Morphological changes of the multifidus muscle in patients with symptomatic lumbar disc herniation

Clinical article

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Object. Lumbar disc herniations are associated with segmental muscle alterations of the ipsilateral segmental multifidus muscle. The aim of the present study was a histopathological analysis of the myopathological changes of the multifidus muscle and correlation with the duration of radicular symptoms.

Methods. Multifidus muscle biopsies were performed in 20 patients during discectomy. Specimens were obtained from the area of the multifidus muscle innervated by the nerve from the level of the affected disc. Histopathological findings were classified according as neurogenic tissue syndrome and nonspecific myopathological syndrome, and these results were correlated with the duration of radicular symptoms.

Results. Results of multifidus muscle biopsies were classified as neurogenic tissue syndrome in 12 patients and as nonspecific myopathological syndrome in 8. The mean (± SD) duration of radicular symptoms was 10.75 ± 7.9 months in patients with neurogenic tissue syndrome and 4.37 ± 3.9 months in patients with a nonspecific myopathological syndrome. There was a positive correlation between group assignment and symptom duration (correlation coefficient 0.457, p = 0.043).

Conclusions. A long duration of radicular symptoms is associated with a neurogenic tissue syndrome, whereas a nonspecific myopathological tissue syndrome is seen in patients with shorter duration of symptoms. This suggests that patients with long duration of radicular symptoms originating from a lumbar disc herniation have an increased risk for neurogenic muscular changes, and that consideration should be given to an earlier surgical intervention.

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Key Words • lumbar disc herniation • multifidus muscle • myopathy • tissue syndrome

The multifidus muscle is strongly developed in the lumbar area and plays an important role in stabilization of this area of the spine.16,21 The muscle is innervated by the medial branch of the posterior root of the segmental nerve, and this innervation is always unisegmental;10 there is no collateral innervation. Looking at the rising interest in the role of the multifidus in dynamic stabilization of the lumbar spine,9 the morphological characteristics of the muscle in cases of unilaterally disturbed innervation should be of great importance.

In patients with acute ischial pain, Hides et al.5 showed a reduction of the cross-sectional area (CSA) of the affected segment of the muscle on the same side. Hodges et al.9 confirmed this in an experimental study in pigs with induced nerve root lesions and rapid atrophy of the ipsilateral multifidus muscle at the level innervated by the affected nerve root. In patients with chronic low-back pain, the CSA of the multifidus is significantly smaller unilaterally if there is a unilateral pain distribution.3 Mattila et al.13 found a hypotrophy of Type 2 fibers and rare signs of degeneration and reinnervation consisting of fiber group atrophy. Histological investigations by Zhu et al.25 demonstrated selective angular atrophy of Type 2 fibers, which became more obvious with greater patient age and longer duration of symptoms. Additionally, they found nonspecific pathological changes, including nuclear centralization, “moth-eaten” fibers, fiber groupings, and target fibers. Similar results have been reported by Zhao et al.24 and Yoshihara et al.23

The aims of the present study are histological evaluation of the myopathological fiber changes, grouping of identified changes into known myopathological tissue syndromes,2 and correlation of the findings with the duration of radicular symptoms. Our primary hypothesis was that a time-dependent change in the quality of muscle fiber pathology occurs within the segmental multifidus muscle.

Abbreviation used in this paper: CSA = cross-sectional area.
Multifidus changes in symptomatic lumbar disc herniation

Methods

This study was performed according to the guidelines of the ethical committee of the medical faculty of the University of Magdeburg and approved by the committee.

We performed a biopsy of the multifidus muscle in 20 patients, who underwent microscopic discotomy for lumbar disc herniation (15 men and 5 women, mean age 46 years). In 12 patients the affected segment was L4–5, in 7 L5–S1, and in 1 L3–4. In all patients a standard microdiscotomy was performed using microscopic visualization. The duration of radicular symptoms was assessed from the medical records. The biopsy specimen was taken from the multifidus muscle ipsilateral to the affected site and affected nerve root as described by Yoshihara et al. The muscle tissue was fixed on a cork platelet according to the fiber direction, immediately stained with 2-methylblue, shock-frozen in isopentane, and cooled in liquid nitrogen. From these deep-frozen muscle specimens, frozen sections of 10 μm were cut using a microtome (HM505, Mikro M); the sections were then stained with H & E. For histological analysis we used a Zeiss Aionphot equipped with a 20 LD Acroplan objective. Histopathological evaluation of the muscle specimens was performed as described by Jerusalem and Zierz and Engel and Franzini-Armstrong, focusing on criteria (elongated, degenerating, and regenerating fibers with pyknotic nuclear clumps) that distinguish neurogenic tissue syndrome from non-specific myopathological syndrome, as well as searching for possible signs of myositic or myopathic changes. All histological assessments were performed by a senior neuropathologist (W.S.). The number of muscle fiber alterations was determined as a percentage related to 100 evaluated fibers per assessed visual field. Ten visual fields were analyzed per case.

According to the criteria mentioned above, neurogenic tissue syndrome was diagnosed when the elongated muscle fibers and/or pyknotic nuclear clumps were pronounced. Also, in cases in which fiber hypertrophy was present without any other fiber alteration, the muscle changes were assigned to the neurogenic tissue syndrome. The muscle tissue was assigned to the nonspecific myopathological syndrome when degenerating, regenerating fibers were present together with nonpronounced fiber elongations and/or pyknotic nuclear clumps.

Statistical Analysis

We used a Student t-test of unpaired samples for comparison of the 2 groups (neurogenic syndrome vs nonspecific myopathological syndrome). Because the allocation to a myopathological syndrome was based on the presence of different alterations, only a semiquantitative analysis was possible and no additional statistical comparison would be of value.

The Pearson correlation test was performed to assess the correlation between muscle fiber change (any muscle fiber change) and duration of symptoms. Probability values < 0.05 were considered significant.

Results

Muscle fiber alterations were found in all 20 of the patients in our study (that is, the muscle could not be classified as normal in any of the cases). Furthermore, there were no typical alterations that would be diagnostic for myopathic or myositic tissue syndrome. Altogether 12 patients had muscle fiber alterations characteristic of a neurogenic tissue syndrome (Table 1). Two of these 12 cases were borderline (Cases 3 and 18), but they were classified as neurogenic on the basis of the

<table>
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<th>Case No.</th>
<th>% Regen Fibers</th>
<th>% Degen Fibers</th>
<th>% Elong Fibers</th>
<th>% PNCs</th>
<th>Hypertrophy†</th>
<th>Sx Dur in Mos</th>
<th>Musc Def‡</th>
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* The percentage values given for the fiber alterations and the nuclear conglomerates were calculated based on evaluation of 100 fibers per visual field and 10 visual fields per case. Abbreviations: Def = deficit; Degen = degenerating; Dur = duration; Elong = elongated; Musc = muscular; PNC = pyknotic nuclear clump; Regen = regenerating.
† The presence or absence of fiber hypertrophy is indicated by + or –, respectively.
‡ Muscular deficit was assessed on a scale of 1–5, where 1 indicates palsy and 5 no deficit.
presence of fiber hypertrophy (Case 3) and the presence of elongated fibers and the concomitant absence of regenerating and degenerating fibers (Case 18). Figures 1–4 demonstrate typical histological findings. If there were no typical alterations diagnostic for either a myopathic or myositic syndrome, the cases were classified as nonspecific myopathological syndrome (Table 2).

All patients presented with sensory disturbances in the area of the affected nerve root, but the motor deficit was more pronounced in the patients with shorter duration of symptoms and nonspecific myopathological syndrome (Tables 1 and 2).

The mean (± SD) duration of radicular symptoms in the 12 cases categorized as neurogenic tissue syndrome was 10.75 ± 7.9 months. In cases categorized as nonspecific myopathological syndrome the mean duration of radicular symptoms was 4.37 ± 3.9 months. The difference between the 2 groups was statistically significant (p = 0.047, Student t-test for unpaired samples).

The correlation analysis using the Pearson correlation test showed a positive correlation (r = 0.457) between nonspecific myopathological or neurogenic tissue syndrome and the duration of symptoms (p = 0.043) (Fig. 5). No correlation between any single fiber alteration and duration of symptoms was found. There was no statistically significant difference between the 2 groups with respect to motor deficits (p = 0.134).

Discussion

In patients with a herniated lumbar disc, we found myopathological alterations at the level of the multifidus muscle innervated by the compressed nerve. A qualitative change of these alterations from a nonspecific myopathological syndrome to a neurogenic syndrome over time was demonstrated as shown by the positive correlation.

Previous histological investigations by Zhu et al., Zhao et al., and Yoshihara et al. showed mostly atrophied Type 2 fiber as single alterations. Zhu et al. emphasized a more pronounced Type 2 fiber atrophy with a longer duration of symptoms. The age-dependency of the structure of the rectus spinae muscle was investigated by Mannion et al. using muscle biopsies in patients with low-back pain. The authors also investigated the relation-
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TABLE 2: Data summary for nonspecific myopathological syndrome

<table>
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<tr>
<th>Case No.</th>
<th>% Regen Fibers</th>
<th>% Degen Fibers</th>
<th>% Elong Fibers</th>
<th>% PNCs</th>
<th>Hypertrophy</th>
<th>Sx Dur in Mos</th>
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<td>mean</td>
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ship between duration of symptoms and changes within the rectus spinae muscle. Multivariate analysis revealed a lower number of Type 1 fibers and a higher percentage of Type 2 fibers with longer duration of low-back pain. In the present study, we performed a histopathological analysis and classified the more complex myopathological changes into well-known tissue syndromes. Thus, it is shown that there is a qualitative change of muscle alteration toward a neurogenic tissue syndrome over time but not only for single findings. Although we found no clear cutoff point when the change to a neurogenic tissue syndrome occurs (Fig. 5), in our study it was found only in patients who had experienced radicular symptoms for at least 4 months. This might be seen as minimal time limit for the occurrence of a neurogenic tissue syndrome.

It is obvious from Tables 1 and 2 that in our study motor deficits were more pronounced within the patients with a nonspecific myopathological syndrome, although this difference did not reach statistical significance (probably due to the low number of cases studied). The more pronounced motor deficits in this group might have led to an earlier necessity for surgical intervention, which would prevent those patients from reaching the 4-month threshold for the occurrence of a neurogenic tissue syndrome.

In terms of clinical consequences of earlier surgical decompression, our data support the slightly favorable results reported for early surgery in patients with persisting radicular symptoms. As it is still very difficult to determine the optimal timing for a surgical intervention, our data might add some valuable points for decision-making, although others have addressed the importance of multifidus changes in case of low-back pain and sciatica. Barker et al. demonstrated a reduced CSA of the multifidus with longer duration of low-back pain by means of MR imaging. Hides et al. found segmental muscular atrophies on sonographic examination but did not find a correlation between severity of the symptoms and the amount of atrophy. Rantanen et al. showed that the persistence of intraoperative pathological findings of the multifidus muscle 5 years after surgery correlated with poor outcome. Interestingly, LeHuec et al. found worse results after the implantation of lumbar total disc replacement in patients with > 50% fatty degeneration of the multifidus muscle as determined by MR imaging. In light of our results, it would be very interesting to know whether these MR imaging findings correlate with histopathological changes. Kjaer et al. found a relationship between low-back pain and the fat content of the multifidus muscle in adults but did not draw any conclusion about whether the pain or the fatty degeneration occurred first. In an ultrasound study, Hides et al. demonstrated a reduced CSA of the multifidus muscle in patients suffering from acute low-back pain who were treated with pain medication for 10 weeks. Those treated with additional physiotherapy did not have those prolonged reduction in CSA.

There might be a possibility of treating these changes through selective physiotherapy measures that should be investigated in further studies. These measures should address balancing capabilities of the lumbar spine to activate the multifidus as a unisegmentally acting muscle.

Our histopathological data from the present study suggest a relatively low regeneration ability of multifidus muscle fibers in patients with lumbar disc herniation and radicular symptoms. According to Schultz and Snow, satellite cells do need time after activation to be able to start the process of regeneration. The relatively low number of regenerating muscle fibers found in our study might be seen as an impaired regeneration capability of the affected muscle, but it could also be due to a pain-related reflexive disturbance of the muscle function, which...
is well known in the muscle atrophy occurring after knee injuries and surgeries. Further studies should be directed toward the assessment of the function of satellite cells in the regeneration of muscle fibers. The impaired capacity for regeneration, which we found especially in the neurogenic tissue syndrome, could be a possible reason for muscular disability with persisting symptoms after a herniated disc surgery. Overall these preliminary findings of general segmental muscle changes concurrent with radicular compression warrant further prospective investigation—including MR imaging, ultrasound, and histological studies—to better delineate the mechanism, sequelae, and treatment options in patients with lumbar disc herniation and radicular symptoms.

Conclusions

We conclude that myopathological changes do occur in the multifidus muscle in cases of symptomatic lumbar disc herniation. These changes can be divided into a neurogenic tissue syndrome and a nonspecific myopathological syndrome, as none of our patients showed a normal muscle fiber pattern or a myopathic or myositic syndrome. The reasons for this shift of the myopathological pattern of the muscle cannot be derived from the results of our investigation.

In summary, our data suggest that for patients with a longer duration of radicular symptoms, surgical decompression should be considered in order to avoid neurogenic tissue syndrome with its possible sequelae for the long-term function of the unsegmental multifidus muscle.

Disclaimer

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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