(a) The results of the group where surgery was performed in the mobile sections (cervical, thoracolumbar and lumbar) of the spine are indicated in Table 4. It shows that in 35 patients with surgical stabilisation of 1–2 FSUs, mechanical stabilisation was achieved in all cases without metal failure or improper placement of the fixation device. A total of 14 out of 35 patients (40%) of this group had FROSM. Of 11 patients with surgical stabilisation longer than two FSUs, six (55%) failed to achieve mechanical stabilisation due to metal failure or improper placement of the implant. Of the remaining five patients, four had FROSM. In summary, the number of patients with less than satisfactory result of the >2 FSUs was 10 out of 11, while that of the 1–2 FSUs group 14 out of 35. The difference between the two groups was statistically significant (exact probability test, $P = 0.007$). Patients who had laminectomy alone had a lowest rate (23.5%) of FROSM.

(b) In five patients, the less-mobile section, the thoracic spine, was fixed. Long fixation up to 5–7 FSUs in three patients did not cause FROSM. The other two had laminectomy alone. One of them had FROSM. This patient also had a severe chest injury with multiple rib fractures.

Table 1 Type and level of initial spinal surgery in 68 patients

Level of spinal surgery	Type of spinal surgery: Fixation or fusion with bone grafting or both[a] FSU 1–2	FSU > 2	Laminectomy alone	Total
Cervical, thoracolumbar and lumbar	35	11	17	63
Thoracic	0	3	2	5
Total	35	14	19	68

[a]Laminectomies were also done in four patients of the group

Table 2 Reasons for second operation on the spine in 10 patients

Reasons for second operation	No. of patients
Incorrect design of the operation (insufficient surgical stabilisation)	4
Improper placement causing instability	3
Insufficient length causing instability	0
Metal breakdown with long fixation	1
Too long implant causing discomfort	2
Total	10

Table 3 Type of second operation on the spine in 10 patients

Type of operation	No. of patients
Removal of long rods	2
Replacement of long rod with short fixation	1
Previous fusion reinforced with another	3
Revision of previous fixation	2
Additional fixation	2
Total	10

Table 4 Mobility of the spine of 46 patients with surgical stabilisation on mobile (cervical, thoracolumbar and lumbar) sections of the spine

Effectiveness of fixation	Number of patients Extent of 1 fixation: 1–2 FSU With FROSM	1–2 FSU Without FROSM	> 2 FSU With FROSM	> 2 FSU Without FROSM	Total
Stabilisation not achieved	0	0	0	6	6
Stabilisation achieved	14	21	4	1	40
Total	14	21	4	7	46

Discussion

While there are numerous publications devoted to spinal stabilisation after surgery in acute traumatic spinal cord-injured persons, the authors did not discover one describing the mobility of the spine.

For many years after the introduction of Harrington rods in 1958, long fixation (> 2 FSUs) was the treatment of choice for decades for the acute traumatically spinal cord-injured persons despite the fact that these fixations were originally designed for the management of scoliosis.[2–7] When long stabilisation is used in mobile section of the spine, its mobility can be severely restricted.

Short fixation that can achieve satisfactory stabilisation without sacrificing mobility of the mobile sections of the spine is possible with various methods.[8–10] The techniques are not discussed herein because they are not the focus of this paper. Short fixations are at the same time less traumatic than long ones. However, in spite of the effectiveness and advantages of short fixation, long fixation was still performed more than necessary in the mobile sections of the spine (Figure 3). If solid stabilisation is achieved in such long fixation, the remaining decades of life of the paraplegics and tetraplegics involved are unnecessarily restricted.

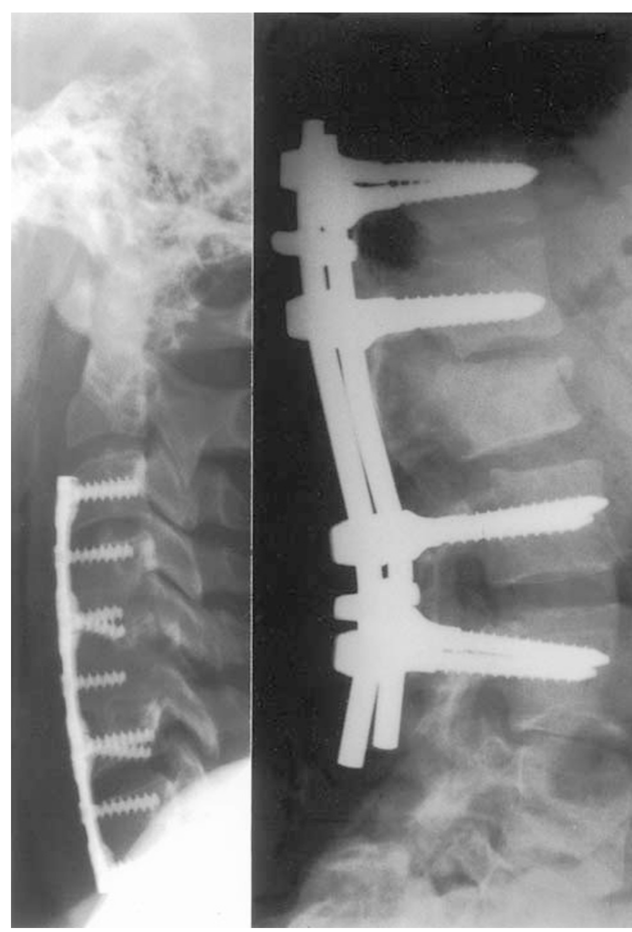


Figure 3 Long fixation involving mobile section of the spine

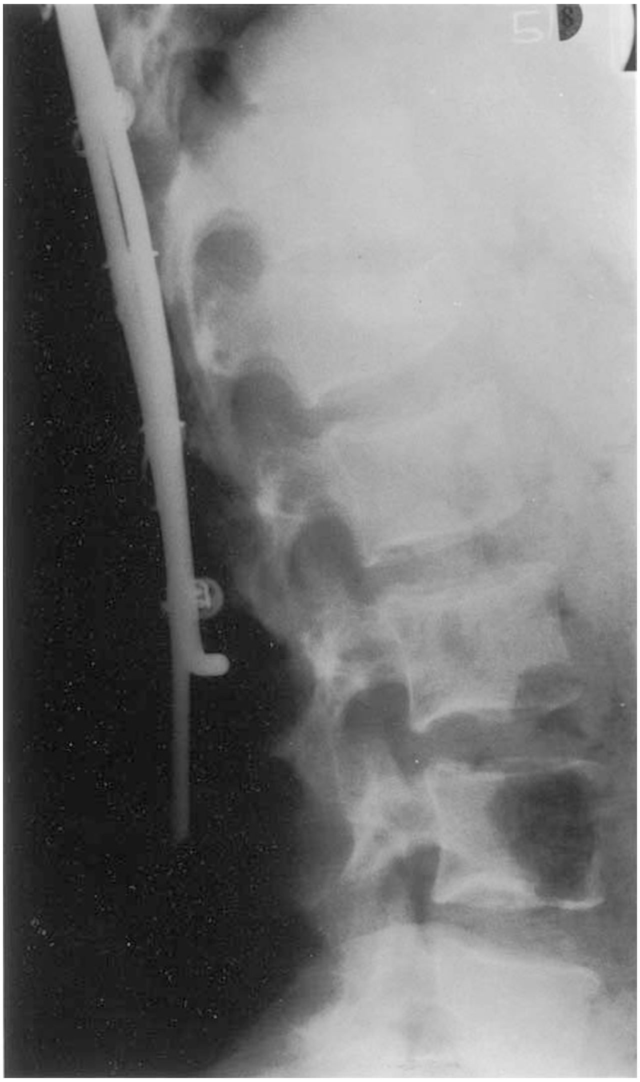


Figure 4 Metal failure after long fixation

Long fixation does not necessarily offer more stability when it fails for technical reasons. Long fixation is associated with greater mechanical stress leading to metal failure (Figures 3 and 4). This occurred more often in thoracolumbar and lumbar stabilisation. In the above-mentioned patient with 13 FSUs fixed, the metal failure was probably caused by the stress exerted on the lower part of the device in the more mobile thoracolumbar and lumbar sections of the spine. Long fixation also involved more technical difficulties, particularly in anterior spinal surgery. Improper placement of the screws into or near the disc space without proper grip of the cortical bone was more common (Figure 3). All the metal problems that occurred in long fixations indicated failure of mechanical stabilisation. The implants concerned became useless or troublesome foreign bodies and often needed replacement or removal.

It is of note that patients who had laminectomy alone also had FROSM although with a lower rate. The overall rate of FROSM in the entire series was six out of 19 patients (31.6%). The basis of this is not clear from this study, but excessive dissection of the periosteum from the posterior elements of the spine may have given rise to unnecessary ossification.

While it is crucial that spinal stabilisation is achieved, it is also important to salvage mobility of every FSU. The shorter the stabilisation the greater the mobility of the paralysed. The greater the mobility of the paralysed the better their quality of life.

Conclusions

1. In planning major surgery on the spine of paraplegics and tetraplegics, future spinal mobility must be borne in mind.
2. Surgical stabilisation of more than two FSUs in the mobile section (cervical, thoracolumbar and lumbar) of the spine poses a high risk of metal failure or FROSM.
3. Long stabilisation in the thoracic spine does not adversely affect mobility.
4. Laminectomy alone can be associated with FROSM. Posterior dissection, especially periosteal stripping, should be kept to a minimum.

Acknowledgement

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