Assessment of dynamic traction therapy in lumbar disc herniation by clinical and magnetic resonance imaging outcomes

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Abstract—

Introduction*: "Dynamic traction therapy" (DTT) is a new standardized conservative treatment option in lumbar disc herniation. This study aimed to evaluate the therapeutic effect of DTT in lumbar disc herniation, by correlating both clinical and magnetic resonance imaging (MRI) outcomes.*

Materials and methods: *In a total of 27 patients (mean age 50.5±9.1), who underwent standardized DTT, MRI was performed before and after therapy and evaluated by two independent radiologists individually and blindly; both grading intervertebral discs according to Pfirrmann classification in terms of degeneration, morphology, localization and nerve root affectation. The effect of standardized DTT on painful herniated discs was correlated with numerical pain rating (NPR) scale from 0 to 10 and clinical outcome.*

Results: *Significant MRI changes were found in images after therapy compared to before therapy regarding morphology and nerve root affectation ($p< 0.05$), but disc degeneration grading showed only a tendency towards improvement ($p> 0.05$), interestingly showing a better disc hydration after therapy. Patients' NPR decreased from a mean value of 10 to 1 after completed therapy, thus showing a significant change in pain ($p< 0.001$). Clinical outcome measurements improved significantly after therapy ($P<0.001$), however changes of MRI grading did not significantly correlate with pain rating and clinical outcome ($p>0.05$).*

Conclusion: *Lumbar disc herniation grading showed a positive correlation with patients' decreased NPR after undergoing standardized DTT, therefore our preliminary results might impact in the therapeutic management of patients complaining of lumbar disc pathology, however further longitudinal studies are recommended.*

Keywords— Intervertebral disc herniation, traction therapy, Magnetic resonance imaging.

I. INTRODUCTION

One of the main reasons for back pain and disability all over the world is degeneration of intervertebral discs, such as painful herniated vertebral discs. Intervertebral disc prolapse, protrusion, or extrusion accounts for 5% -10% of all low back problems, but constitute the most common causes of nerve root pain and surgical intervention in the lumbar region.[1,2] Disc herniation may develop slowly over time or suddenly in presentation with neurological deficits. The effect brought about by disc herniation ranges from being completely asymptomatic to devastating acute cauda equine compression. The size of the herniation may be correlated to the symptoms, but there are no strict rules to do so. [3-5]

Disc herniation can be accurately and precisely categorized and staged into different sub-groups namely disc bulging, disc protrusion, disc extrusion further divided into subligamentous and transligamentous, and disc sequestration using Magnetic Resonance Imaging (MRI). The accuracy of diagnosing disc herniation via MRI is reflected in comparative studies where the agreement of MRI with surgical findings was 90%, while on the other hand of CT was only 78%. [6]

Treatment modalities include conservative measures with physiotherapy, rehabilitation, weight control, anti-inflammatory measures, epidural steroid injections, analgesia assisted traction therapy, lumbosacral back support and stem cell therapy.[7-9] The outcome of the treatment depends on the location of the prolapse, clinical condition of the patient and time of presentation and treatment.[10]DTT is a new standardized conservative treatment option affecting the lumbar spine in total. To the best of our knowledge, no data are available on its therapeutic effect with MRI correlation on patients with painful disc herniation. We therefore aimed at evaluating this new conservative therapy in patients with lumbar disc herniation by assessing it by both clinical and MR imaging outcomes

II. MATERIALS AND METHODS:

For this retrospective study ethical committee approval was obtained from ethical committee board and informed written and oral consents were obtained from all patients. Demographic data, clinical symptoms and MRI was evaluated in 30 consecutive patients presenting with severe low back pain. MRI of the lumbar spine was available before and after DTT in a time interval of 3 month. The overall number of therapy sessions of each patient until the end of treatment was documented.

Dynamic traction Therapy (DTT): The therapeutic device "Gamma Swing" (Figure 1) is a dynamic traction system which allows patients to be pulled up to a free-hanging position using slings which are fixed onto the distal lower legs. The therapy was performed in 3 steps starting with lifting of the pelvis, being followed by an elevation of the trunk with contact of the shoulders to the base and the free hanging position. During each phase of standardized therapy with duration of 5 minutes for each phase an oscillation movement with a frequency of up to 100 swings per minute was applied to the patient. These rhythmic oscillations especially help the muscles to relax. When therapy was finished, (about 15 minutes with all three positions) the patient was let down to the conveyer belt, the extension straps were removed and after resting a minute, the patient was sat up. The treatment was done two times per week for about 3 weeks.

FIGURE (1): DYNAMIC TRACTION THERAPY DEVICE

General exclusion criteria were; pregnancy, clinically relevant diseases of the cardiovascular system, lung, liver, kidney, gastrointestinal tract, eye, musculoskeletal system and any tumour.

Clinical evaluation: Within routine documentation of the treatment, the Schober sign and the fingertip-to-floor distance were assessed at the start and at the end of each therapy session. The numerical pain rating (NPR) was assessed for each patient ranging from 0 equalling no pain, to 10 equalling the maximum pain [11] before starting DTT and at the end of the completed therapy. At the end of the treatment period the overall satisfaction was rated with a range from excellent, to good, intermediate and disappointing. Any complications during DTT treatment were recorded for each treatment session individually.

MRI: MRI (sag SET1 500/15, sag TSE T2 3000/110, Matrix 384, FOV 200; ax SET1 500/14, ax TSET2 3000/110, Matrix 384, FOV 180, SL 3mm) were evaluated by two different radiologists (observer 'A' and observer 'B') individually and

blindly, both grading all segments of the lumbar intervertebral discs according to the scale of Pfirrmann classification [12] (Table 1). The grading scale of disc degeneration was divided into signal intensity (equalling the normal disc), signal intensity with horizontal bandage, intermediate signal intensity, hypointense with normal to decreased height and hypointense collapsed being the worst possible grade. The morphology of intervertebral disc was divided into normal, protrusion, extrusion (prolapse), migration and sequestration. The third aspect assessed was nerve root affectation caused by the herniated disc, ranging from no affectation, possible (suspected) affectation, to an affectation and finally to a displacement of the nerve root. [12]

TABLE 1
KEYS OF THE POSSIBLE DISC DEGENERATION RATING, MORPHOLOGY, LOCALIZATION AND NERVE ROOT AFFECTATION.

Disc degeneration	Grade	Morphology	Grade	Localisation	Grade	Nerve root affectation	Grade
Hyperintense	0	Normal	0	Normal	0	no	0
Hyperintense, with horizontal bandage	1	Protrusion	1	centre	1	suspected	1
Intermediate signal intensity	2	Extrusion (Prolapse)	2	right/left: far lateral	2	affection	2
Hypointense, normal to decreased height	3	Migration	3	right/left: posterolateral	3	displacement	3
hypointense, collapsed	4	Sequestration	4	right/left: foraminal	4		

III. STATISTICAL ANALYSIS

For all nominal and ordinal variables, mean value and standard deviation were calculated. For two observers' interobserver correlation (A vs. B), the collected data were analysed via T-Test and Spearman-Test.[13] To assess changes in the image-grading before and after DTT, the Wilcoxon-Test and T-Test were used.

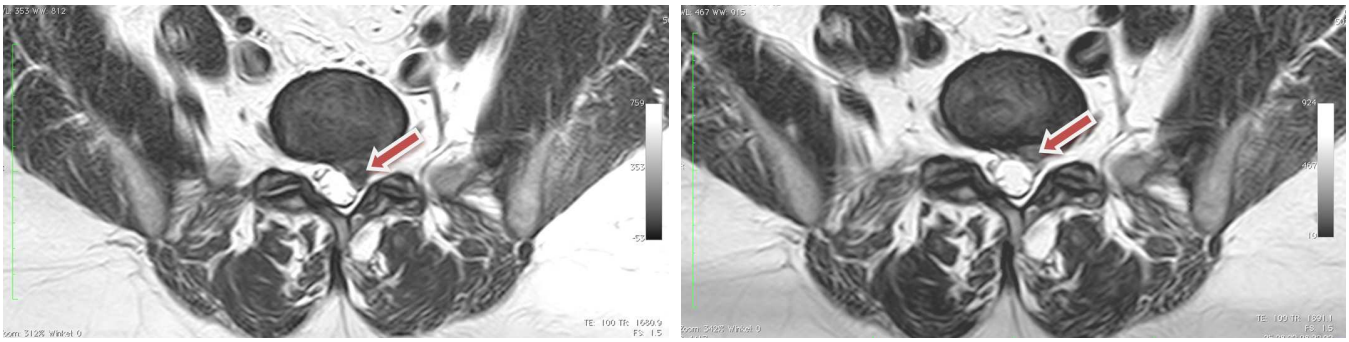

FIGURE (2): AXIAL T2WI MRI OF A PATIENT BEFORE (A) AND AFTER (B) TREATMENT. THE MORPHOLOGY GRADING OF THE DISC CHANGED FROM GRADE 4 (SEQUESTRATION) TO GRADE 2 (PROLAPSE).

IV. RESULTS

Time interval between the two MRI (before and after therapy) of 3 patients were beyond 18 months and were therefore excluded, hence 27 patients (15 males, 12 females) were evaluated in total.

Descriptive Statistics: The age range of patients (n=27) was 28-69 years (mean ± SD; 50.54 ± 9.14). Each patient averaged around 7 therapy sessions with DTT device (range between 4-15 sessions).

The total number of vertebral segments (L1-S1) was 135. The main descriptive statistics for all nominal and ordinal variables of 27 patients were determined (table 2).

TABLE 2
THE NOMINAL AND ORDINAL VARIABLES' DESCRIPTIVE STATISTICS OF PATIENTS EVALUATED IN THE STUDY

	Mean ± Std
Overall therapy sessions per patient	**7.07 ± 2.73**
Overall satisfaction	**1.04 ± 0.19**
Disc degeneration before (A)	2.11 ± 1.06
Disc degeneration after (A)	2.06 ± 1.07
Morphology before (A)	1.06 ± 1.15
Morphology after (A)	0.93 ± 1.03
Localisation before (A)	0.99 ± 1.08
Localisation after (A)	0.97 ± 1.13
Nerve root affection before (A)	0.50 ± 0.92
Nerve root affection after (A)	0.36 ± 0.75
Disc degeneration before (B)	2.03 ± 1.09
Disc degeneration after (B)	1.98 ± 1.05
Morphology before (B)	0.85 ± 1.11
Morphology after (B)	0.70 ± 0.96
Localisation before (B)	0.84 ± 1.15
Localisation after (B)	0.77 ± 1.12
Nerve root affection before (B)	0.47 ± 0.86
Nerve root affection after (B)	0.31 ± 0.70

Std = Standard Deviation; before = before starting DTT; after = after completing DTT; A = observer A; B = observer B;

In total, there were 198 therapy sessions and no complications were reported during and after any of them. All 27 patients rated the treatment after completing the whole therapy program. The patients' satisfaction ratings were mainly excellent (96.4%), only one patient rated the treatment as good' (3.6%). The fingertip-to-toe test mean value decreased significantly from 15.61 cm before therapy to 11.33 cm after therapy ($p< 0.001$), however for the Schober sign, the mean value increased significantly from 13.86 before therapy to 14.14 cm after therapy ($p< 0.001$). The mean value of NPR before therapy was 10, which was significantly decreased to 1.09 after therapy ($p < 0.001$). (table 3)

TABLE 3
SUMMARY OF THE CLINICAL OUTCOME MEASUREMENTS OF PATIENTS.

	Mean ± Std
Finger-to-toe before	15.61 ± 14.11
Finger-to-toe after	11.33 ± 13.11
Schober sign before	13.68 ± 1.18
Schober sign after	14.14 ± 1.13
NPR before	10.00 ± 0.00
NPR after	1.09 ± 17.05

MRI changes results: The results for disc degeneration demonstrated 10 negative ranks, 4 positive ranks and 96 ties showing a mean value of the paired differences (before vs. after) of 0.05, indicating a non-significant difference (p= 0.06). The morphology grading showed 27 negative ranks, 7 positive ranks and 101 ties, with a paired differences' mean value of 0.15 (Figures 3 **a** and **b**) and nerve root affection grading was 25 negative ranks, 3 positive ranks and 107 ties with a paired differences' mean value of 0.15. Both showed significant differences between before and after therapy ($p<0.001$).

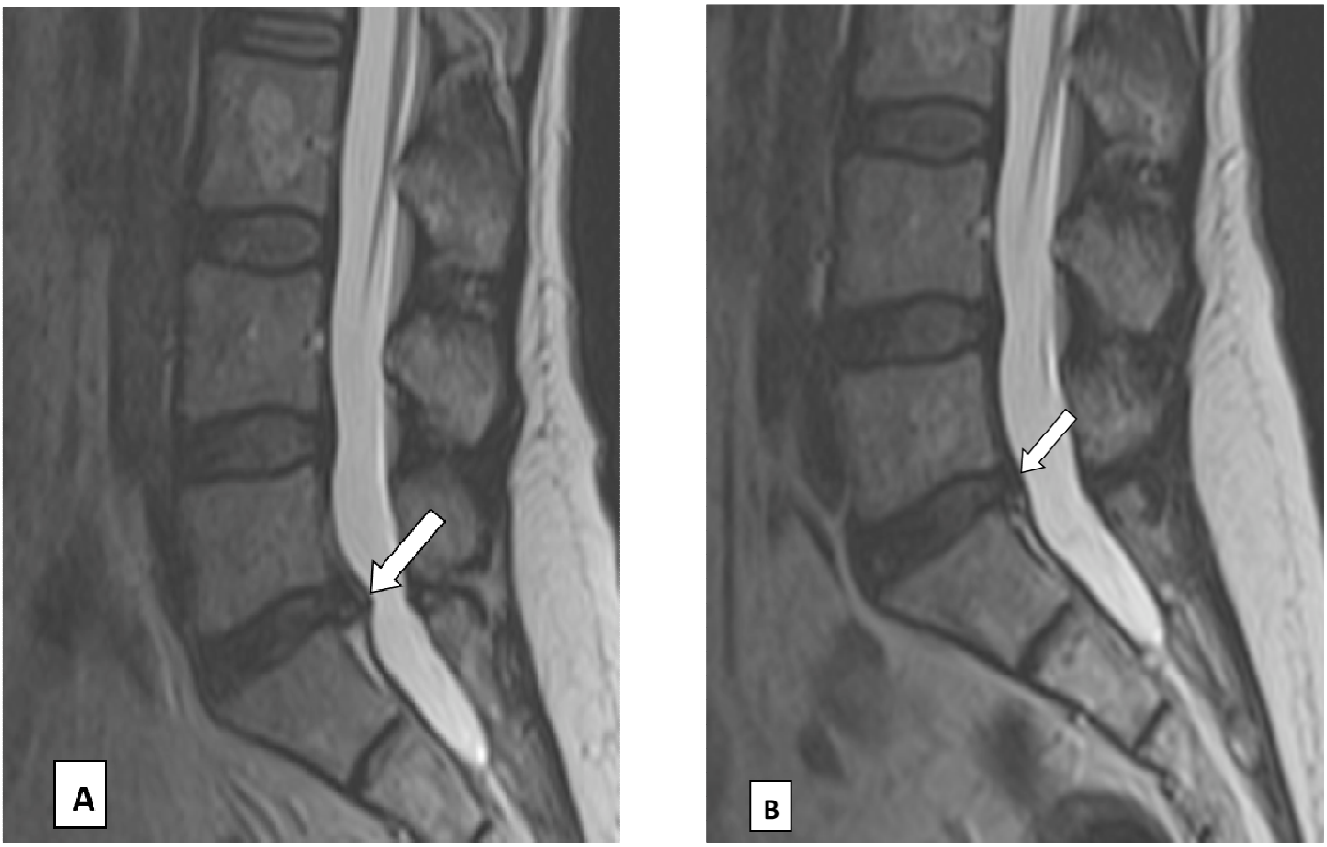

FIGURE (3) SAGITTAL T2WI MRI OF A PATIENT BEFORE (A) AND AFTER (B) TREATMENT. THE MORPHOLOGY GRADING CHANGED FROM GRADE 2 (PROLAPSE) TO GRADE 1 (PROTRUSION).

Interobserver results: The results as regarding disc degeneration and morphology showed excellent agreement between the two observers both before and after therapy (0.93 and 0.91, and 0.89 and 0.85 kappa values respectively).

The results of nerve root affectation showed excellent agreement before therapy and substantial agreement after therapy (0.92 and 0.71 kappa values respectively ($p< 0.05$).

The correlation coefficients for disc degeneration grading, morphology grading and nerve root affection grading were 0.93 and 0.92, 0.85 and 0.83, and 0.89 and 0.71 before and after therapy respectively with highly significant Interobserver agreement by Spearman-Test ($p<0.001$).

MRI correlation with NPR: Numerical pain rating was compared to disc degeneration grading before and after end of therapy (P = 0.21 versus 0.15 respectively), to morphology grading before and after therapy (P = 0.35 versus 0.25 respectively) and to nerve root affection grading before and after therapy (P = 0.25 versus 0.13 respectively). No significant correlation was found between pain rating and any of the MRI grading variables ($p>0.05$).

V. DISCUSSION

Symptomatic disc degenerations are a major problem and many patients suffer from extensive pain for a long time. The basic treatment options for painful disc herniations range from conservative to surgical treatment. The majority of herniated discs will heal themselves in about six weeks and do not require surgery [8]. The first step in the treatment of patients with symptomatic intervertebral disc herniation should always be a 4-6-week course of conservative therapy (unless the symptoms

require surgery), even though studies show that the long-term benefit (pain reduction) of percutaneous disc decompression (surgery) is better than conservative therapy.[14]

The 'Gamma Swing' device represents a conservative extension therapy option with a special focus on dynamic influence on the vertebral spine, providing mobilization under traction to reduce back pain and possibly prevent surgery. In fact no patient needed surgery and DTT has shown in this study to reduce the patients' back pain. Also, DTT treatment can easily be combined with other conservative therapies, what should be proven in further studies.

The main focus of this study was to evaluate DTT as a conservative therapeutic option for disc herniation assessed both by clinical and MR imaging outcomes. For this purpose MRI before and after therapy was separately and independently graded by two different radiologists ensuring that the results were consistent. Compared to Zou et al [15]the interobserver agreement was good and similar or even better correlations were found. In total, the levels of agreement showed that the gradings of the two observers were significantly reliable. A study by Kim et al [16] showed that MRI grading can be quite variable between radiologists, especially in the spinal region. The results of the MRI grading showed significant changes in the morphology and nerve root affectation grading between before and after therapy, thus indicating a positive effect of DTT on the herniated intervertebral disc. Although the change of disc degeneration was not significant, a tendency towards a better disc hydration could still be found, seen by an increased fluid content in the discs when using MRI. The NPR of patients in this study indicates a positive effect of DTT. For almost every patient the pain rate was cut in half or even more 26 out of 27 patients had a decrease of at least 4 NPR units which is considered a significant improvement in NPR [14]. Further, the results of the fingertip-to-toe test showed that there was a highly significant difference between both 'before' and 'after' therapy measurements ($p< 0.001$). No complications occurred during and after therapy, therefore DTT seems to be a non-invasive, safe and cost effective therapeutic option for patients with painful disc herniation. Actually, most patients enjoyed the therapy sessions because it was relieving and relaxing, which is important for patient compliance rates.

In some patients, the MRI grading did not change at all, but the clinical presentation improved significantly, in line with previous studies as well [3-5].This might be explained on the basis of the contribution of many factors that may cause back pain such as apophyseal vertebral joints and muscle tensions. All these factors may be positively affected by DTT, which may give a great advantage to this device.

Besides small number of patients, another major limitation of this study was its retrospective nature and the lack of control group with whom the results could be compared. Additionally, the number of treatment sessions varied. The duration of the positive effect of DTT and the need to have another traction therapy in an already asymptomatic patient in order to prolong the positive effect was not assessed.

Therefore, further prospective studies with long-term follow-up assessment of both clinical and MRI outcomes are ongoing. The possibility of avoiding long period of back pain, immobilization and even surgery using a safe and non-invasive therapy technique seems worthwhile for patients.

VI. CONCLUSION

According to our preliminary results the treatment with DTT device should be considered in a conservative therapy regimen when treating patients with disc herniation who are not in need for emergency surgical interference.

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