Service Evaluation: Evaluating the use of MRI Measurements as better prognostic indicators than BMI

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Ethical Approval Not Required

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Abstract:

Aims:

To find better prognostic factors for degenerative disc disease (DDD) and herniated nucleus pulposus (HNP) than body mass index (BMI), that are easily measurable on magnetic resonance Imaging (MRI).

Methods:

Data for patient reported outcome measures (PROMS) and subcutaneous fat thickness (SCFT) were already available. The size of disc prolapse (SODP), the epidural fat area (EFa) and the Pfirrmann Grade were measured on MRIs. The 5 factors were then compared for correlation with a two-tailed Pearson's test.

Results:

SCFT does not significantly correlate with EFa, SODP or PG. The PROMS do not significantly correlate with EFa, SCFT, SODP or PG.

Conclusion:

SCFT has no apparent association with EFa, SODP, or PG. Additionally the SCFT, EFa, SODP and PG show little promise as prognostic indicators, but further work should be done with a more experienced data collector.

Introduction:

In a normal intervertebral disc (ID), there is a constant cycle of synthesis of substances such as proteoglycans, type II collagen and non-collagenous proteins, produced by chondrocyte like cells to make up the matrix of the nucleus pulposus (NP). These constituents are then degraded cyclically as various cytokines are secreted by macrophages (that enter the ID in response to injury) which inhibit the production of the aforementioned constituents, whilst simultaneously they promote the production of matrix metalloproteinases – the effectors of matrix degradation. DDD can occur when abnormal constituents are synthesised, or when the balance between synthesis and degradation is abnormal (1). Lumbar DDD is known to be a cause of lower back pain (2, 3) and it also has an association with herniation of the NP through the annulus fibrosus (AF) (4). HNP is where degeneration of the ID leads to the more fluid NP (5) protruding through the AF, often impinging nerve roots (6). The prevalence of DDD has been shown to be greater than 90% in both men and women over 50 years (3), meaning that measurable factors which may indicate patient outcomes on diagnosis are needed.

MRI is used as one of the first line investigations in the UK for the treatment of suspected discogenic low back pain and it allows the visualisation of both DDD and HNP(7).

Several measurements can be taken from a spinal MRI - a number of which have shown to be relevant to pathology and patient outcomes. It has been shown for example that reduced epidural fat (EF) can lead to an increased duration of symptoms in spinal stenosis (8). Another measurement seemingly of note is sub-cutaneous fat thickness (SCFT), as it has been previously highlighted that this is increased in patients with DDD (9). Also, the size of disc prolapse (SODP) can be measured via an MRI, and somewhat counterintuitively, it has been previously shown that the SODP does not

indicate whether conservative treatment will be successful (10). The Pfirrmann Grade (PG) is a radiological criterion used to assess the severity of DDD and this too can be taken from an MRI (11).

Aims and Objectives:

The aim of this project was to look at some of the aforementioned measurements in a retrospective cohort and investigate whether they affected patient outcomes. Also, as a high BMI has previously been implicated in both HNP and DDD (12, 13), another aim was to see if other more specific variables such as SCFT and EF were associated, and if there needed to be future studies of these measurements (amongst others) as prognosticators for disease progress. There were seven key questions I was looking to answer:

1) Does SCFT correlate with the SODP?

2) Does SCFT correlate with patient reported outcome measures (PROMS)?

3) Does the SODP correlate with the PROMS?

4) Does SCFT correlate with PG?

5) Does EFa correlate with the PROMS?

6) Does PG correlate with PROMS?

7) Does SCFT correlate with EFa?

Methods:

Initially I carried out a short review of the literature using Medline to ascertain if there were any standards of measurement and also, to give myself better background knowledge on the subject matter. I excluded articles that measured SCFT anywhere other than adjacent to the spinal canal, for example, measurements of abdominal SCFT.

The purpose of this study was to understand if any measurements were potentially better prognostic factors than BMI which is often used in current practice as a prognostic factor. In view of this, the study did not require ethical approval as it was a service evaluation rather than research. The need for ethical approval is also diminished as this study anonymises all participants and is a pure radiological study.

165 patients with T2 weighted spinal MRIs showing either HNP or DDD were initially included, however after taking initial measurements, 22 patients were excluded as a)The given ID number showed no patient records (n=13), b)the image quality was too poor to take accurate measurements (n=1), c)the patients ID number had no associated MRI of the spine (n=7) or d)the patient had herniations at multiple spinal levels (n=1). Data was received that had previously been collected, including PROMS and SCFT. The PROMS included were a combined Neck Disability Index/Oswestry Disability Index (NDI/ODI), the Patient Health Questionairre-9 (PHQ-9 = Measurement of depression severity), the Generalised Anxiety Disorder Assessment 7 (GAD-7), the Visual Analogue Scale for back/neck pain (VAS-B/N) and EQ5D VAS (a measurement of the patient's perspective of their health). The EQ5D VAS was missing for a large proportion of the data so this study focuses on the other four PROMS, so as not to exclude a large proportion of the data set.

The MRIs were then measured by a third-year medical student to find SODP (mm^2), EFa (mm^2) and PG. The SCFT and PROMS were already provided. The SCFT had been measured centrally (in line with the spinous process on axial MRI), and from the right and left edges of the ID giving a total of three measurements. The SCFT had been measured at L3/L4, L4/L5 and L5/S1. At each level the mean of the central, left, and right measurements was taken and this represents SCFT in the data. The measurements were taken using a freehand measurement tool from the software used for radiological viewing by the health board in which the study was carried out - Synapse. The DDD was rated between 1 and 5 according to the Pfirrmann grading criteria (11). After completing the measurements IBM SPSS Statistics 27 was used to determine correlation between variables, using a two-tailed Pearson test, with statistical significance being accepted at 0.05 and strong significance being 0.01.

Results:

After exclusions, the SODP for patients in the data set who had suffered a HNP (n=86), was compared with the SCFT as discussed in the method. There was no significant correlation between the SODP and the SCFT. At L3/4 the Pearson correlation (r) for SCFT with SODP was -0.019 (significance (s) = 0.865), at L4/5 r=0.019 (s=0.863) and at L5/1 r=0.005 (s=0.961).

		Size of disc prolapse	l5/1 average	l4/5 average	L3/4 average
Size of disc prolapse	Pearson Correlation	1	.005	.019	-.019
	Sig. (2-tailed)		.961	.863	.865
	N	86	86	86	86
l5/1 average	Pearson Correlation	.005	1	.977**	.957**
	Sig. (2-tailed)	.961		<.001	<.001
	N	86	86	86	86
l4/5 average	Pearson Correlation	.019	.977**	1	.972**
	Sig. (2-tailed)	.863	<.001		<.001
	N	86	86	86	86
L3/4 average	Pearson Correlation	-.019	.957**	.972**	1
	Sig. (2-tailed)	.865	<.001	<.001	
	N	86	86	86	86

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 1: Results showing no correlation between SCFT and SODP. (L5/1 average = Mean SCFT at level L5/S1; L4/5 average = Mean SCFT at level L4/L5; L3/4 average = Mean SCFT at level L3/L4)

SCFT also showed no significant correlation with the PROMS. Looking at SCFT at L3/L4 r= 0.109 (s=0.323) for NDI/ODI, r=0.113 (s=0.304) for PHQ-9, r=0.164 (s=0.134) for VAS and r=0.105 (s=0.339) for GAD-7. Moving on to SCFT at L4/L5 r=0.076 (s=0.489) for NDI/ODI, r=0.088 (s=0.482) for PHQ-9, r=0.153 (s=0.163) for VAS and r=0.071 (s=0.519) for GAD-7. Finally, for SCFT at L5/S1 r=0.102 (s=0.355) for NDI/ODI, r=0.130 (s=0.234) for PHQ-9, r=0.176 (s=0.107) for VAS and r=0.102 (s=0.354) for GAD-7.

		PHQ-9	NDI / ODI	GAD-7	VAS Neck/Back	L3/4 average	I4/5 average	I5/1 average
PHQ-9	Pearson Correlation	1	.679**	.867**	.437**	.113	.088	.130
	Sig. (2-tailed)		<.001	<.001	<.001	.304	.422	.234
	N	85	85	85	85	85	85	85
NDI / ODI	Pearson Correlation	.679**	1	.629**	.610**	.109	.076	.102
	Sig. (2-tailed)	<.001		<.001	<.001	.323	.489	.355
	N	85	85	85	85	85	85	85
GAD-7	Pearson Correlation	.867**	.629**	1	.450**	.105	.071	.102
	Sig. (2-tailed)	<.001	<.001		<.001	.339	.519	.354
	N	85	85	85	85	85	85	85
VAS Neck/Back	Pearson Correlation	.437**	.610**	.450**	1	.164	.153	.176
	Sig. (2-tailed)	<.001	<.001	<.001		.134	.163	.107
	N	85	85	85	85	85	85	85
L3/4 average	Pearson Correlation	.113	.109	.105	.164	1	.971**	.956**
	Sig. (2-tailed)	.304	.323	.339	.134		<.001	<.001
	N	85	85	85	85	85	85	85
I4/5 average	Pearson Correlation	.088	.076	.071	.153	.971**	1	.977**
	Sig. (2-tailed)	.422	.489	.519	.163	<.001		<.001
	N	85	85	85	85	85	85	85
I5/1 average	Pearson Correlation	.130	.102	.102	.176	.956**	.977**	1
	Sig. (2-tailed)	.234	.355	.354	.107	<.001	<.001	
	N	85	85	85	85	85	85	85

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 2: Results showing that SCFT had no correlation with the PROMS. (L5/1 average = Mean SCFT at level L5/S1; L4/5 average = Mean SCFT at level L4/L5; L3/4 average = Mean SCFT at level L3/L4)

SODP showed a weak negative correlation with one of the PROMS, but this was not quite statistically significant. A lower score means better outcomes in ODI/NDI, PHQ-9, VAS-B/N and GAD-7, so a negative correlation would mean that with increasing SODP, outcomes were better. SODP showed no significant correlation with NDI/ODI, with r=0.091 (s=0.409). SODP also showed no significant correlation with VAS-B/N, as r=-0.001 (s=0.995). SODP showed no significant correlation with GAD-7 with r=-0.183 (s=0.094). SODP was weakly negatively correlated with PHQ-9 as r=-0.215 but was not quite statistically significant with s=0.054.

		Size of disc prolapse	PHQ-9	NDI / ODI	GAD-7	VAS Neck/Back
Size of disc prolapse	Pearson Correlation	1	-.210	-.091	-.183	-.001
	Sig. (2-tailed)		.054	.409	.094	.995
	N	85	85	85	85	85
PHQ-9	Pearson Correlation	-.210	1	.679**	.867**	.437**
	Sig. (2-tailed)	.054		<.001	<.001	<.001
	N	85	85	85	85	85
NDI / ODI	Pearson Correlation	-.091	.679**	1	.629**	.610**
	Sig. (2-tailed)	.409	<.001		<.001	<.001
	N	85	85	85	85	85
GAD-7	Pearson Correlation	-.183	.867**	.629**	1	.450**
	Sig. (2-tailed)	.094	<.001	<.001		<.001
	N	85	85	85	85	85
VAS Neck/Back	Pearson Correlation	-.001	.437**	.610**	.450**	1
	Sig. (2-tailed)	.995	<.001	<.001	<.001	
	N	85	85	85	85	85

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 3: Results showing SODP has some weak negative correlation with the PROMS

There was no significant correlation between SCFT and PG. For PG with L3/L4 SCFT, r=0.073 (s=0.388), for PG with L4/L5 SCFT, r=0.101 (s=0.230) and for PG with L5/S1 SCFT, r=0.087 (s=0.305).

		Pfirmann Grade at worst level (Where relevant)	L3/4 mean	L4/5 mean	L5/1 mean
Pfirmann Grade at worst level (Where relevant)	Pearson Correlation	1	.073	.101	.087
	Sig. (2-tailed)		.388	.230	.305
	N	142	142	142	142
L3/4 mean	Pearson Correlation	.073	1	.974**	.954**
	Sig. (2-tailed)	.388		<.001	<.001
	N	142	142	142	142
L4/5 mean	Pearson Correlation	.101	.974**	1	.975**
	Sig. (2-tailed)	.230	<.001		<.001
	N	142	142	142	142
L5/1 mean	Pearson Correlation	.087	.954**	.975**	1
	Sig. (2-tailed)	.305	<.001	<.001	
	N	142	142	142	142

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 4: Results showing no significant correlation between PG and SCFT. (L5/1 mean = Mean SCFT at level L5/S1; L4/5 mean = Mean SCFT at level L4/L5; L3/4 mean = Mean SCFT at level L3/L4)

EFa also showed no significant correlation with the PROMS. For EFa with NDI/ODI r=0.180 (s=0.098), for EFa with GAD-7 r=0.015 (s=0.0.872), for EFa with VAS-B/N r=0.128 (s=0.167) and for EFa with PHQ-9, r=0.085 (s=0.365).

		Epidural fat area (mm^2)	NDI / ODI	PHQ-9	GAD-7	VAS Neck /Back
Epidural fat area (mm^2)	Pearson Correlation	1	.180	.085	.015	.128
	Sig. (2-tailed)		.053	.365	.872	.167
	N	118	116	115	114	118
NDI / ODI	Pearson Correlation	.180	1	.615**	.487**	.511**
	Sig. (2-tailed)	.053		<.001	<.001	<.001
	N	116	116	114	113	116
PHQ-9	Pearson Correlation	.085	.615**	1	.822**	.422**
	Sig. (2-tailed)	.365	<.001		<.001	<.001
	N	115	114	115	114	115
GAD-7	Pearson Correlation	.015	.487**	.822**	1	.412**
	Sig. (2-tailed)	.872	<.001	<.001		<.001
	N	114	113	114	114	114
VAS Neck /Back	Pearson Correlation	.128	.511**	.422**	.412**	1
	Sig. (2-tailed)	.167	<.001	<.001	<.001	
	N	118	116	115	114	118

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 5: Results showing no statistically significant correlation between EFa and the PROMS.

Interestingly, PG also showed no significant correlation with the PROMS. For PG with NDI/ODI, r=-0.035 (s=0.707), for PG with GAD-7 r=-0.05 (s=0.552), for PG with VAS-B/N r=-0.143 (s=0.124) and for PG with PHQ-9 r=-0.02 (s=-0.836).

Finally, SCFT also showed no significant correlation with EFa. For EFa with L3/L4 SCFT r=0.082 (s=0.372), for EFa with L4/L5 SCFT r=0.074 (s=0.422) and for EFa with L5/S1 SCFT r=0.045 (s=0.626).

Discussion:

It has been shown in other studies that the PROMS do show worse outcomes in DDD patients with a high BMI (14) and this may suggest that BMI is in fact a better prognostic indicator than SCFT for outcomes regarding DDD, given that the results here show no significant correlation. However, a high BMI has been shown previously to not effect the PROMS for HNP patients (15). This may suggest that whilst excess body weight plays a role in DDD outcomes, neither excess weight nor excess fat is implicated in the outcomes of HNP patients.

Not many studies are available regarding the correlation of the PROMS and the EFa and the same applies for correlation between SCFT and the SODP. Based on these results EFa is not an indicator of outcomes in neither DDD nor HNP patients and SCFT has no bearing on the SODP. To say either point with any certainty however, more studies would need to be carried out looking into these areas in order to corroborate the findings.

The only correlation found that was even close to being statistically significant was a weak negative correlation between the SODP and the GAD-7 score. The reason for this is unclear, as it suggests that as the size of disc prolapse increases, the anxiety experienced by patients decreases. One possible explanation could be linked to the fact that anxiety has previously been shown to increase a person's pain sensitivity (16). It may be that patients who are generally more anxious are more likely to feel more pain from limited disease and present to healthcare services, skewing the GAD-7 correlation, so that smaller disc prolapses are more commonly observed in more anxious patients. I think this may be a brash assumption however, as there is not enough evidence to suggest that smaller disc prolapses are any less painful than large disc prolapses.

Interestingly, the PG was also shown to have no statistically significant correlation with the PROMS. Given that this is an established radiological grading method, a significant correlation might be expected, however it has been noted previously that the PG does not have an impact on the PROMS (17).

EFa has previously been shown not to correlate with waist circumference and BMI (18), so the result here, showing that EFa also has no significant correlation with SCFT reinforces the idea that neither excess fat nor excess body weight has an impact on the total EFa.

It has previously been found that dorsal SCFT has no impact on DDD (19) and the results here demonstrate the same result through use of the PG. These results have reinforced a previous negative finding, strengthening the evidence of this point.

Conclusions and Limitations:

The results previously mentioned suggest that EFa, SCFT, SODP and PG do not hold great promise as indicators of outcomes for patients with either DDD or HNP. Additionally, SCFT does not show any significant correlation with EFa, SODP or PG.

The validity of this study however may be affected by the following limitations:

- All measurements were carried out by a third-year medical experience with no previous experience of making measurements on an MRI. This is likely to affect the validity of this study.
- The PROMS and SCFT data were previously collected by another team for use in another study. Therefore, the validity of this data cannot be commented on.
- All measurements were taken by a freehand drawing tool so the reproducibility is likely to be affected.

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