The correlation between magnetic resonance imaging and the operative and clinical findings after lumbar microdiscectomy

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Abstract. Fifty-four consecutive patients were studied prospectively with magnetic resonance imaging before microdiscectomy, and the findings correlated with clinical symptoms before and after operation. A sequestered fragment was found in 59% of cases, a subligamentous disc sequestration in 25% and a disc protrusion in 16%. The levels operated on were L4/5 – 36%, L5/S1 – 62.5%, and one at L3/4; 71% were laterally placed, 10% lay intraforaminal and 10% medial. The diameter of the protrusion was 4 mm to 13 mm for the craniocaudal extension, and 5 mm to 18 mm for the anteroposterior extension. No correlation could be found between a neurological deficit and the size of the prolapse. A positive correlation was present between the increasing degree of canal obstruction and the degree of disc degeneration determined by imaging for extrusions, subligamentous disc sequestrations and free sequestrations. Nerve root inflammation and enlargement was seen in 36% of the images, corresponding to an operative finding of 32%. Magnetic resonance imaging is a helpful preoperative diagnostic investigation which shows structural changes in the disc and the correct localisation and size of the disc sequestration, but there was no correlation between the imaging findings and the clinical symptoms.

Résumé. Dans une étude prospective 54 patients d'un âge moyen de 41 ans ont été examinés avant une microdiscectomie au moyen d'un protocole IRM standardisé. Les résultats de l'IRM ont été mis en corrélation avec les symptômes cliniques avant et après chirurgie et les constatations opératoires. 59% des patients avaient un fragment libre, 25% un séquestre sous-ligamentaire du disque et 16% une

protrusion du disque au niveau L4/5 (36%) ou L5/S1 (62%) et aussi une au niveau L3/4. 71% de celles ci étaient situées médiolatralement, 10% latéralement ou intraforaminal et 10% seulement avaient une localisation médiale. Les diamètres de la protrusion discale variaient de 4 à 13 mm pour l'extension craniocaudale et de 5 à 18 mm pour l'extension antéro-postérieure. Aucune corrélation entre un déficit neurologique et la taille du prolapse discal ont été trouvée. Une corrélation existe entre le degré d'augmentation de l'obstruction du canal et le degré de la dégénération du disque déterminé à l'aide du l'IRM pour les extrusions, les séquestres sous-ligamentaires et les séquestres libres. L'inflammation et l'agrandissement de la racine du nerf se montraient dans 36% des IRM correspondant à 32% intra-opératoires. Le IRM est une technique diagnostique importante préopérative pour permettre la localisation correcte, et pour une prévision de la grandeur de la séquestration discaire. Il n'existe pas de corrélation entre le IRM et les symptômes cliniques.

Introduction

Good clinical results after microdiscectomy vary from 60% to 90% [12] which is comparable to chemonucleolysis [14, 21, 23], but better than percutaneous discectomy or laser ablation [6, 7, 18]. The main reason for poor results after discectomy is associated with lateral recess stenosis or central stenosis, which account for 65% to 71% of the failures [5].

Since the introduction of magnetic resonance imaging (MRT), the diagnosis of disc degeneration and disc protrusion has been significantly improved compared to when using computerised tomography (CT) [1, 2, 10]. The better discrimination between disc tissue and the spinal cord, the superior determination of the ex-

tent of the protrusion and the water content of the disc on sagittal and axial images makes MRI a valuable investigation. CT myelography is still preferable for spinal stenosis. MRI studies in selected volunteers have shown an incidence of 36% of disc protrusion and extrusion in those without symptoms [3]. It therefore is important to define the correlation between preoperative MRI and the operative findings, as well as the possible prediction of neurological deficits, or clinical symptoms, from the size and site of the protruded fragment. Sometimes patients with persistent pain are operated on because of abnormal images, even though the clinical findings are not conclusive. No study has so far proved a close correlation between the size or site of the disc sequestration and clinical symptoms.

The purpose of this study was to correlate preoperative MRI with the findings before and after operation, and to determine MRI predictors for the indications and outcome.

Material and method

Patients

Fifty-four patients were evaluated prospectively by MRI before undergoing microdiscectomy. Their mean age at operation was 41 years (range 19 to 72 years), and 60% were men. Only patients without obvious bony degeneration were included. Thirty-four per cent were more than 10% overweight, but 89% of those were only 20%, or less, than normal; 55% smoked at the time of operation. Most patients (62%) were office workers, 34% did moderately heavy work and 4% were labourers.

The preoperative clinical examination, MRI scans and the operation records were available, and in 91% a follow up examination was carried out to correlate the MRI findings with the outcome.

Methods

Every patient was investigated before operation using a standard clinical and neurological protocol. A 0.5 Tesla Philips Gyroscan MR imager with 4 different echo sequences, ranging from spin echo sequences to gradient echo sequences, was used (Table 1).

The MR images were evaluated independently by 2 radiologists who knew nothing about the clinical features and one orthopaedic surgeon. After review, the grading for each disc was evaluated and the one chosen by 2 of the reviewers was accepted. The evaluation was made with regard to site, configuration and the size of the sequestration. The degree of degeneration of the 5 lumbar discs were graded with regard to their signal intensity and the differentiation between the nucleus and the annulus.

Table 1. The repetition, echo delay times, and swip angles for the four sequences used

	Spin echo	Sequence		Gradient echo sequence
	T1 weighted images	Proton weighted images	T2 weighted images	
TR	450 ms	1800 ms	1800 ms	500 ms
TE	30 ms	30 ms	90 ms	27 ms
Swip angle	—	—	—	20°

TR=repetition time, TE=echo delay

Results

Before operation, the patients had sciatic pain for an average of 12 months (range 1 to 72 months). The straight leg raising test was positive at less than 60° in 91%, of whom 21% also had a contralateral positive straight leg raising test. Segmental specific motor and sensory loss without signs of nerve root tension was present in 9%. Sensory differences were found in 54%, as well as decreased reflexes, which were more frequently seen at the S1 level. A motor deficit was present in 27% of the patients (Fig. 1).

Review of the operation records showed a free sequestered disc fragment in 59%, a subligamentous disc sequestration in 20% and a disc protrusion in 16%; in every patient, the nucleus material had perforated the posterior annulus and was still in contact with the disc. Of 54 patients, the most frequently involved segment was L5/S1 – 62.5%, while 36% of the operations were performed at L4/L5 and only one at L3/4.

Histology

The disc fragment or protrusion showed calcification in more than 90% of cases, with regressive degenerative changes and necrosis, and chondrocytes arranged in clusters. In most cases, specimens of the nucleus and annulus, as well as cartilage from the endplates, were obtained at operation (Fig. 2).

MRI findings

The images showed a disc protrusion which correlated with the level of clinical symptoms, with one exception; a neurinoma, which had not been previously diagnosed, was found at operation in this patient, because the MRI was not performed with intravenous gadolinium.

The size and site of the protrusion was identified in the axial plane. In 71% the protrusion was mediolateral;

Fig. 1. Distribution of the motor, reflex and sensory deficit at the two lower lumbar segments. There was a significant higher reflex and sensory deficit at the L5/S1 level ($P < 0.05$)

Fig. 2. Histological composition of the disc material obtained at operation

Fig. 3. Correlation between the decrease in disc height with disc sequestration or bulging. There is a significant correlation between degree of disc degeneration and decrease in disc height ($P<0.05$)

it lay lateral or intraforaminal in 19% and was medial in 10%. The site of the sequester on MRI and the motor or sensory deficit did not correlate in the chi-square test. The configuration of the protrusion was investigated. In 72% the diameter was greater in the sagittal than vertical plane, with a range of 4 mm to 13 mm for the craniocaudal and 5 mm to 18 mm for the anteroposterior extension. When small protrusions were compared with large, there was no significant correlation with the neurological deficit. The average extension into the canal decreased significantly from a free sequester to a disc protrusion to a subligamentous sequestration to a protrusion ($P<0.05$). There was no significant correlation when the disc lesion was compared with the neurological deficit or clinical symptoms. When the site of the free sequestered fragments was analysed, 36% were displaced in a caudal direction and 18% in a cranial direction, 5% having disc material above and below the disc. When the degree of displacement was correlated with the clinical symptoms, 82% of the displaced disc fragments showed at least 3 abnormal histological findings, while these were significantly less frequent (63%) in undisplaced discs.

Inflammation and enlargement of the involved nerve root was seen in 36% of the MRIs, which correlated with the operative finding in 32%. The sensitivity of MRI was 100% and the specificity 94%.

The degree of degeneration of the 5 lower lumbar discs with respect to disc height was evaluated on MRI: 70% of the discs operated on showed decreased height compared to 46% with bulging discs, and 7% had neither sequestration or bulging. The correlation of disc height decrease with disc degeneration on MRI was highly significant ($P<0.01$) (Fig. 3).

Fig. 4. Second echo of T2-weighted images for sequestered, protruded and intact discs. There is a significant positive correlation between the loss of signal intensity and degree of degeneration ($P<0.05$)

When sequestered, protruded and intact discs were analysed with respect to their signal intensity, the second echo of the T2-weighted image showed the highest correlation between structural disc damage and loss of signal intensity. Sequestered discs generally showed a low signal intensity, while bulging discs showed a distribution from no signal to intermediate and to high, with a peak for low signal intensity. In contrast, so-called intact discs were generally signal intense, but they also showed a distribution over the whole range (Fig. 4).

The neurological deficit, straight leg raising and reflexes were evaluated at follow-up in 49 patients and compared with the MRI findings obtained before operation. There was no significant correlation with the clinical symptoms and the MRI findings. MRI had no predictive value with respect to outcome and neurological signs.

Discussion

The demographic data of our patients treated by micro-discectomy with respect to age, sex and distribution of level were similar to other studies [8, 11, 12, 19]. MRI may be helpful in evaluating lumbar root pain and it has been reported that in older patients the incidence of free sequestration increases and protrusion decreases [4, 24]. This agrees with our MRI findings, where the discs show less signal decrease in the protruded segments compared with the free sequestrations.

The correct determination of the involved level and side of the prolapse is important, and in most of our patients (62%) the L5/S1 level was involved, which confirms the findings of others [8, 15, 26]. Biomechanical studies have shown that this is the level which is most heavily loaded, and that the forces acting at the junction of the mobile spine to the immobile sacrum are higher than in the other lumbar segments [17]. Comparison of the operative findings and the MRI localisation of the site and distribution of the disc protrusions showed that there is a highly significant correlation especially with nerve root inflammation and swelling.

MRI showed that the spinal canal is narrowed by an average of 20% in protrusions and 40% in sequestered discs. There was significant correlation between narrowing and the type of disc lesion, but the size did not cor-

relate with the type of lesion. No correlation was found between either the site or the size of the protrusion.

Decrease in height of the intervertebral disc has been regarded as an indication of degeneration. A decrease in disc height has been found to correlate with a decrease in signal intensity [13, 16, 27]. This was confirmed in our study where the height of the disc was reduced in 70% in those undergoing operation, whereas discs with normal signal intensity had only a 7% decrease in height. This also correlates well with the histological findings where we found that increasing disc degeneration occurred with increasing age, leading to sequestration. The best MRI sequence demonstrating this was found to be the second echo of the T2-weighted image, which showed a higher correlation between signal intensity and histological changes in the disc. The low signal intensity on MRI most likely correlates with a decrease of disc height as a sign of degeneration [11, 19, 22]. While in our study only an indirect correlation could be observed, Terri et al. compared MRI and histology [20].

The histological study of the disc tissue confirms what has also been shown by other authors. Yasuma reported in a histological study of sequestered disc material that annulus and cartilage end plate were found as well as nucleus tissue [24]. A disc prolapse is not something which happens as a single event where the nucleus pulposus is pressed out by a high pressure. The process is an ongoing degeneration of the disc which then may extrude some material. Mostly nucleus pulposus and annulus fibrosus has been found in the second and third decades, while in the fourth mainly annular material was present. In the older patients end plate cartilage was seen more frequently [9].

MRI is able to demonstrate accurately the structural changes in the disc, the size and the site of the sequestrum or protrusion. However, these images are not useful in predicting neurological deficit, and therefore should not be used as indication for surgery unless there is strong correlation with the clinical findings. Clinical follow-up demonstrated no significant correlation with the MRI images.

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