

## COMPARISON OF BIOMECHANICAL CHANGES IN RESPECT OF PAIN SCORES AFTER LUMBAR FUSION

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### Abstract

Low back pain is one of the leading causes of disability, some patients don't respond to conservative therapy, and must undergo surgery. The aim of our study was to investigate the results of lumbar fusion operations, especially considering the changes in the sagittal range of motion (ROM) in the adjacent segments, thoracic, lumbar region and pain. 13 patients were involved, who had lumbar LIV/V rigid fusion (TLIF) operation, and still had low back pain symptoms. For the biomechanical measurement we used the Spinal Mouse, a computer associated device, based on electromagnetic impulses. For estimating the pain we used the 3D pain questionnaire (West-Haven-Yale Multidimensional Pain Inventory [WHYMPI]).

In the outline analysis we found that the decrease in pain and improvement of symptoms after a lumbar fusion is definitely the result of increased thoracic segment hypermobility, decreased lumbar segment hypomobility, decreased proximal adjacent segment hypomobility and, increase of the distal adjacent segment hypomobility. The sagittal range of motion (ROM) of the whole spine, as the hypomobility is corrected towards the normal ROM resulted in decrease of pain. In conclusion we can notice when using semirigid systems for bridging adjacent segments, it is important to secure the hypermobility of the thoracic spine, and the mobility of the proximal segment.

**Keywords:** spinal mouse; lumbar fusion; Range of Motion; hypermobility; hypomobility; adjacent level syndrome

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### Introduction

In our research we have investigated the results of lumbar fusion operations, especially considering the changes in ROM in the thoracic, lumbar spine, in the adjacent segments of fusions and pain. In the literature the adjacent segment syndrome is known to develop next to the stabilized segment because of the increased shear forces. Our hypothesis is that the changes in the symptoms and pain is in correlation with hypo- and hypermobility and the lack of movement of the fused segment is compensated by other segments of the spine.

### Patients and methods:

13 patients were involved, who had had lumbar LIV/V rigid fusion (TLIF) surgery, and still had low back pain symptoms. None of the patients had morphological disorder (proven by CT or MRI), nor had symptoms of radiculopathy. The patients were: 6 male (mean age  $36 \pm 6$  years), 7 female (mean age  $34.5 \pm 5.5$  years). Neurological involvement (lumbar stenosis or compression), systemic disorders, inflammatory disease and obesity ( $BMI > 31 \text{ kg/m}^2$ ) were exclusion criteria.

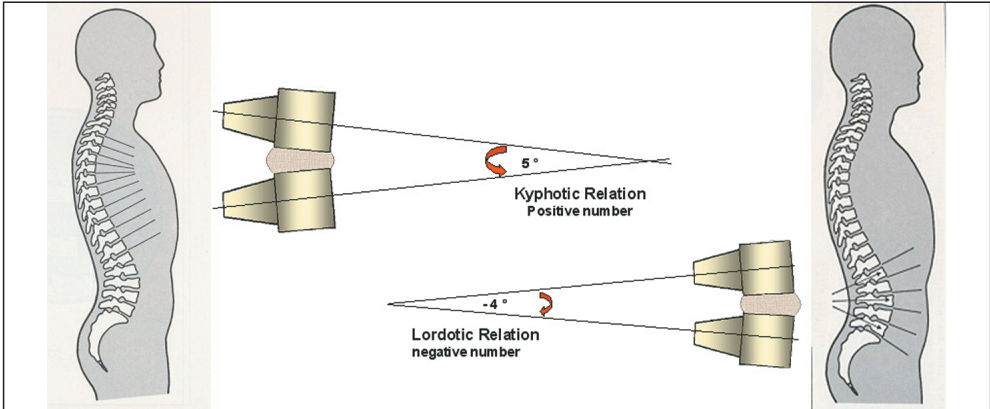


Figure 1. The kyphotic and lordotic angles

### Measurement and parameters

For the biomechanical measurement we used the Spinal Mouse, a computer associated device, based on electromagnetic impulses. The device senses the deflexion of the levels of the spinal processes as it moves along the spinal column. The data is forwarded by bluetooth to a PC. The measured values are processed by the computer, and based on standardized data, the acquired data is represented in 2 or 3 dimension. The position of the vertebrae, the functional shift of the vertebrae, and their relation to each other is evaluated by the Spinal Mouse. The kyphotic angle is marked by +, the lordotic by the – sign (Figure 1, 2).

During the study we used the functional test of the set. The validity parameters of Spinal Mouse (Figure 3).

The Spinal Mouse was calibrated by a ZEBRIS ultrasound-based measuring method with WINSPINE software. The accuracy and the reproducibility of the method were appropriate, because the maximum value of intraobserver variation is 0.97 degrees (18.8%), that of interobserver variation is 1.54 degrees (27.1%). The maximum value of the average difference between the angles determined by the two methods is 1.62 degrees (26.6%).

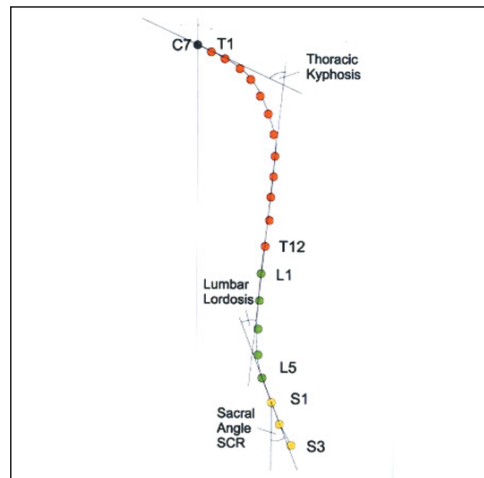


Figure 2. The measurement of thoracic kyphosis and lumbar lordosis

<b>Variability</b> (standard deviation SD, n = 50)			
(A) = trained	(B) = untrained	Systematic (invariant spine shape – laying position)	
(A): SD= +/- 0.8°	(B): SD= +/- 1.3°	Intraindividual (repeated upright position after walking)	
(A): SD= +/- 1.3°	(B): SD= +/- 1.8°		
<b>Intra-rater reproducibility</b> (n = 50)			
mean correlation coefficient r for segmental angles			
(A): r = 0.97	(B): r = 0.94		
<b>Inter-rater reproducibility</b> (4 trained raters; 20 healthy probands)			
cross-correlation coefficient r = 0.93			
<b>Comparison with functional radiograph</b> (Th11 to sacrum)			
flexion – extension:	r(seg)= 0.84	r(lumb) = 0.95	
upright-flexion:	r(seg)= 0.87	r(lumb) = 0.98	

Figure 3. The variability and reproducibility of the Spinal Mouse

During the measurement we marked the spinal processes of the C7 vertebra, and the lumbosacral link, we drew a line between these two points, above the spinal processes from C7 to the sacrum. At the beginning of the measurement patient was standing in an upright position with his arms down. The patient must bend over with hanging arms (F:flexion), then we asked them to lean back (E:extension). We got the total sagittal movement range from the difference of flexion and extension, this is the Flexion-Extension Index (FEI: F-E). The FEI was measured on the total thoracic and lumbar region, and in the segments of the lumbar region (Th12/L1, L1/L2, L2/L3, L3/L4, L4/L5, L5/S1). The relation to the normal range is marked with the index *n*, *n* + if it is the positive range, – if it is the negative range, 0 if it is the normal range. The relation to the mean value is marked with the index *m* (+ if it is positive, – if it is negative, 0 if it is in the median). For the segmental angles, the FEI values of the segments above and below the fusion were used in the lumbar region. The difference between the values at the follow up after one and three years (FEI *n,m*) were marked with DFEI (*n,m*)

## Measurement of the pain

We used the 3D pain questionnaire (West-Haven-Yale Multidimensional Pain Inventory WHYMPI) for estimating pain and only the part which applied specifically to the pain (I/1, total score: 18) was taken into account. The percental change of the total score demonstrated the amount of improvement.

## Statistical analysis

For the statistical analysis of the correlation between pain-scale and the DFEI values, the Spearman's rank correlation coefficient test was used. After Rho statistical analysis by a permutation test, we got the value of *P*.

## Results (Figure 4)

In the outline analysis we found that the values of the lumbar region were in the negative range or in the normal range. The values were in the positive range, or in the normal range at the thoracic region.

Patient's code	D Pain	DFEI ups;n,m	DFEI dos;m	DFEI dos;n	DFEI th;n	DFEI th;m	DFEI l;n	DFEI l;m
1	-1	4	1	0	12	12	8	8
3	-1	5	4	0	0	0	1	1
8	-1	-1	-2	-2	-1	-2	5	5
10	-1	-3	no data	no data	0	1	-5	-10
4	1	-1	2	0	-6	-6	-1	-1
5	1	5	no data	no data	8	22	-3	-3
9	1	3	no data	no data	0	15	10	10
6	2	0	no data	no data	-8	-8	0	4
11	2	0	-1	-1	-3	-3	-5	-5
13	2	-7	7	2	0	5	10	10
12	3	-7	no data	no data	0	-12	-18	-18
2	4	1	-12	0	-18	-18	-7	-7
7	4	-1	-2	0	0	-2	-14	-14

Figure 4. The results of the measurement

1. There is an inverse correlation between the increase of the pain and the positive change from the normal range of the DFEI values in the thoracic region. ( $p=0.09366$ ,  $\rho=-0.3903177$ )
2. There is an inverse correlation between the increase of the pain and the positive change of the mean DFEI values in the thoracic region. ( $p=0.02340$ ,  $\rho=-0.5595029$ )
3. There is an inverse correlation between the increase of the pain and the change of the DFEI values in the lumbar region to the normal range ( $p=0.02288$ ,  $\rho=-0.56169$ )
4. There is an inverse correlation between the increase of the pain and the positive change from the mean DFEI values in the lumbar region. ( $p\text{-value}=0.06175$ ,  $\rho=-0.4492978$ )
5. There is an inverse correlation between the increase of the pain and the positive change from the normal range of the DFEI in the proximal adjacent segment ( $p=0.1067$ ,  $\rho=-0.3034631$ )
6. There is a correlation between the increase of the pain and the positive change from the normal range of the DFEI in the distal adjacent segment ( $p=0.09793$ ,  $\rho=0.5107458$ )

## Conclusions

From the significant ( $P \leq 0,05$ ) – /2,3/ and trendlike ( $0,1 > p > 0,05$ ) – /1,4,5,6/ correlations of the above results the following conclusions were made:

The decrease in pain and improvement of symptoms after a lumbar fusion is definitely the result of the increase of the thoracic segment's hypermobility. Hence the range of motion of the spine is controlled by the thoracic segment as it compensates the hypomobility of the lumbar spine with its hypermobility.

The second biomechanical factor contributing to the improvement of symptoms after lumbar fusion is the sagittal ROM of the whole spine, as the hypomobility is corrected towards the normal ROM and these results in decrease of pain.

Similar conclusions can be drawn about the mobility of the proximal segment above the fusion. The distal adjacent level has increased hypomobility after a successful operation .

## Summary

The balancing role of the thoracic spine after a lumbar stabilization is of high importance. Hence a decision about such operation or the extension – if required, needs careful planning to preserve the ROM of the thoracic segment. The preoperative ROM of the T-spine is a good indicator of the success of the operation and has to be considered when predicting the results.

When using semirigid systems for bridging neighboring segments, it is important to secure the mobility of the proximal segment. The hypomobility or rigid fixation of the distal segment also has to be considered.

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