

# BMJ Open Quality Unintended consequences: quantifying the benefits, iatrogenic harms and downstream cascade costs of musculoskeletal MRI in UK primary care

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## ABSTRACT

**Objectives** The largest proportion of general practitioner (GP) magnetic resonance imaging (MRI) is musculoskeletal (MSK), with consistent annual growth. With limited supporting evidence and potential harms from early imaging overuse, we evaluated practice to improve pathways and patient safety.

**Methods** Cohort evaluation of routinely collected diagnostic and general practice data across a UK metropolitan primary care population. We reviewed patient characteristics, results and healthcare utilisation.

**Results** Of 306 MSK-MRIs requested by 107 clinicians across 29 practices, only 4.9% (95% CI  $\pm 2.4\%$ ) appeared clearly indicated and only 16.0% (95% CI  $\pm 4.1\%$ ) received appropriate prior therapy. 37.0% (95% CI  $\pm 5.5\%$ ) documented patient imaging request. Most had chronic symptoms and half had psychosocial flags. Mental health was addressed in only 11.8% (95% CI  $\pm 6.3\%$ ) of chronic sufferers with psychiatric illness, suggesting a solely pathoanatomical approach to MSK care. Only 7.8% (95% CI  $\pm 3.0\%$ ) of all patients were appropriately managed without additional referral. 1.3% (95% CI  $\pm 1.3\%$ ) of scans revealed diagnoses leading to change in treatment (therapeutic yield). Most imaged patients received pathoanatomical explanations to their symptoms, often based on expected age or activity-related changes. Only 16.7% (95% CI  $\pm 4.2\%$ ) of results appeared correctly interpreted by GPs, with spurious overperception of surgical targets in 65.4% (95% CI  $\pm 5.3\%$ ) who suffered ‘low-value’ (ineffective, harmful or wasteful) post-MRI referral cascades due to misdiagnosis and overdiagnosis. Typically, 20%–30% of GP specialist referrals convert to a procedure, whereas MRI-triggered referrals showed near-zero conversion rate. Imaged patients experienced considerable delay to appropriate care. Cascade costs exceeded direct-MRI costs and GP-MSK-MRI potentially more than doubles expenditure compared with physiotherapist-led assessment services, for little-to-no added therapeutic yield, unjustifiable by cost–consequence or cost–utility analysis.

**Conclusion** Unfettered GP-MSK-MRI use has reached unacceptable indication creep and disutility. Considerable avoidable harm occurs through ubiquitous misinterpretation and salient low-value referral cascades for two-thirds of imaged patients, for almost no change in treatment. Any marginally earlier procedural intervention

for a tiny fraction of patients is eclipsed by negative consequences for the vast majority. Only 1–2 patients need to be scanned for one to suffer mismanagement. Direct-access imaging is neither clinically, nor cost-effective and deimplementation could be considered in this setting. GP-MSK-MRI fuels unnecessary healthcare utilisation, generating nocebic patient beliefs and expectations, whilst appropriate care is delayed and a high burden of psychosocial barriers to recovery appear neglected.

## INTRODUCTION

General practitioner (GP) direct access musculoskeletal (MSK) magnetic resonance imaging (MRI) is widespread, under well-intentioned aspirations for earlier disease detection, efficient patient journeys and reduction of referrals by enabling greater GP management. One in 10 patients with back pain presenting to primary care receives advanced imaging.<sup>1</sup> Despite consistent imaging growth, there is a paucity of supporting evidence in this setting.

Imaging interpretation is nuanced as incidental age or activity-related findings are highly prevalent in asymptomatic joints (table 1). There are calls to shift away from a purely pathoanatomical model, towards a biopsychosocial approach to care, reducing ‘low-value’ (ineffective, harmful or wasteful) overuse and overdiagnosis.<sup>2,3</sup>

## Concerns around GP-MSK-MRI

Early MSK-MRI is linked to greater disability and prolonged recovery,<sup>4,5</sup> with non-guideline imaging associated with transition to chronic back pain.<sup>6</sup> Findings can negatively affect patient perceptions, with lower confidence in conservative management, fear that exercise may worsen the condition, loss of control, over-reliance on surgery as well as poorer functional outcomes.<sup>7–12</sup> Cognitions influence distress, disability and quality-of-life.<sup>13</sup> The term ‘Victims of

**Table 1** Expected age or activity related epidemiological findings in musculoskeletal MRI

Body part	Prevalence
Neck	Up to 87% of asymptomatic individuals may have bulging discs, <sup>107</sup> with 58% of younger, asymptomatic athletes showing cervical disc degeneration. <sup>108</sup>
Shoulder	60% of asymptomatic older adults show subacromial bursitis on MRI and around half have rotator cuff tears, <sup>109 110</sup> whilst up to 72% of middle-aged individuals have asymptomatic superior labral tears. <sup>111</sup> In younger, asymptomatic athletes, 65% can have rotator cuff tears and 88% rotator cuff tendinosis. <sup>112</sup> 52% of pre-teen athletes demonstrate asymptomatic activity-related 'abnormal' shoulder MRIs. <sup>113</sup> With the exception of large rotator cuff tears, systematic review suggests little-to-no correlation between shoulder imaging findings and shoulder symptoms. <sup>28 114</sup>
Low back	At age 60, 88% of asymptomatic adults will have disc degeneration, 70% will show disc bulges, 50% will show facet degeneration and 23% spondylolisthesis. <sup>115</sup> Lumbar stenosis is seen in upto 20% of those under the age of 40. <sup>116</sup> Moderate or severe spinal stenosis is seen in up to 64% of those in their 50s and 93% in those in their 80s. The majority are asymptomatic, as only 17.5% of those with severe central stenosis may have symptoms. <sup>117</sup> In younger, asymptomatic adolescent sports players, up to 85% may show MRI changes including disc bulges, facet arthropathy as well as pars lesions. <sup>118</sup> Even 22% of asymptomatic children can show disc degeneration on MRI. <sup>119</sup>
Hip	Labral tears are seen in up to 69% of asymptomatic adults, <sup>120</sup> or even 89% of asymptomatic athletes <sup>121</sup> and labral cysts in 50% of dancers. <sup>122</sup> Acetabular dysplasia is seen in around 15% of asymptomatic people, with bilaterality in up to 39.5% of cases. <sup>123 124</sup> Cartilage defects may be seen in 12% of asymptomatic individuals. <sup>125</sup>
Knee	The majority of people with meniscal tears have no recent symptoms. <sup>126</sup> Meniscal tears are seen in around a third of middle-aged asymptomatic individuals, where 97% of knees will show incidental 'abnormalities', including bucket-handle tears. <sup>127</sup> Above the age of 40, MRI shows osteoarthritis features in up to 43% of asymptomatic individuals <sup>128</sup>
Ankle and Foot	Tibial stress fractures have been seen in 41% of asymptomatic runners. <sup>129</sup> In ankle MRI of asymptomatic amateur marathon runners, up to 80% may show tendon changes, 48% ligament injuries and 27% achilles tendinopathy. <sup>130</sup> Up to 37% of people may have incidental 'abnormal' anterior talofibular ligaments. <sup>131 132</sup> Achilles tendon changes may be seen in up to 63% of asymptomatic individuals, and retrocalcaneal bursal changes in 68% of runners. <sup>133</sup> Morton Neuroma's is present in 26%–33% of asymptomatic individuals. <sup>134 135</sup>

Modern Imaging Technologies' describes harmfully disease-labelling patients as a result of increased imaging access,<sup>14</sup> while incidental findings also place pressure on GPs.<sup>15</sup> A high proportion of GP-MSK-MRI may be inappropriate,<sup>16</sup> and disseminated scanning is an implicated driver behind 'low-value' arthroscopies.<sup>17</sup> Expanding use of specialist tests down to primary care, dubbed 'diagnostic downshift', often has unintended clinical and economic impacts.<sup>18</sup>

Imaging consequences include unnecessary surgical referrals. There has been a shift away from conventional surgical approaches in favour of conservative therapy for many common conditions. Shoulder decompression,<sup>19 20</sup> rotator cuff repair,<sup>21</sup> shoulder labral repair,<sup>22</sup> osteochondroplasty for femoroacetabular impingement<sup>23</sup> and knee meniscectomy<sup>24</sup> are just some examples. Strict procedural criteria are enforced in some regions, while some high-volume spinal injections have been decommissioned.<sup>25</sup> Non-specialists may be unfamiliar with such trends and even GPs with 'special interest' have been shown to hold antiquated beliefs, most resistant to current evidence.<sup>26</sup>

Radiology reporting has significant inter-observer variability,<sup>27</sup> for example agreement between radiologists and

specialists is as low as 44% in shoulder MRI.<sup>28</sup> GPs cannot review images to clinically correlate findings, limited to written reports. Furthermore, GPs express low confidence in MSK conditions,<sup>29</sup> raising doubt over specialist diagnostic interpretation.

Lower disease prevalence in primary care results in lower yields from diagnostic strategies and guidelines have increasingly called for more selective imaging.<sup>30 31</sup> Additionally, investment in readily accessible and evidenced community MSK 'interface' triage services,<sup>32–35</sup> recommended in national MSK transformation strategy,<sup>36</sup> calls into question the need for continued GP-MSK-MRI access.

### Utility of GP-MSK-MRI

One randomised controlled trial of knee MRI access almost two decades ago showed only modest improvement in GP confidence, with no change in diagnosis or treatment.<sup>37</sup> Cost-effectiveness was shown based on marginal, clinically non-significant improvements.<sup>38 39</sup> A recent multicentre randomised controlled trial demonstrated no difference in quality-of-life from GP knee-MRI, with no reduction in orthopaedic referrals, while lacking cost-effectiveness.<sup>40</sup>

Both studies relied on self-report for utilisation. Meta-analysis suggests little-to-no outcome benefit from GP MSK imaging.<sup>41</sup> Despite concerns around imaging overuse and iatrogenic downstream consequences,<sup>42–44</sup> we found no studies quantifying recent UK GP-MSK-MRI benefits or harms to inform commissioning decisions.<sup>45</sup>

## AIMS & OBJECTIVES

This evaluation aimed to assess the utility of MSK-MRI in primary care, quantifying the appropriateness of use, interpretation and both therapeutic and harmful cascades, to inform local pathway development and improve patient safety as part of a sector-wide quality improvement initiative.

## METHODS

### Participants and design

Diagnostic suppliers provided activity data for January to December 2017 across three UK National Health Service (NHS) clinical commissioning groups (CCGs) in a metropolitan centre. Primary care records from invited practices were reviewed by clinical staff in this observational cohort evaluation of routinely collected data (retrospective study of prospectively collected data). A random number generator was used to select cases to avoid sampling bias. MRI request, results and least 12 months of follow-up records were required for inclusion.

### Procedures and measures

Diagnostic ‘value’ goes beyond accuracy or direct-costs and evaluation frameworks cover accessibility, interpretation, as well as diagnostic and therapeutic yield (change in diagnosis and treatment based on results).<sup>46 47</sup> Therefore, patient characteristics were captured from records, along with timeframes, results, details of follow-up discussion, subsequent management or referral activity and outcomes from specialist referrals, including ‘conversion rate’ (patients receiving a specialist intervention). Conversion rate is a limited, yet accessible commonly adopted proxy measure for ‘low-value’ surgical or procedural MSK referrals, also highlighting therapeutic yield. Joint injections available in primary care were not considered specialist intervention.

### Analysis

Assessing ‘appropriateness’ of requesting and interpretation is subjective.<sup>45 48</sup> Guidelines vary, often lacking detail, or setting-of-care. Data were reviewed by two clinicians. Reviewer one was a local GP, accredited in pain medicine, sector-wide commissioning policy chair for evidence appraisal and the local MSK and diagnostics clinical lead, managing pathway development. Reviewer two was a consultant extended-scope physiotherapist and clinical director of the local community MSK-interface service. Evaluators categorised imaging indication as ‘likely’, ‘unclear’ or ‘unlikely’. Results were similarly classified as to whether they contained clinically relevant or incidental

findings and whether GPs interpreted findings correctly, based on records and subsequent management. Categorisation was based on evaluators’ expert opinion.

GP referral choices reflect their clinical impression. ‘Procedural’ referrals were classified as those sent directly for orthopaedic or spinal neurosurgical opinions, as well as to services for consideration of spinal injections. The local recommended pathway, to the physiotherapist-led community MSK-interface service, comprises triage and early patient access to physiotherapy, podiatry, rheumatology, orthopaedic and pain specialist expertise, with onward referral for surgical or secondary care input, where necessary. This interface service can also triage referrals following MRI findings, to direct appropriate patients to secondary care without additional consultation, based on results. Whilst there may be many reasons for a more specialist opinion, since such input is available within the community interface pathway, post-MRI GP referrals bypassing this recommended triage reflect setting an expectation of a structural target for which an interventional procedure may be likely. Such specialist opinions following MRI also carry a cost implication.

Cost–consequence and cost–utility analysis was performed based on recorded healthcare utilisation, which was recorded temporally as pre-MRI, peri-MRI (organised at the same clinical encounter as the MRI request) or post-MRI.

Descriptive and inferential statistics were computed in Microsoft Excel with Analysis ToolPak, using ‘Wald method’ two-tailed 95% CIs for proportion point estimates.  $\chi^2$  analysis was used to compare the audited sample against wider distribution of scans, while linear regression was used to compare practice imaging rate against appropriateness of imaging and interpretation. For both, p values were considered significant at the alpha level <0.05. Inter-rater reliability of all initial judgements by both evaluators was demonstrated both by weighted kappa measurement and percent agreement.<sup>49</sup>

### Patient and public involvement

As part of local quality improvement in MSK pathway design, patient ‘champions’ and representatives from patient charity groups were interviewed. Patients echoed confusion over mixed messaging around their imaging results. The negative impact of clinician language was raised. Patients wanted more consistency than experienced, prompting this evaluation.

## RESULTS

### Patient and scan characteristics

During 2017, 6,621 MSK-MRIs were performed for a primary care population of approximately 670,000. The mean annual rate was 9.9 (range 0.2–31.8) GP-MSK-MRIs per-1,000 registered patients. Greater than 100-fold variation in requesting-rate reflects unwarranted variation in care.

Twelve cases were excluded due to incomplete records. A total of 306 MRI referrals (144 males and 162 females) were reviewed, requested by 105 different GPs and two

**Table 2** Body part scans

	Scans within sample of GP-MSK-MRIs (342 body part scans for 306 referred patients)	Scans within all GP-MSK-MRIs (6,621 MRI referrals)
Cervical spine	11% (n=38)	16.1% (n=1,071)
Thoracic spine	4% (n=12)	5.7% (n=377)
Lumbar spine (inc. sacrum and sacroiliac joint)	28% (n=97)	40% (n=2,664)
Shoulder	4% (n=15)	7.3% (n=484)
Elbow	<1% (n=1)	<1% (n=48)
Wrist/hand/fingers	<1% (n=1)	1.9% (n=127)
Hip	6% (n=20) (4 × cases requested bilateral imaging)	6% (n=397)
Knee	40% (n=139) (4 × cases requested bilateral imaging)	35% (n=2,345)
Ankle/foot	4% (n=14) (2 × cases requests for bilateral imaging)	8.78% (n=581)
Other (sternum, sternoclavicular, brachial plexus, thoracic inlet, axillae, clavicle, scapula, upper arm, forearm, coccyx, groin, thigh, lower leg)	1% (n=5)	1.3% (n=84)

$\chi^2$  analysis of body parts in the sample against the distribution in all scans, revealed  $\chi^2=9.54$ ,  $df=9$  with  $p=0.388$ , that is, no significant difference, suggesting a sample representative of all MRIs.

GP, General practitioner (GP); MSK, musculoskeletal.

practice nurses across 29 practices, providing a 95% CI sampling error  $\leq 5.6\%$ . Practices covered a range of deprivation scores, from decile 2 to 9, including small (523) to large (19,533) list sizes, training and non-training practices, as well as high and low referrers. Median patient age was 53 (range 13–90, IQR 24 years). One-third of cases represented symptoms greater than 1 year, with remaining cases evenly distributed between acute (less than 7 days), 7–28 days, 29–84 days, 85–126 days and 127–365 days. Patient MRI request was documented in 37.0% (95% CI  $\pm 5.5\%$ ,  $n=113$ ), including recommendations from private physiotherapists, social contacts or other specialties, such as emergency departments. Median wait-time from request to scan was 12 days (range 1–99 days). GPs prescribed sedation for 1.3% (95% CI  $\pm 1.3\%$ ,  $n=4$ ) and referred for open MRI in 0.3% (95% CI  $\pm 0.6\%$ ,  $n=1$ ). 23.9% (95% CI  $\pm 4.8\%$ ,  $n=73$ ) had prior imaging. 19.0% (95% CI  $\pm 4.4\%$ ,  $n=58$ ) had prior radiographs (most with degenerative changes), 2.3% (95% CI  $\pm 1.7\%$ ,  $n=7$ ) had prior MRI and 1.6% (95% CI  $\pm 1.4\%$ ,  $n=5$ ) had prior ultrasound. Conservative therapy (such as physical therapy or exercise) was documented in only 16.0% (95% CI  $\pm 4.1\%$ ,  $n=49$ ) prior to MRI. Body parts scanned are shown in [table 2](#).

Growing demand has been met by increased supply, with routine scanning within 2 weeks. There is, however, fragmentation among a multiprovider landscape. Preappointment imaging was often not available at specialist consultation when carried out by alternate providers.

Direct imaging costs for the 306 patients came to £38,746.00, based on 2017/2018 NHS national tariff (local variation can exist).<sup>50</sup> This comprised 186 single area scans, 110 two or three part scans and 10 scans including more than three body parts.

[Table 3](#) demonstrates prognostic flags for chronic pain.<sup>51</sup> 51.0% (95% CI  $\pm 5.6\%$ ,  $n=156$ ) had at least one psychosocial risk factor (orange, yellow, blue and black flags). During the study period, support, either from GP, mental health or third sector, was documented in only 11.8% (95% CI  $\pm 6.3\%$ ,  $n=12$ ) of the 101 chronic cases (symptoms >84 days) with orange flags (not including continuing ongoing medication).

### MRI Ordering, Findings and Cascades

70.3% (95% CI  $\pm 5.1\%$ ,  $n=215$ ) of MRI requests directly copied GP records, varying in detail, often limited for robust vetting. Six requests were amended by radiology providers (two sacroiliac scans rejected and additional body parts added to four requests).

[Table 4](#) shows indicated requests, incidental and relevant findings, as well as interpretation, along with initial inter-rater agreement. Only 16.3% (95% CI  $\pm 6.2\%$ ,  $n=22$ ) of 135 knee cases were traumatic, mostly low-energy twists or falls whilst walking. 63.0% (95% CI  $\pm 8.1\%$ ,  $n=85$ ) of knee patients were above age 50, with predominantly degenerative conditions.

Only 5.9% (95% CI  $\pm 2.6\%$ ,  $n=18$ ) of MRI results were unremarkable. 87.3% (95% CI  $\pm 3.7\%$ ,  $n=267$ ) likely contained incidental findings. 8.2% (95% CI  $\pm 3.1\%$ ,

**Table 3** Presence of ‘flags’ for musculoskeletal pain

Flag	Flag description	Cases where present and common themes
Red Flags	Signs of serious pathology, for example, fracture, malignancy	4.2% (95% CI $\pm$ 2.3%, n=13) History of cancer, trauma, suspicious radiograph changes and urinary disturbance
Orange Flags	Psychiatric symptoms such as depression or personality disorder	42.5% (95% CI $\pm$ 5.5%, n=130) Predominantly affective disorders of anxiety and depression, but also psychosis and substance dependence
Yellow Flags	Beliefs, emotional responses, pain behaviours, for example, catastrophising, avoidance behaviours, interest in passive treatments only, etc.	22.9% (95% CI $\pm$ 4.7%, n=70) Fear avoidance (refusing physiotherapy without diagnosis) and negative structural beliefs about their condition
Blue Flags	Perceptions between occupational work and health, for example, that work or employers will cause further difficulty	18.0% (95% CI $\pm$ 4.3%, n=55) Predominantly disputes with employers with majority medically signed off work long-term
Black Flags	Systemic obstacles, such as legal issues	8.0% (95% CI $\pm$ 3.0%, n=23) Legal proceedings relating to assaults, road traffic accidents, marriage, disability or housing

n=25) had findings thought likely relevant to symptoms, with 42.9% (95% CI  $\pm$ 5.5%, n=131) of unclear relevance to symptoms.

7.5% (95% CI  $\pm$ 3.0%, n=23) never consulted for the issue again, likely reflecting self-resolution. Results were discussed with the same requesting clinician in only 47.1% (95% CI  $\pm$ 5.6%, n=144) of cases.

GPs appeared to correctly interpret MRI changes, with appropriate advice and management in only 16.7% (95% CI  $\pm$ 4.2%, n=51) of cases. MRI interpretation was unclear in 7.2% (95% CI  $\pm$ 2.9%, n=22) and grossly erroneous in 68.6% (95% CI  $\pm$ 5.2%, n=210), reflected by the high level

of post-MRI procedural specialist referrals highlighted in yellow in table 5.

9.8% (95% CI  $\pm$ 3.3%, n=30) of patients had no associated referrals. 7.8% (95% CI  $\pm$ 3.0%, n=24) were safely, autonomously managed by the GP (without misdiagnosis, nor referral to other services).

66.7% (95% CI  $\pm$ 5.3%, n=204) of patients had 229 post-MRI referrals for suspected structural targets. These were to ‘tier 2’ MSK clinics and secondary care orthopaedic, neurosurgery, neurology (mis-referred for injection for radiculopathies) and pain clinics for spinal procedures. There were no referrals to pain services for

**Table 4** MRI indication, results and interpretation of findings

		Likely	Unclear	Unlikely	Inter-rater agreement of initial independent assessments
Scan indicated		4.9% (95% CI $\pm$ 2.4%, n=15)	9.8% (95% CI $\pm$ 3.3%, n=30)	85.0% (95% CI $\pm$ 4.0%, n=261)	Weighted kappa 0.23 (95% CI $\pm$ 0.12), 78.6% (95% CI $\pm$ 5.3%) observed agreement
Incidental findings present	5.9% (95% CI $\pm$ 2.6%, n=18) unremarkable findings	87.3% (95% CI $\pm$ 3.7%, n=267)	3.3% (95% CI $\pm$ 2.0%, n=10)	3.6% (95% CI $\pm$ 2.1%, n=11)	Weighted kappa 0.70 (95% CI $\pm$ 0.11), 90.7% (95% CI $\pm$ 4.0%) observed agreement
Clinically relevant findings present		8.2% (95% CI $\pm$ 3.1%, n=25)	42.9% (95% CI $\pm$ 5.5%, n=131)	43.1% (95% CI $\pm$ 5.5%, n=132)	Weighted kappa 0.23 (95% CI $\pm$ 0.08), 44.2% (95% CI $\pm$ 5.6%) observed agreement
Findings interpreted correctly by GP	7.5% (95% CI $\pm$ 3.0%, n=23) not discussed again	16.7% (95% CI $\pm$ 4.2%, n=51)	7.2% (95% CI $\pm$ 2.9%, n=22)	68.6% (95% CI $\pm$ 5.2%, n=210)	Weighted kappa 0.84 (95% CI $\pm$ 0.06), 90.2% (95% CI $\pm$ 4.0%) observed agreement

GP, general practitioner.

**Table 5** Associated referral activity for imaged patients

	Pre-MRI referrals	Peri-MRI referrals	Post-MRI referrals	First to follow-up ratio	First attendance unit cost	Follow-up unit cost	Episode of care cost	Total (costs)	Costs (post-MRI referrals only)
Community MSK interface (tier 1 physiotherapy):	31	35	52	1:3			£100.00	118 x £100.00 = £11,800.00	52 x £100.00 = £5,200.00
Community MSK interface (tier 2 'surgical or procedural'):	7	11	131	1:2			£125.00	149 x £125.00 = £18,625.00	131 x £125.00 = £16,375.00
Community MSK interface (tier 2 rheumatology):	0	1	2	1:3			£150.00	3 x £150.00 = £450.00	2 x £150.00 = £300.00
Secondary care referrals generated by MSK-interface Service:	0	0	7 x orthopaedic 2 x neurosurgery	1:1.8 1:1.6	£153.00 £198.00	£60.00 £73.00	£261.00 £314.80	(7 x £261.00) + (2 x £314.80) = £2,456.60	(7 x £261.00) + (2 x £314.80) = £2,456.60
Secondary care (orthopaedics):	0	0	59	1:1.8	£153.00	£60.00	£261.00	59 x £261.00 = £15,399.00	59 x £261.00 = £15,399.00
Secondary care (neurosurgery):	2	0	30	1:1.6	£198.00	£73.00	£314.80	32 x £314.80 = £10,072.00	30 x £314.80 = £9,444.00
Secondary care (pain clinic):	0	1	3	1:2	£202.00	£72.00	£346.00	4 x £346.00 = £1,348.00	3 x £346.00 = £1,038.00
Secondary care (neurology):	0	0	6	1:1.6	£193.00	£97.00	£348.20	6 x £348.20 = £2,089.20	6 x £348.20 = £2,089.20
Secondary care (rheumatology):	1	0	7	1:3.9	£265.00	£89.00	£612.10	8 x £612.10 = £4,896.80	7 x £612.10 = £4,284.70
Secondary care (other):	1 x urology 1 x gastroenterology	0	1 x endocrinology 1 x general surgery	1:2					
<b>Total:</b>	<b>41</b>	<b>48</b>	<b>299</b>					<b>£67,137.20</b>	<b>£56,586.50</b>
<b>Reasons for post-MRI GP 'procedural' referrals</b>	<b>A wide range of findings underpinned post-MRI procedural opinion referrals. Common themes included: possible nerve root impingement from disc changes, stenosis due to arthropathy, or wedging of vertebrae in spinal imaging; meniscal tears, possible loose bodies, ganglion cysts or changes in anterior or medial collateral ligaments in knee imaging; gluteal medial tendonopathy in hip imaging; and subacromial bursitis or rotator cuff tears in shoulder imaging.</b>								

Post-MRI 'procedural' GP referrals for surgical or specialist injection opinions highlighted in yellow.

**Table 5 ASSUMPTIONS:**

1. First to follow-up ratios based on national 2017 hospital attendance data.<sup>136</sup>
2. Unit costs based on 2017 NHS national tariff costs.<sup>49</sup> Secondary care costs are under-estimated as local market-forces-factor variation above national tariff was not included.
3. MSK first to follow-up ratios and episode of care costs, imaging and referral rates based on consensus of published evidence,<sup>32</sup> national tariff, published business cases<sup>137, 138</sup> and local contract data (North West London CCGs 2018).
4. Community MSK-interface service tier 2 'surgical or procedural' referrals included those to extended scope physiotherapist orthopaedics as well as pain services for consideration of spinal injections.
5. Secondary care neurology was a frequent spurious GP referral pathway for suspected radiculopathic symptoms.
6. Non-MSK referrals not included in analysis totals.

MSK, musculoskeletal.

the documented purpose of a pain management or rehabilitation programme. Imaging can further fragment MSK care as 60.1% (95% CI  $\pm 5.5\%$ ,  $n=184$ ) had multiple pre-MRI, peri-MRI or post-MRI referrals for the same condition. Many underwent GP-MSK-MRI while under concurrent care of other services. There was little-to-no documentation of patient-demand for post-MRI specialist referrals, nor of any shared decision-making.

Three ‘false-positives’ for serious disease (two cauda equina syndrome (CES)) and one osteomyelitis) in clinically unsuspecting cases, resulted in cascades of emergency referrals, further investigation, and patient distress. All were ultimately dismissed as clinically irrelevant. In low-prevalence settings, even highly specific tests result in high false-positive rates.

Therapeutic yield (change in treatment based on results) was 1.3% (95% CI  $\pm 1.3\%$ ,  $n=4$ ). One patient received total knee replacement (which does not require MRI), with documented lack of benefit. One underwent cervical decompression for presumed radiculopathy, received no benefit, subsequently underwent cubital tunnel decompression, with no benefit, ultimately diagnosed with medically unexplained symptoms. Suprascapular nerve block for neck pain was offered but declined by one patient. One patient, diagnosed with knee osteoarthritis, which again does not require MRI, insisted on meniscectomy for a tear, rather than the arthroplasty recommended.

65.4% (95% CI  $\pm 5.3\%$ ,  $n=200$ ) of imaged patients erroneously referred post-MRI directly for procedural opinions were not offered a specialist intervention; all ultimately advised to manage conditions conservatively. Their needs should have been met via the established community MSK-interface triage pathway, with tier 1 physiotherapy appropriate first-line management for the majority.

Of the 244 patients referred to physiotherapist-led services, 64.8% (95% CI  $\pm 6.0\%$ ,  $n=158$ ) were only referred after MRI results, a median delay of 32 days. 10.8% (95% CI  $\pm 3.5\%$ ,  $n=33$ ) of imaged patients were referred only to procedural secondary care pathways, waiting many months longer, only to be told they should receive physiotherapy.

Linear regression showed little correlation between practice imaging-rate and the rate of likely or unclear indicated requests ( $r=0.10$ ,  $r^2=0.01$ ,  $p=0.62$ ), nor the rate of post-MRI ‘low-value’ cascades ( $r=0.24$ ,  $r^2=0.06$ ,  $p=0.20$ ). Low imaging-rate practices had similar (in)appropriate requesting and cascades to high imaging-rate practices.

### Cost-effectiveness

A cost-consequence analysis is shown in [table 6](#), comparing GP direct access to MSK-MRI and secondary care referrals, versus the recommended community MSK-interface pathway for triage and management.

Patient satisfaction from imaging and potentially earlier referral of four surgical candidates from GP-MSK-MRI unlikely warrants the variation in care, fragmentation,

significant misdiagnosis, as well as doubling of costs compared with a pathway where MRI responsibility is shifted further along the clinical journey, to the MSK-interface service (see [table 6](#)). GP-MRI direct costs were £38,746.00, while generating greater cascade costs of £53,135.20.

Additional therapeutic benefit for the GP-MSK-MRI pathway was only potentially demonstrated in one case of arthroscopic meniscectomy, for which quality-of-life-years (QALY) gain is 0.04 QALYs over a 9-year time horizon.<sup>52</sup> With a £69,332.90 cost difference between diagnostic strategies, the cost-utility incremental cost-effectiveness ratio is £1,733,322.50 (£69,332.90/0.04) per QALY for the GP-MSK-MRI diagnostic strategy, astronomically greater than UK willingness-to-pay thresholds of £20,000–30,000 per QALY.<sup>53</sup>

### DISCUSSION MRI ordering

Only 4.9% (95% CI  $\pm 2.4\%$ ,  $n=15$ ) of MRIs appeared indicated. Patient demand, rather than clinical need, often influenced requesting. Causal structure-pain relationships are ambiguous, yet individuals often seek exact structural diagnoses.<sup>54 55</sup> These do not change management for the overwhelming majority of primary care presentations, based around education and goal-focused therapy. However, only 16.0% (95% CI  $\pm 4.1\%$ ,  $n=49$ ) received conservative therapy prior to imaging.

While concern around sinister pathology may motivate imaging, no malignancy was identified in this, although limited, sample. UK guidelines<sup>56</sup> do not advocate GP-MSK-MRI for MSK malignancy, with alternate pathways for suspicious presentations. Furthermore, systematic review does not show faster time-to-cancer-diagnosis, nor improved outcomes, from GP advanced diagnostics.<sup>57</sup> Additionally, suspected CES requires same-day evaluation, not outpatient imaging. Of note, ‘red-flags’ lack validity and specificity in primary care, for example 80% of back pain patients may have at least one,<sup>58</sup> while 64% of those with malignancy may have none.<sup>59</sup>

GPs almost always documented CES screening in low back pain (despite being unlikely to ever see a true CES),<sup>60</sup> while rarely addressing highly prognostic psychosocial flags.<sup>51 61–77</sup> Most presentations were chronic, in itself not necessarily indication for imaging. The high burden of psychosocial distress seen reflects the bi-directional relationship between chronic pain and mental health.<sup>78</sup> Support for such potential recovery barriers was documented in only 11.8% (95% CI  $\pm 6.3\%$ ,  $n=12$ ) of those with chronic pain and psychiatric illness. Poor clinician recognition of pain psychosocial factors is echoed in other studies.<sup>54 79 80</sup> Imaging overuse suggests practice wedded to the pathoanatomical approach alone, which may shift focus to irrelevant structural findings, distracting clinicians and patients from unmet psychosocial needs.

Spinal imaging was often requested for referred pain or minimal sensory symptoms, without suspicious features.

**Table 6** Cost–consequence analysis

	<b>Current pathway: gp direct-access to MSK-MRI +/- referral to community or secondary care MSK services</b>	<b>Alternate (recommended) pathway: all patients assessed in community MSK-interface triage service</b>
Direct imaging costs	306 MRI referrals (£38,746.00) (see <a href="#">table 2</a> )	10 MRI referrals (£11,600.00)
MRI follow-up appointment with GP	293 GP appointments (£8,790.00)	N/A
Community MSK-Interface referrals (tier 1)	118 referrals (£11,800.00)	245 referrals (£24,500.00)
Community MSK-Interface (tier 2 extended scope physiotherapists, orthopaedic, pain & rheumatology specialists)	149 x tier 2 (£18,625.00) 3 x tier 2 rheumatology (£450.00) = £19,075.00	61 referrals (£7,625.00)
Secondary care referrals	109 secondary care referrals (see <a href="#">table 5</a> ) = £33,805.00	9 x orthopaedic (£2,349.00) 3 x pain (£1,038.00) 2 x neurosurgery (£629.60) 1 x rheumatology (£612.10) = £4,628.70
MSK-service-generated secondary care referrals	9 MSK-generated referrals (£2 456.60)	(see row above)
Surgical procedures	1 x total knee replacement (£5,328.00) 1 x cervical decompression (£7,332.00) 1 x arthroscopic partial meniscectomy (£3,014.00) = £15,674.00	1 x total knee replacement (£5,328.00) 1 x cervical decompression (£7,332.00) = £12,660.00
<b>Total pathway cost</b>	<b>£130,346.60</b>	<b>£61,013.70</b>
	<b>Cost difference of £69,332.90 between pathways</b>	

**Table 6 ASSUMPTIONS:**

- Unit and episode costs explained in [table 5](#), based on 2017/2018 NHS National Tariff. GP costs based on NHS England report.<sup>139</sup>
  - Assumes all 306 patients are referred into community MSK-interface service. Estimates suggest 80% of patients are seen in tier 1 physiotherapy, 20% in tier 2 service, 5% referred on to secondary care and 3% have MRI organised, based on published data,<sup>140</sup> and local service contract data (North West London CCGs 2018).
  - Assumes no GP-access to MSK-MRI and that current 'bypassing' GP secondary care referrals would all be directed into the MSK service, as per local recommended pathway.
  - Procedure costs estimated from NHS national 2017/2018 reference costs.<sup>141</sup>
  - Since 90% of imaged patients were at some point seen in the community MSK-interface service, similar surgical outcomes can be assumed for both groups. However, a patient with osteoarthritic atraumatic knee pain, not willing for knee replacement, is unlikely to be referred for partial meniscectomy from the MSK service. Meniscectomy in osteoarthritis is not recommended by numerous guidelines, no better than physical therapy,<sup>142</sup> nor sham-surgery<sup>24</sup> and linked to earlier subsequent knee replacement.<sup>143</sup> Within the community MSK-interface service, MRI or surgical referral would have been unlikely, supported by local audit (Parkunan, Healthshare NHS Community MSK Services, 2018) showing no orthopaedic referrals for degenerative meniscal tears from the service.
- GP, general practitioner; MSK, musculoskeletal; N/A, not applicable.

Identifying radicular symptoms is nuanced due to overlapping innervation territories, myotomal or sclerotomal pain referral and examination differences between small and large nerve fibres. Many conditions mimic neuropathy and there was no documented use of validated diagnostic tools such as the Leeds Assessment of Neuropathic Symptoms and Signs (LANSS) or the Douleur Neuropathique 4 (DN4). For foot, ankle or shoulder MRIs, ultrasound would often have been more appropriate, if necessary. Similarly, if required, plain radiographs should have replaced most knee MRIs for atraumatic elderly presentations. Many scans occurred for degenerative conditions in late decades, where MRI has a limited role.

**Imaging interpretation, referrals and cascades**

Only 5.9% (95% CI  $\pm 2.6\%$ , n=18) of MRIs were unremarkable, reflecting ubiquitous (often incidental) findings. Incidental findings were also intra-abdominal, such as fibroids, haemangiomas and diverticular disease. With such high

prevalence of imaging changes, imaging for reassurance is therefore problematic, despite contrary clinician beliefs.<sup>54</sup> Furthermore, evidence shows tests contribute little towards reassurance.<sup>81 82</sup> While some GPs hold MSK expertise, only half of results were discussed with the requesting clinician familiar with the presentation.

Only 16.7% (95% CI  $\pm 4.2\%$ , n=51) of MRI reports appeared correctly interpreted. Most patients received pathoanatomical explanations, based on often incidental age-expected findings. Medicalising terminology reduces self-reported health,<sup>83</sup> increases anxiety, perceived severity and preference towards invasive management.<sup>84</sup> Structural disease-labelling can be nocebic, increasing fear-avoidance behaviours, perceptions that physical therapy is incompatible with recovery and over-reliance on surgical intervention.<sup>7-12</sup> This places pressure on specialists to subsequently re-frame engrained expectations away from a surgical fix. Negative patient cognitions,

which endure for years,<sup>85</sup> may influence MSK pain-related distress, disability and quality-of-life.<sup>13</sup>

GP referrals to surgical or pain interventional specialties have conversion-rates of 20%–30%,<sup>34 86–90</sup> whilst conversion is around 75% for referrals from MSK-interface services.<sup>32 35 91</sup> However, conversion to a procedure was only 1.9% (95% CI  $\pm 1.9\%$ , n=4) for such GP referrals following MRI. MRI-access is unlikely to reduce referrals due to such deterioration in decision-making. While GP-MRI may reduce some community MSK-interface referrals, such pathways are more likely to benefit patients,<sup>32</sup> as well as being more cost-effective.

90.2% (95% CI  $\pm 3.3\%$ , n=276) had one-or-more referrals to other services, equally capable of organising imaging, where appropriate, reflecting the additional input required beyond a test for persisting symptoms. GP-MSK-MRI does not appear to enable more autonomous management. Only 7.8% (95% CI  $\pm 3.0\%$ , n=24) were safely managed within primary care, without misdiagnosis, overdiagnosis or further referral.

GP-MSK-MRI potentially accelerated procedures for 1.3% (95% CI  $\pm 1.3\%$ , n=4) of imaged patients, of which only one improved, following a non-guideline intervention. However, erroneous over-perception of structural pathology resulted in delays, often of months, to appropriate care, with ‘low-value’ procedural referrals and potentially enduring negative perceptions for 65.4% (95% CI  $\pm 5.3\%$ , n=200) of imaged patients. With a mean 9.9 MRI-scans per 1,000 GP-registered patients, we can extrapolate adverse consequences for 6.5 per 1,000 registered, or >4,000 patients annually across the study population. If misdiagnosis, mis-referral and delay-to-care are considered patient harm, the number-needed-to-harm (NNH) is only 1.5 (1/0.654). NNH is traditionally rounded-down, placing NNH at one for GP-MSK-MRI. Considering the likelihood-to-be-helped-versus-harmed metric,<sup>92</sup> (likelihood-of-benefit divided by likelihood-of-harm), the likelihood of therapeutic yield versus mismanagement from GP-MSK-MRI is as low as 0.02 (1.3/65.4). This is a limited metric, aggregating all gains and losses, but gives an approximation of the direction of trade-offs.

While MRI spending is a low proportion of MSK system costs,<sup>93</sup> cascades alter the economic analysis. Cascade costs were significantly greater than direct-imaging costs. There was little-to-no added therapeutic yield and compared with physiotherapist-led assessment services, both cost-consequence and a crude cost-utility incremental cost-effectiveness ratio, do not justify GP-MSK-MRI funding. Cost-utility studies often neglect full costs, that is, all additional unindicated scans occurring for the small yield of patients who receive benefit, as well as unintended cascades.

### Changing behaviour

Guidelines alone have limited impact, as over one-third of scans were lumbar, against 2016 National Institute for Health and Care Excellence recommendations against routine use in primary care.<sup>30</sup> Pressure from patients,

other health professionals, defensive practice, risk-aversion, educational deficiencies and action-bias all drive ‘low-value’ testing. ‘Illusory-causation’ describes our propensity to perceive spurious causal relationships.<sup>94</sup> Widespread, often incidental, MRI findings create erroneous positive feedback to GPs, or ‘belief-reinforcement’, bolstering aberrant ordering behaviours. ‘Harms’ are not immediately tangible and without accurate real-time feedback, decision-making heuristics cannot be improved.

Benchmarking practice MRI-rates alone may be an inadequate quality-indicator as this lacked correlation to MRI appropriateness or interpretation. Education, incentives and behavioural ‘nudges’ within electronic ordering systems, may help, with limited impact.<sup>95–98</sup> While there is scope to improve radiology reporting,<sup>99</sup> benefit is mixed.<sup>12 100</sup> Educating on the low utility and potential harm of imaging, challenging beliefs and persuading that less-is-more, can be difficult, introducing back-fire and reactance effects.<sup>54 101–103</sup> This may be onerous within brief GP consultations, particularly when the majority expect imaging.<sup>104</sup>

Lack of access barriers or wait-time rationing can result in supply-induced demand. Per capita commissioned scanning capacity should be scrutinised, as supply-side volume controls can effectively contain inefficiencies.<sup>105</sup> Lack of clinical or cost-benefit, along with prevalent harm, invites consideration for GP-MSK-MRI deimplementation. Furthermore, the financial case underlying funding of MSK-interface services often includes assumptions around reduced imaging costs, unlikely to be realised with ongoing unfettered GP-MRI access.

### Strengths and limitations

Random selection, with only 12 cases excluded, from a 1-year sample, diverse range of practices, clinicians and patients likely reflects UK practice.

Primary care records robustly capture healthcare utilisation, across providers and sectors. Records may not reflect real-world symptoms, nor consequences in all domains such as physical, psychological, social, financial, treatment burden and dissatisfaction.<sup>106</sup> Without patient-orientated outcome measures, the cost–utility assessments are largely estimated. Other studies, however, did not demonstrate significant quality-of-life benefits.<sup>38–40</sup> The cost–consequence estimates also compared against average activity patterns seen in the MSK-interface service, rather than a matched comparator group.

While we could not capture exact consultation dialogue, there was documentation in the majority of cases to demonstrate inaccurate perception of surgical targets, reflected by the subsequent higher-cost, triage-bypassing, direct referrals for surgical or procedural opinions.

Different cascades may be seen in regions without readily accessible MSK-interface pathways, which may themselves induce demand. While there was no difference between the two radiology providers, it may be worth evaluating more providers for potential reporting variation.

Separate evaluators mitigated individual rating bias inherent in measures based on expert opinion, without strict dichotomous criteria. There was only 'fair' agreement regarding MRI indication ( $k=0.23$ , 95% CI  $\pm 0.12$ ) and clinical relevance of findings ( $k=0.23$ , 95% CI  $\pm 0.08$ ), reflecting the subjective nature of such judgements. There was substantial agreement ( $k=0.70$ , 95% CI  $\pm 0.11$ ) regarding incidental findings and almost perfect inter-rater agreement regarding result interpretation ( $k=0.84$ , 95% CI  $\pm 0.06$ ). In all initial disagreement, consensus was achieved following further individual case review, including documented specialist consultations. Despite subjectivity of some measures, the extreme outcomes are unlikely explained by evaluator bias alone.

We did not have a comparator group of non-imaged patients. However, we could contrast against conventional GP referral conversion rates, including those without MSK-MRI access. The high proportion of 'low-value' post-MRI referrals could be related to confounding characteristics of imaged patients. However, such a high rate of referral cascades with near-zero conversion, provides convincing signal on the disutility of post-MRI care in this setting, even without comparator analysis.

### Summary and policy implications

Structural pathology can change management, and imaging is useful in trauma, investigating rare sinister disease, or guiding specific procedures. Whilst judicious imaging with qualified interpretation no doubt occurs within primary care, this appears to be infrequent. Expanding MRI use outside of specialist settings is problematic, with significant imaging indication creep in primary care. Widespread 'biostatistically normal-for-age', or activity-related expected findings, along with a shift away from conventional surgical approaches, creates a salient problem of GPs overperceiving spurious surgical or procedural targets from imaging reports. MRI may appease biases underlying clinician autonomy and patient satisfaction, yet generates aggregate harm, through misdiagnosis and overdiagnosis. Imaging stewardship and improving the mixed messaging around results are priorities. Whilst a tiny fraction of patients may receive earlier surgery through GP-MSK-MRI, this is eclipsed by negative consequences for the vast majority. Less than two patients require MRI in primary care for one to suffer avoidable low-value cascades. As well as resource waste, this generates delay to appropriate care along with potentially nocebic patient perceptions impacting management and outcomes, which can endure for years. Such consequences raise overlooked safety and effectiveness concerns across currently commissioned imaging services. GP-MSK-MRI deimplementation may be appropriate, shifting scanning capacity to community-based MSK services in the UK. This will likely be more clinically and cost-effective, reducing iatrogenic harm and enabling primary care to focus on unmet psychosocial patient needs and delivering guideline care.

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