J. Phys. Ther. Sci. 32: 173–191, 2020

The Journal of Physical Therapy Science

Review Article

Does low back pain or leg pain in gluteus medius syndrome contribute to lumbar degenerative disease and hip osteoarthritis and vice versa? A literature review

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Abstract. [Purpose] Gluteus medius syndrome is one of the major causes of back pain or leg pain and is similar to greater trochanteric pain syndrome, which also presents with back pain or leg pain. Greater trochanteric pain syndrome is associated with lumbar degenerative disease and hip osteoarthritis. The objective of this review was to demonstrate gluteus medius syndrome as a disease entity by reviewing relevant articles to elucidate the condition. [Methods] Gluteus medius syndrome was defined as myofascial pain syndrome arising from the gluteus medius. We performed a search of the literature using the following keywords: "back pain", "leg pain", "greater trochanteric pain syndrome", "degenerative lumbar disease", "hip osteoarthritis", and "gluteus medius". We reviewed articles related to gluteus medius syndrome and described the findings in terms of diagnosis and treatment based on the underlying pathology. [Results] A total of 135 articles were included in this review. Gluteus medius syndrome is similar as a disease entity to greater trochanteric pain syndrome, which presents with symptoms of low back pain and leg pain. Gluteus medius syndrome is also related to lumbar degenerative disease, hip osteoarthritis, knee osteoarthritis, and failed back surgery syndrome. [Conclusion] Accurate diagnosis of gluteus medius syndrome and appropriate treatment could possibly improve lumbar degenerative disease and osteoarthritis of the hip and knee, as well as hip-spine syndrome and failed back surgery syndrome.

Key words: Gluteus medius syndrome, Low back pain, Greater trochanteric pain syndrome

(This article was submitted Sep. 19, 2019, and was accepted Nov. 7, 2019)

INTRODUCTION

Medical expenditures for the management of degenerative disease are increasing because of population aging around the world[1, 2)]. Degenerative disease and chronic pain have been well investigated to decrease the costs and social resources required for proper management of degenerative disease and its associated pain. However, the mechanism of pain in degenerative disease is often of unknown origin[3, 4)].

As causes of back pain, leg pain, or hip pain, lumbar disk herniation, lumbar spinal canal stenosis (LSCS), or hip osteoarthritis can be considered differential diagnoses. In daily clinical practice, the prevalence of these conditions is not so high[5–7)], and sometimes the source of the pain cannot be readily identified. Other causes of low back pain such as degenerative disk disease and degenerative facet joint disease are difficult to identify as sources of pain because the diagnosis is usually

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resource-intensive, with high cost and risk in terms of proper diagnosis and management. As a result of these factors, undiagnosed back pain or leg pain is widespread in daily clinical practice; consequently, there remains a great need for improvement in pain management systems.

The term "gluteus medius syndrome (GMedS)" appeared in several reports[8–11] as the gluteus medius (GMed) was identified as the muscle most commonly associated with low back pain or leg pain and the diagnosis of myofascial pain syndrome (MPS)[11, 12]. MPS is simply defined as pain accompanied by confirmation of pain trigger points in specific muscles[13, 14]. However, the causes of back pain are various, and diagnosis is difficult based on confirmation of trigger points only[5]. Low back pain is usually accompanied by lumbar disk or facet joint degeneration or several other conditions[5]. A diagnosis of MPS does not necessarily rule out other pathology and usually the presence of a various pathologies tends to complicate pain management[5]. Although the MPS complication rate is very high in pain management, the relationship between MPS and degenerative disease is still unknown. Various hypotheses regarding MPS have been proposed based on the muscle sliding theory, nerve compression theory, and the muscle energy theory[14–17]. Recently trigger point block injection under ultrasound guidance has allowed visualization of muscle sliding and has facilitated symptomatic relief[18] and this may confirm the role of muscle sliding in the improvement of symptoms, but this is yet to meet consensus.

The prevalence of MPS within the context of chronic back pain or non-specific back pain is about 70–90%[11, 19, 20], while the prevalence of myofascial trigger points (MTrPs) in GMed namely GMedS within the context of chronic low back pain or nonspecific low back pain is about 38–68%[11, 20, 21]. GMedS is treated by physiotherapy, manual trigger point therapy, or trigger point block injection[10, 11, 22], and in difficult cases by surgical decompression of the GMed or the cluneal nerve[10, 23].

Related conditions include the greater trochanteric pain syndrome (GTPS) or trochanteric bursitis, which are similar to GMedS. GTPS presents with pain around the hip and is often accompanied by low back pain or leg pain and could be associated with hip osteoarthritis or lumbar degenerative disease (LDD)[24–33]. The pathology may be caused by trochanteric bursitis or gluteal tendinopathy. LDD has been reported to be related to GTPS[34, 35], and GMedS is also accompanied by low back pain and some symptoms of LDD are possibly attributed to GMedS. Numerous reports have pointed out that hip osteoarthritis is related to GTPS or decreased GMed strength[36–40]. Thus, some symptoms of hip osteoarthritis can be possibly attributed to GMedS.

The objective of this review was to demonstrate GMedS as a disease entity, which is a major cause of low back pain or leg pain, and associated with LDD and hip osteoarthritis. Relevant articles were searched for and reviewed to clarify the diagnosis and treatment of GMedS.

METHODS

GMedS was defined as a form of MPS arising from the GMed often accompanied by low back pain, leg pain, or hip pain. A literature review was carried out in PubMed electronic databases for related English-language articles using the following keywords during the period of 1 to 31 May 2019.

1. "back pain" and "gluteus medius"
2. "leg pain" and "gluteus medius"
3. "greater trochanteric pain syndrome" and "gluteus medius"
4. "hip osteoarthritis" and "gluteus medius"
5. "lumbar degenerative disease" and "gluteus medius"
6. "lumbar degenerative disease" and "greater trochanteric pain syndrome"

Titles and abstracts were reviewed to identify articles related to GMedS. Articles related to GMedS were subjected to a full-text review and their reference lists were checked for other articles related to GMedS. Relevant articles from the reference lists were also screened and included as appropriate. Our search yield 135 articles, and the resulting literature were divided into 6 categories.

1. Relation between GTPS and GMedS.
2. Relation between back pain and GMed.
3. Relation between LDD and GMed.
4. Relation between hip osteoarthritis and GMed.
5. Relation between leg pain and GMed.
6. Surgery-related symptoms related to GMed.

Inclusion criteria

•The keywords "gluteus medius" or "hip abductor" are included in the title or abstract.

Exclusion criteria

•Case reports with fewer than 5 cases.
•Surgical treatment with total hip arthroplasty (THA).
•No values/figures that are clearly related to GMed and back pain or leg pain.

RESULTS

A total of 135 articles were included in this review (Tables 1–12[41–167]).

As described in the Introduction, GTPS presents with chief complaints of pain around the hip and is related to hip osteoarthritis or LDD caused by gluteal tendinopathy or trochanteric bursitis[24–32] (Table 1).

The prevalence of GTPS was reported to be about 1.8% among patients in a primary care clinic[51], and about 20% of patients with hip pain or low back pain[26]. However, the definition or pathology of GTPS differs depending on the era of the report or and also differs between reports[30, 31]. Thus, it may be difficult to consider all such presentations as the same disease entity. The prevalence of cases of GTPS with trochanteric bursitis is reported to be rather low; the prevalence of gluteal tendinopathy is 14% on all MRI in cases of hip pain[44] and about 8% for cases of trochanteric bursitis[46]. There are strong imaging diagnostic correlations to GTPS[46, 49, 52]; however, gluteal tendinopathy has also been reported poorly in relation to hip pain[53, 54]. Still many reports adopt simple diagnostic criteria for GTPS like pain with tenderness around the hip[26, 30, 31, 64, 168, 169], and may be related to the gluteal muscles (GMed and gluteus minimus). It is then possible that GTPS is part of the symptomatology of GMedS because GTPS is similar to GMedS.

Hip abductor strength, and walking speed were decreased in GTPS cases comparison with healthy controls[59, 60]. Hip range of motion on the affected side compared with the contralateral side was significantly decreased in GTPS[58], and muscle strength is useful for diagnosing GTPS.

GTPS is treated using various methods including rest, reduced weight-bearing, medication, exercise, corticosteroid injection, extracorporeal shockwave therapy (ESWT), and surgical intervention[29–32] (Tables 2 and 3). Treatments related to the GMed include corticosteroid injection, ESWT, exercise, and surgical intervention. Better results were obtained with ESWT or exercise than with corticosteroid injection[66]. For cases unresponsive to conservative treatment, surgical treatment is also reported to be successful (Table 3).

Low back pain is defined as pain extending from the lowest rib to the gluteal groove. Nevertheless, GMedS is often complicated with MPS of the multifidus or quadratus lumborum or other muscles[11, 20]. Usually pain is not limited to the affected region in the GMed or simple low back pain in GMedS or GTPS.

The prevalence of GMedS within the context of chronic back pain or nonspecific back pain is high, as noted in the Introduction section, and many reports suggest that the GMed is involved in back pain (Table 4). In chronic back pain, muscle strength of hip abductor or GMed is significantly decreased[20, 88–90, 93]. On electromyography (EMG), the amplitude of GMed was significantly increased by back pain provoked group[87, 92, 96], and EMG co-activation of the GMed was more significantly observed in a provoked pain group[91, 96]. GMed contraction evaluated using ultrasound was significantly decreased in a low back pain group[99]. GMed is significantly associated with back pain[93], and is the most commonly involved muscle in back pain and low back pain[11, 12].

Table 1. Characteristics of GTPS related to GMed

Report	Cases	References to GMedS
Swezey RL[41]	Patients with LBP (n=70)	31/70 (44.3%) were diagnosed with TB
	Patients with TB (n=31)	LDD was a complication in 31/31 (100%)
		Hip OA was a complication in 6/31 (19.3%) of TB
Collée G et al.[42]	Patients with LBP (n=100)	35% were diagnosed as TB/GTPS
Collée G et al.[43]	Patients with LBP (n=40, 124, 40)	18–45% were diagnosed with GTPS
Kingzett-Taylor A. et al.[44]	Patients with buttock, lateral hip, and groin pain (n=250)	GMed tear was confirmed in 14% on MRI
Howell GE et al.[45]	OA hips that underwent arthroplasty (n=176)	20% of cases had confirmed degenerative pathology of the hip abd.
Bird PA et al.[46]	Patients with chronic GTPS (n=24)	GMed tear was confirmed in 45.8% on MRI
		GMed tendinitis was confirmed in 62.5% on MRI
		TB was confirmed in 8% on MRI
Tortolani PJ et al.[47]	Patients with LBP (n=247)	20% was diagnosed with GTPS
Connell DA et al.[48]	Patients with greater trochanteric pain (n=75)	53 (74.7%) patients showed evidence of GMed tendinopathy on ultrasonography
		8 (10.7%) patients had fluid pooling in the trochanteric bursa
Cvitanic O et al.[49]	Hips with gluteal tendon tear (n=15)	Diagnostic accuracy of gluteal tendon tear on MRI was 91%
Sayegh F et al.[50]	Patients with GTPS (n=300)	Leg pain was a complication in 77.7%
		LDD was a complication in 79.4%

Table 1. Continued.

Report	Cases	References to GMedS
Lievense A et al.[51]	Patients with greater trochanteric pain (n=164)	Prevalence of GTPS was 1.8% among all primary care patients
		14.6% had hip OA
		8.5% had LBP
		9.8% had knee OA
Walker P et al.[34]	Patients with GTPS (n=97)	TB was found in 43.3% on SPECT
		Gluteal tendinopathy was found 36.1% on SPECT
		LDD was found in 76.3% on SPECT
		Active articular hip disease was found in 2% on SPECT
		Occurrence of gluteus tendinitis was correlated with spinal disease
Segal NA et al.[26]	Patients with lateral hip pain (n=1,786)	Prevalence of GTPS was 23.5%
		Prevalence of bilateral GTPS was 15.0%
		Bilateral GTPS was significantly associated with physical activity (20-m walk time and chair stand time)
		Ipsilateral and contralateral knee OA was significantly correlated with GTPS
		LBP was significantly correlated with GTPS
Lequesne M et al.[52]	Patients with persistent GTPS (n=17)	94.1% of patients had GMed tear and trochanteric bursitis on MRI
Woodley SJ et al.[53]	Patients with unilateral hip pain (n=40)	Difficulty with diagnosing GTPS on MRI
		Bursitis was confirmed in 33% who were symptomatic and 46% who were asymptomatic
		Gluteal tendon pathology was confirmed in 53% who were symptomatic and 28% who were asymptomatic
Blankenbaker DG et al.[54]	Hip MRI (n=131)	Asymptomatic gluteal tear was confirmed in 33.1% of cases on MRI
		Gluteal tear was not associated with hip pain
Iagnocco A et al.[55]	Patients with hip OA (n=75)	22.7% of cases had gluteal tendinopathy
Long SS et al.[56]	Patients with greater trochanteric pain (n=877)	20.2% had trochanteric bursitis; 49.9% had gluteal tendinosis
Lindner D et al.[57]	Patients with lateral hip pain who underwent GMed repair surgery (n=47)	100% had partial or complete gluteal tears and 91% had trochanteric bursitis
Ebert JR et al.[58]	Patients with symptomatic hip abd. tear (n=149)	Patients with hip abd. tears demonstrated significantly lower abd. strength and active ROM on the affected limb
Allison K et al.[59]	Patients with chronic unilateral gluteal tendinopathy (n=50)	Significantly decreased hip abd. strength in the GTPS group
Fearon A et al.[60]	Patients with GTPS (n=38)	GTPS and OA group had significantly lower walking speeds compared with asymptomatic controls
	Patients with hip OA (n=20)	GTPS and OA groups had significantly higher pain levels compared with asymptomatic controls
		GTPS and OA groups had significantly worse SLS results compared with asymptomatic controls
		GTPS and OA groups had significantly lower hip abd. strength compared with asymptomatic controls
Pozzi G et al.[61]	Patients with FAI (n=189)	Gluteal tendinopathy was confirmed in 72 cases (38.1%) on MRI; GTPS was confirmed in 74 cases (39.2%)
Ganderton C et al.[62]	Post-menopausal patients with chronic GTPS (n=8)	GMed and GMin were significantly activated on EMG in GTPS group
		Significantly decreased peak torque strength of hip abduction in GTPS group
Tan L et al.[35]	Patients with LDD (n=273)	50.5% had GTPS

GTPS: greater trochanteric pain syndrome; GMed: gluteus medius; Gmin: gluteus minimus; LBP: low back pain; TB: trochanteric bursitis; LDD: lumbar degenerative disease; OA: osteoarthritis; abd.: abductor; FAI: Femoroacetabular impingement; SLS: single-leg squat test; MRI: magnetic resonance imaging; SPECT: single-photon emission computed tomography.

Table 2. Conservative treatments of GTPS related to GMed

Report	Cases	Treatment	Outcomes
Swezey RL[41]	Patients with TB (n=31)	Cs injection (Cs+lidocaine)	Symptoms relapsed in 3/31 (9.7%)
Ege RKJ et al.[63]	Patients with TB (n=33)	Cs injection	Relapsed in 9/33 (27.2%) after 23 months
Shbeeb MI[64]	Patients with TB (n=75)	Cs injection (Cs+lidocaine)	77% showed improvement after 1 week 68% showed improvement after 6 weeks 61% showed improvement after 26 weeks
Sayegh F et al.[50]	Female patients with GTPS diagnosed on physical examination (n=150)	Peritrochanteric Cs injection	Cs injection significantly improved pain and physical function (Oswestry Disability Index), but symptoms gradually worsened over 4 years
Lievense A et al.[51]	Patients with greater trochanteric pain (n=164)	Medication (55%) Cs injection (37%) Physiotherapy	52% showed transient improvement 66% showed improvement 66% showed improvement
Walker P et al.[34]	Patients with GTPS (n=97)	Cs injection	30/48 (62.5%) improved for 6 weeks Cases with LDD were significantly more recurrent
Furia JP et al.[65]	Patients with chronic GTPS (n=33)	ESWT	79% had excellent or good outcomes after 12 months Roles and Maudsley score was greater in ESWT group
Rompe JD et al.[66]	Patients with unilateral GTPS (n=299)	Home training including hip abd. training	Treatment was successful in 7% after 1 month; 41% after 4 months; 80% after 15 months
		Cs injection (Cs+lidocaine)	Treatment was successful in 75% after 15 months; 51% after 4 months; 48% after 15 months
		ESWT	Treatment was successful in 13% after 1 month; 68% after 4 months; 74% after 15 months
Cohen SP et al.[67]	Patients with GTPS (n=32)	Fluoroscopy guided Cs injection	No significant differences between blind injection and fluoroscopy-guided injection
Uliassi NW[68]	Patients with GTPS (n=60)	Cs injection (Cs+lidocaine)	No significant differences between Cs injection and usual care groups
Mautner K et al.[69]	Patients with tendinopathy diagnosed by MRI (n=16)	Ultrasound-guided PRP injection	81% showed improvement
McEvoy JR et al.[70]	Patients with GTPS (n=41)	Cs injection to greater trochanteric bursa	Cs injection to greater trochanteric bursa significantly improved pain
	Patients with GTPS (n=24)	Cs injection to subgluteus medius bursa	Cs injection to subgluteus medius bursa did not improve pain
Estrela GQ et al.[71]	Patients with GTPS (n=60)	Ultrasound guided Cs injection	No significant benefit in ultrasound-guided group
Lee JJ et al.[72]	Patients with recalcitrant GTPS (n=21)	Ultrasound-guided intratendinous PRP injection	Ultrasound-guided intratendinous PRP injection significantly improved ADL and function (HHS, HOS-ADL, HOS-Sports score)
Ribeiro A et al.[73]	Patients with chronic GTPS (n=10)	Ultrasound-guided PRP injection	There was no significant benefit in PRP group compared with Cs injection group
Jacobson JA et al.[74]	Patients with GTPS unresponsive to conservative treatments (n=15)	PRP injection	Both ultrasound-guided fenestration and PRP injection improved pain
Tan L et al.[35]	Patients with LDD (n=73)	Cs injection	Treatment was effective in 49.3%
Fitzpatrick J et al.[75]	Patients with GTPS (n=80)	PRP injection vs. Cs injection	PRP injection improved HHS significantly more than CS injection

TB: trochanteric bursitis; GTPS: greater trochanteric pain syndrome; Cs: corticosteroid; ESWT: extracorporeal shockwave therapy; PRP: platelet-rich plasma; GMed: gluteus medius; LDD: lumbar degenerative disease; HHS: Harris Hip Score.

Table 4 shows the treatment results of LBP in terms of GMed. Treatment of back pain originating from the GMed is typically by trigger point injection (TPI), which was found to significantly improve pain assessed using the numerical rating scale (NRS)[11] (Table 5). For cases unresponsive to conservative treatment, GMed decompression surgery was found to significantly improve pain NRS score and function (Japanese Orthopaedic Association/ Roland-Morris Disability Question-

Table 3. Operative treatments of GTPS related to GMed

Report	Cases	Treatment	Outcomes
Brooker AF[76]	Patients with refractory TB (n=5)	Decompression by fenestration of bursa	All cases achieved pain relief and average HHS score was improved
Kagan A[77]	Patients with unresponsive TB (n=7)	GMed repair/fasciotomy	All cases achieved pain relief and one case had weakness of the GMed
Govaert LH et al.[78]	Patients with chronic TB (n=12)	Trochanteric osteotomy	Outcomes were very good in 6/12 (50%) and good in 5/12 (41.7%)
	*5 cases refractory to bursectomy		Pain and physical function (Merle d'Aubigné and Postel Method) were significantly improved
Baker CL et al.[79]	Patients with refractory TB (n=42)	Endoscopic bursectomy	44/45 (97.8%) had improved symptoms/postoperative average JOA score
Davies H et al.[80]	Patients with GTPS unresponsive to conservative treatment (n=16)	GMed/GMin repair and bursectomy	11/16 had significant reduction of hip symptoms; 5/16 had relapse
Voos JE et al.[81]	Patients with GMed tear (n=10)	Endoscopic gluteus medius repair	All cases had complete resolution of pain; MMT of hip abd. was improved
Walsh MJ et al.[82]	Patients with GTPS unresponsive to conservative treatments (n=72)	Gluteal tendon repairs	More than 90% of cases were pain-free or had minimal pain; repair surgery significantly improved hip score
Davies H et al.[83]	Patients with unresponsive TB with tear of hip abd. by MRI (n=23)	Open gluteal tendon repair	23/23 had significant improvement in VAS, OHS, and SF-36 PCS
Chandrasekaran S et al.[84]	Patients who underwent endoscopic GMed repair (n=24)	Endoscopic GMed repair	Age-matched non-surgery group had significantly greater strength than the surgery group; GMed strength is a possible risk factor for surgical intervention

TB: trochanteric bursitis; GTPS: greater trochanteric pain syndrome; Cs: corticosteroid; abd.: abductor; ESWT: extracorporeal shockwave therapy; PRP: platelet-rich plasma; GMed: gluteus medius; GMin: gluteus minimus; LDD: lumber degenerative disease; JOA: Japanese Orthopaedic Association; VAS: visual analogue scale; HHS: Harris Hip Score; OHS: Oxford Hip Score; SF-36: MOS Short-Form 36-Item Health Survey.

naire scores)[10, 23] (Table 6). Many articles discussed the diagnosis and treatment with respect to the relationship between low back pain and the GMed.

Because low back pain is related to the GMed and LDD is related to back pain, LDD should also be related to the GMed. However, there are only few reports on the association between LDD and GMedS (Table 1). Walker et al. performed single-photon emission computed tomography (SPECT) in patients with GTPS, and found about 48.4% of cases of GTPS had LDD, the majority of which were facet joint disease[34]. Swezey et al. and Sayegh et al. also reported on the relationship between TB/GTPS and LDD. Tan et al. reported that 50.5% of LDD cases had GTPS and 49.3% of cases were responsive to corticosteroid injection to the trochanteric bursa[35]. LDD is related to GTPS and LDD is possibly related to the GMed and GMedS.

Hip osteoarthritis has characteristic radiological features. However, images of hip osteoarthritis on X-ray films do not always reveal the source of the osteoarthritic pain[4]. Pain from hip osteoarthritis is regarded as very wide ranging, often radiating around the knee and it is sometimes hard to distinguish between osteoarthritis of the knee and of the hip.

Numerous reports have pointed out the relationship between the GMed and hip osteoarthritis (Table 7). GTPS is complicated by hip osteoarthritis 2–20%[34, 41, 51]. GMed tear was confirmed in 20% of cases following THA[45]. Hip abductor muscle strength and GMed volume were significantly decreased and GMed intensity on ultrasound was significantly higher in hip osteoarthritis[110, 111, 113–118, 125, 128, 129]. Moreover, EMG activity of the GMed was significantly increased[109, 120, 124]. In terms of treatment of hip OA, physiotherapy and manual therapy involving the hip abductors significantly improved hip function and relieved pain (Table 8)[134–136].

GMed-responsive radiating pain lesions have been reported around the hip[13], but GMedS causes pain radiating from the knee to the lower leg or even the foot[8, 170]. The pain in GMedS is not limited to pain around the hip as it is in GTPS.

About 30% of cases of leg pain are reported to be GMedS and 50% of GMedS cases present with leg pain[11]. While 77.7% of GTPS is complicated by leg pain[50], 44.2% of trochanteric bursitis involved leg pain radiating around the knee[25]. Tortolani et al. reported that 62.7% of GTPS patients diagnosed by spine surgeons were misdiagnosed[47]. It is sometime difficult to diagnose GTPS or GMedS.

Most known cases of MPS with radiating lower leg pain are piriformis syndrome[171, 172]. Other muscles responsible for leg pain include the GMed and gluteus minimus[11, 13]. The prevalence of GmedS is higher than that of MPS of the piriformis

Table 4. Characteristics of LBP related to GMed

Report	Cases	References to GMedS
Njoo KH et al.[85]	Patients with chronic LBP (n=61)	MTrPs of GMed constituted 34% of cases
Farasyn A et al.[86]	Patients with LBP (n=42)	PPT of GMed was significantly decreased in the LBP group
Nelson-Wong E et al.[87]	Healthy participants without LBP after exercise loading test (n=23)	EMG amplitude was significantly higher in the LBP-provoked group
Bewyer KJ et al.[88]	Pregnant female patients with LBP (n=16)	GMed strength was lower in the LBP group
Arab AM et al.[89]	Patients with LBP (n=200)	Hip abd. strength was significantly weaker than in controls
Kendall KD et al.[90]	Patients with nonspecific LBP (n=10)	Hip abd. strength was significantly weaker than in controls
Marshall PW et al.[91]	Healthy participants without LBP after exercise loading test (n=24)	GMed coactivation on surface EMG was significantly higher in the LBP-provoked group
Chen CK et al.[19]	Patients with LBP (n=126)	80/126 (63.5%) had MPS
		Facet complications were present in 43.1%, LSCS in 33.8%, disc in 30.8%
		MTrPs of GMed was 12.1%
Iglesias-González JJ et al.[21]	Patients with nonspecific LBP (n=42)	MTrPs of GMed recognized in 35%/38% (affected side/contralateral side)
		Latent MTrPs of GMed identified in 17.0%
Santos FG et al.[92]	Female patients with CLBP after exercise loading test (n=39)	EMG amplitude of GMed significantly decreased and peak time significantly slower during protocol
Pennyey T et al.[93]	Patients with CLBP (n=21)	GMed muscle strength was significantly lower
		EMG activation of GMed was significantly higher during unipedal activity
		No difference in EMG peak of GMed onset time was noted
		LBP was correlated to GMed strength
Kuniya H et al.[94]	Patients with LBP and leg pain (n=834)	113/834 (13.5%) were diagnosed as having superior cluneal nerve entrapment
Cooper NA et al.[20]	Patients with CLBP (n=150)	MMT of GMed was significantly decreased
		MTrPs of GMed was identified in 68.1% of cases
Takla MK et al.[95]	Patients with MPS (n=50)	MPS had significantly lower GMed pressure/pain threshold
Bussey MD et al.[96]	Female hockey players with LBP after exercise loading test (n=14)	GMed coactivation was confirmed by surface EMG and significantly higher in the LBP-provoked group
Imamura M. et al.[12]	Patients with CLBP (n=124)	PPT of GMed had the highest correlation to VAS and RMQ compared with other muscles
Skorupska E et al.[97]	Patients with CLBP and leg pain (n=71)	GMax, GMin, and Piri muscle size were significantly decreased on the affected side compared with the contralateral side
Farahpour N et al.[98]	Patients with LBP and pronated-foot	EMG activation of GMed was significantly higher during walking
Aboufazeli M et al.[99]	Female patients with LBP (n=30)	GMed contraction was significantly decreased in the LBP group on US
Viggiani D et al.[100]	Healthy participants without LBP after standing loading test (n=40)	The pain group developed hip abd. fatigue before the no-pain group
Psycharakis SG et al.[101]	Patients with CLBP exercise aquatic protocol (n=20)	EMG amplitude of GMed was significantly decreased in aquatic exercise compared with land exercise
		EMG amplitude of GMed was not significantly different compared with controls
Kameda M e al.[11]	Patients with LBP (n=83)	MPS was identified in 65/83 (78.3%)
		GMedS was identified in 32/83 (38.6%)

LBP: low back pain; CLBP: chronic LBP; MTrPs: muscle trigger points; GMax: gluteus maximus; GMed: gluteus medius; GMin: gluteus minimus; Piri: piriformis; MPS: myofascial pain syndrome; LSCS: lumbar spinal canal stenosis; abd.: abductor; MMT: manual muscle test; EMG: electromyography; VAS: visual analogue scale; PPT: pressure pain threshold; RMQ: Roland Morris questionnaire; US: ultrasonography.

Table 5. Conservative treatment of LBP related to GMed

Report	Cases	Treatment	Outcomes
Koo TK et al.[102]	Patients with CLBP (n=14)	NIMMO-receptor tonus technique for GMed	NIMMO-receptor tonus technique significantly improved pain (VAS)
Kameda M et al.[11]	MPS patients with LBP (n=26)	ASTR or TPI	Combination treatment of ASTR or TPI significantly improved pain (NRS)
	GMedS patients with LBP (n=18)	ASTR or TPI	Combination treatment of ASTR or TPI significantly improved pain (NRS)

LBP: low back pain; CLBP: chronic LBP; GMed: gluteus medius; GMedS: gluteus medius syndrome; MPS: myofascial pain syndrome; ASTR: active soft tissue release; TPI: trigger point injection; VAS: visual analog scale; NRS: numerical rating scale.

Table 6. Operative treatment of LBP related to Gmed

Report	Cases	Treatment	Outcomes
Kim K et al.[10]	GMedS patients with LBP (n=10)	TPI and GMed decompression surgery	GMed decompression surgery significantly improved pain (NRS) and JOA
Kokubo R et al.[103]	Patients with GMedS (n=17)	TPI, GMed surgical decompression and nerve decompression	Significantly improved pain (NRS)/RMDQ
Matsumoto J et al.[23]	Patients with MCN entrapment (n=11)	GMed surgical decompression and nerve decompression	Significantly improved pain (NRS)/RMDQ/JOA

LBP: low back pain; CLBP: chronic LBP; GMedS: gluteus medius syndrome; MPS: myofascial pain syndrome; MCN: middle cluneal nerve; GMed: gluteus medius; TPI: trigger point injection; VAS: visual analog scale; NRS: numerical rating scale; RMDQ: Roland Morris Disability questionnaire; JOA: Japanese Orthopaedic Association.

(46.7% vs. 13.3%, respectively)[11]. Constriction of peripheral nerves such as the middle cluneal nerve is known to contribute to gluteal pain[23, 94].

Leg pain including patellofemoral pain syndrome (PFPS) is also related to the GMed (Table 9). Pain in knee osteoarthritis was reported to be related to GTPS[26]. GMed strength was significantly decreased in patients with patellofemoral (PF) osteoarthritis[154]. Hip abductor muscle strength was also significantly decreased[137, 139, 142, 143, 148]. GMedS is also possibly related to knee OA and PFPS.

Treatment of GMedS with leg pain, physiotherapy and manual therapy including hip abductors significantly improved hip function and relieved pain[11, 143, 161, 162] (Table 10), and patients with recalcitrant gluteal pain were successfully treated with cluneal nerve decompression surgery[94].

Symptoms of GTPS have been noted postoperatively following THA in about 4%[164, 165] (Table 11). The prevalence is lower in the posterior approach[164], and most cases recovered after steroid injection[164, 165]. Failed back surgery syndrome (FBSS) is defined as recurrence of symptoms after spine surgery[173]. MPS is implicated in 85% of cases of FBSS; the proportion of GMed was about 19%[166]. It is reported that cases of FBSS were treated successfully by GMed decompression and peripheral nerve decompression[167] (Table 12).

DISCUSSION

This review found the three following results: (1) GMedS is a disease entity similar to GTPS, one of the major causes of LBP and leg pain; (2) GTPS shows relations with LDD and hip OA; (3) LBP, GTPS, and hip OA show relations with GMed. Thus, GMedS is one of the major causes of low back pain and leg pain, is related to LDD and hip OA based on this review. MPS of GMed origin has a simple pathology, but this simple pathology appears to have a big impact. Thus, understanding the MPS basis of diagnosis and treatment, the evaluation of target muscles and adjacent peripheral nerve constriction is vital[11, 23, 94, 103].

In most cases, both most of GTPS and GMedS cases respond to conservative treatment; however, there are still unresponsive cases. These treatment methods of GTPS and GMeds possibly affect each other. Further study is needed on treatments for GMedS such as ASTR, TPI, gluteal muscle decompression surgery, and nerve decompression for GTPS. Corticosteroid injection for GTPS has been shown to have less satisfactory long-term results compared with physiotherapy. Intra-tendinous corticosteroid injection possibly may result in some complications and so should not be the first choice of treatment. ESWT and platelet-rich plasma injection are other treatments available for GMedS and should be considered as treatment options. Decompression surgery for GTPS has been already reported with beneficial results[76], however there were also refractory cases to surgical decompression[78]. Thus, an appropriate surgical strategy should be established including peripheral nerve decompression or other effective treatment procedures. Nevertheless, physiotherapy targeting the GMed or hip abductors

Table 7. Characteristics of hip OA related to GMed

Report	Cases	References to GMedS
Širka A et al.[104]	Patients with hip OA (n=56)	GMed atrophy grade was significantly higher in the OA group
Shih CH et al.[105]	Patients with unilateral hip OA (n=20)	Hip abd. strength was lower but not significantly.
Hurwitz DE et al.[106]	Patients with unilateral hip OA (n=19)	Hip abd. kinematics were not significantly lower in the OA group (p=0.087)
Watanabe H et al.[107]	Female patients with unilateral hip OA (n=84)	GMed EMG amplitude was not significantly changed
Watelain E et al.[108]	Patients with unilateral hip OA (n=22)	Hip abd. joint moment was not significantly changed
Sims KJ et al.[109]	Patients with unilateral hip OA (n=19)	GMed EMG amplitude was significantly increased (p=0.037) compared with controls
Arokoski MH et al.[110]	Patients with hip OA (n=27)	Hip isometric abd. strength was significantly lower than in controls
Rasch A et al.[111]	Patients with unilateral hip OA (n=11)	Hip abd. strength was significantly decreased in OA group
Eimre M et al.[112]	Patients with hip OA who underwent GMed biopsy (n=60)	OA was associated with increased sensitivity of mitochondrial respiration to ADP
Kubota M et al.[113]	Patients with bilateral hip OA (n=12)	Peak abd. angle was significantly lower in OA
		Peak abd. joint moment was significantly lower in OA
Amaro A et al.[114]	Patients with hip OA (n=41)	GMed atrophy was correlated with pain score and pain score was correlated with radiographic signs of OA
Rasch A et al.[115]	Patients with unilateral hip OA (n=22)	Hip abd. strength was significantly decreased in the OA group
		GMed/GMin size was significantly decreased in the OA group on MRI
Grimaldi A et al.[116]	Patients with advanced hip OA (n=6)	GMed volume was significantly smaller on the affected side in the severe OA group on MRI
	Patients with mild hip OA (n=6)	
Rasch A et al.[117]	Patients with unilateral hip OA (n=22)	Hip abd. strength was significantly lower on the affected side compared with the contralateral side in the OA group
Youdas JW et al.[118]	Patients with unilateral hip OA (n=20)	Hip abd. strength was significantly lower in the OA group
Fukumoto Y et al.[119]	Patients with hip OA (n=24)	GMed echo intensity was significantly higher (p<0.05)
		GMed size was not significantly changed
Dwyer MK et al.[120]	Patients with unilateral Hip OA (n=13)	GMed EMG amplitude was significantly increased (p=0.037)
Judd DL et al.[121]	Patients with unilateral end-stage hip OA (n=26)	Hip abd. strength was not significantly lower in the OA group (p=0.23)
Hatton A et al.[122]	Patients with symptomatic hip chondropathy diagnosed by endoscopy (n=63)	Dynamic single-leg standing balance was significantly reduced in the OA group
Rutherford DJ et al.[123]	Patients with hip OA (n=20)	Ambulatory individuals with severe OA had less dynamic gluteus medius activation compared with the other two groups.
French HP et al.[124]	Patients with hip OA (n=13)	GMed EMG amplitude was significantly greater in the OA group during step-up and -down exercises
		Hip abd. strength was significantly decreased in the OA group
Zacharias A et al.[125]	Patients with unilateral hip OA (n=20)	Hip abd. strength was significantly decreased compared with the contralateral side and with controls.
	(severe cases n=13)	GMed size was smaller on the affected side in severe OA than on the contralateral side or in controls
Nankaku M et al.[126]	Female patients with unilateral THA (n=74)	Preoperative gluteus medius atrophy was correlated to limping after THA
Momose T et al.[127]	Patients with unilateral hip OA (n=50)	Hip abd. strength was correlated to HHS/CT density
		Hip abd. strength was significantly decreased compared with the contralateral side
Zacharias A et al.[128]	Patients with unilateral hip OA (n=20)	Hip abd. strength significantly decreased compared with controls
		Gluteal muscle atrophy was associated with clinical severity of OA

Table 7. Continued.

Report	Cases	References to GMedS
Loureiro A et al.[129]	Patients with symptomatic hip OA (n=19)	Hip abd. strength was significantly decreased compared with controls GMed volume was not significantly decreased compared with controls
Zacharias A et al.[130]	Patients with unilateral Hip OA (n=20)	GMin EMG amplitude in gait was significantly increased

OA: osteoarthritis; GMed: gluteus medius; GMin, gluteus minimus; abd.: abductor; MRI: magnetic resonance imaging; THA: total hip arthroplasty; EMG: electromyography; HHS: Harris Hip Score; CT: computed tomography.

Table 8. Treatments of hip OA related to GMed

Report	Cases	Treatment	Outcomes
Hoeksma HL et al.[131]	Patients with symptomatic hip OA (n=109)	Manual therapy vs. exercise therapy	Manual therapy was significantly superior in improvement of pain (VAS), ROM, HHS, and walking speed
Stener-Victorin E et al.[132]	Patients with symptomatic hip OA (n=45)	Electroacupuncture (n=15)	VAS and DRI were significantly decreased by treatment at 6 months after the last treatment
		Hydrotherapy (n=15)	VAS and DRI were significantly decreased by treatment at 3 months after the last treatment
		Patient education (n=15)	VAS and DRI were not significantly improved
Veenhof C et al.[133]	Patients with hip or knee OA (n=51)	Behavioral graded activity program vs. exercise therapy and advice	No significant differences were noted between the programs
Wang TJ et al.[134]	Patients with knee or hip OA (n=20)	Aquatic exercise including hip abd.	Hip ROM and GMed strength were improved No change was observed in pain and function
Hinman RS et al.[135]	Patients with hip or knee OA (n=36)	Aquatic exercise including hip abd.	Significant improvements in pain (VAS/WOMAC) and function (WOMAC)
Steinhilber B et al.[136]	Patients with hip OA (n=70)	Tübingen exercise therapy including hip abd.	Tübingen exercise therapy has a significant positive effect on HMS

OA: osteoarthritis; VAS: visual analog scale; abd.: abductor; ROM: range of motion; HHS: Harris Hip Score; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index.

is effective for both GTPS and GMedS and this treatment is widely available[22, 51, 66, 174]. Physiotherapy is thus the most recommended first-line treatment option for both GTPS and GMedS with low back pain and LDD.

Several articles discussed back pain in relation to the GMed. Several degenerative lumbar diseases like facet joint syndrome, disc herniation, and lumbar spinal canal stenosis can cause low back pain but a simple TPI can alleviate the symptoms[10, 11, 94]; most cases of low back pain are possibly complications secondary to MPS. LDD is a complication in half of cases of GTPS; however, 70% of low back pain cases were found to be complicated with LDD by SPECT[175]. GMedS is a major cause of low back pain, therefore GMedS is possibly related to LDD. Involvement of muscles adjacent to the GMed is significantly correlated to low back pain[97, 176], and functional disorders such as GMed atrophy or disfunction of GMedS are possibly related to poor body posture and could worsen low back pain.

Radicular pain exacerbates the symptoms of MPS[177]. However, MPS cases with radicular pain are also responsive to acupuncture and dry needling[97]. There is a possibility that MPS treatment also improves radicular pain. Therefore, accurate diagnosis and treatment of GMedS possibly also treat radicular pains. It is natural that cases of LSCS with impaired hip abductor strength were improved by L5 laminectomy[178]. Radicular pathology or facet joint pain exacerbates GMed dysfunction, which in turn worsens LDD and LDD, then this worsens radicular or facet joint pain. Breaking these vicious cycles may be the key to treatment of chronic back pain or leg pain.

GMedS is often complicated by piriformis syndrome or MPS of the piriformis[11], moreover both GMed and gluteus minimus are adjacent to piriformis[44, 179]. Piriformis syndrome is accompanied by adhesions to adjacent muscles such as GMed[180]. MTrPs may be responsible for nerve constriction directly or indirectly by muscle adhesions.

In cases of MTrPs caused by contracture of the GMed and gluteus minimus, it is sometimes difficult to distinguish between the GMed and gluteus minimus as the source of MTrPs clinically; they are the same pathology. This may be reflected in the fact that both the GMed and the gluteus minimus are involved in the pathology of GTPS. It is difficult to diagnose the GMed and gluteus minimus as the source by physical examination alone. For accurate diagnosis, ultrasound guidance may be necessary[18, 181].

Constriction of the cluneal nerves is a differential diagnosis of hip pain[23]. The symptoms and site of cluneal nerve constriction are similar in presentation to those of MTrPS of the gluteus maximus[23, 93]. Sometimes even water-diluted local

Table 9. Characteristics of leg pain related to GMed

Report	Cases	References to GMedS
Robinson RL et al.[137]	Female patients with PFPS (n=10)	Hip abd. and external rotation strength were significantly decreased compared with the contralateral side and with controls
Bolgla LA et al.[138]	Female patients with PFPS (n=18)	PFPS group generated significantly less hip abd. torque
Willson JD et al.[139]	Female patients with PFPS (n=20)	Hip abd. strength was significantly lower compared with controls
Franettovich M et al.[140]	Female patients with exercise-related leg pain (n=14)	Individuals with a history of exercise-related leg pain demonstrated significantly lower EMG peak activation and lower average EMG activation of GMed
Costa RA et al.[141]	Patients with symptomatic unilateral knee OA (n=25)	Hip abd. strength (peak torque) was significantly decreased compared with the contralateral side
Hinman RS et al.[142]	Patients with symptomatic knee OA (n=89)	Hip abd. strength was significantly decreased compared with controls
Sled EA et al.[143]	Patients with symptomatic medial knee OA (n=40)	Isokinetic hip abd. strength was significantly decreased in the knee OA group
Nakawaga TH et al.[144]	Female patients with anterior knee pain (n=9)	No significant EMG activation of GMed was observed
Bolgla LA et al.[145]	Female patients with PFPS (n=18)	PFPS group generated significantly less hip abd. torque PFPS group also generated greater GMed EMG activity during loading test
Nakawaga TH et al.[146]	Patients with chronic PFPS (n=20)	Patients with PFPS generated less peak eccentric hip abd. torque; EMG amplitude of the GMed was significantly greater in female controls than in female patients with PFPS
Crossley KM et al.[147]	Patients with symptomatic PFJ OA (n=60)	Individuals with PFJ OA ambulated with significantly lower peak hip abd. muscle forces than controls
Baert IA et al.[148]	Female patients with knee OA (n=40)	Hip abd. strength was decreased compared with controls, but not significantly
Bley AS et al.[149]	Female patients with PFPS	PFPS group generated significantly greater EMG activity of GMed and greater hip abd. moment than controls
Izumi M et al.[150]	Hypertonic saline injection	GMed PPT was increased
Rutherford DJ et al.[151]	Patients with moderate knee OA (n=54)	No clear relationship of hip abd. muscle strength with specific amplitude and temporal KAM characteristics was found
Motealleh A et al.[152]	Athletes with PFPS (n=28)	Onset and amplitude of GMed EMG activity were earlier and higher in the manipulation group than in the control group
Tevald MA et al.[153]	Patients with knee OA (n=35)	Hip abd. significantly contributed to physical performance
Sritharan P et al.[154]	Patients with symptomatic OA (n=39)	Calculated GMed force was significantly decreased compared with controls
Orozco-Chaves I et al.[155]	Female patients with PFP (n=24)	PFP group had significantly later onset of GMed EMG, and showed no adaptation to velocity variation
Kalytczak MM et al.[156]	Female patients with PFP (n=14)	EMG values for the GMax and GMed were significantly higher in the eccentric phase than in the concentric phase
Mirzaie GH et al.[158]	Male patients with PFP (n=18)	Significant differences were found in GMed activity in loading tasks
Fuentes-Márquez P et al.[157]	Female patients with chronic pelvic pain (n=40)	MTrPs of GMed was present in 55–87.5% of patients with chronic pelvic pain
Kameda M et al.[11]	Patients with leg pain or hip pain (n=66)	45/66 (69.0%) cases had MPS 20/29 (68.9%) cases had GMedS
Ackland DC et al.[159]	Patients with patellofemoral joint OA (n=51)	Muscle volume was significantly decreased in the OA group

GMax: gluteus maximus; GMedS: gluteus medius syndrome; GMed: gluteus medius; PFP: patellofemoral pain; PFPS: patellofemoral pain syndrome; OA: osteoarthritis; abd.: abductor; PPT: pressure pain threshold; MPS: myofascial pain syndrome; EMG: electromyography; MTrPs: muscle trigger points.

Table 10. Treatments of leg pain related to GMed

Report	Cases	Treatment	Outcomes
Bennell KL et al.[160]	Patients with symptomatic knee OA (n=119)	Isometric contraction of gluteal muscles	No significant difference was found compared with placebo
Veenhof C et al.[133]	Patients with hip or knee OA (n=101)	Behavioral graded activity program vs exercise therapy and advice	No significant difference was found between programs
Sled EA et al.[143]	Patients with symptomatic medial knee OA (n=40)	8-week home strengthening program for the hip abd. muscles	Strengthening program decreased pain (WOMAC)
Bennell KL et al.[161]	Patients with symptomatic medial knee OA and pain (n=45)	Hip strengthening training for 13 weeks	Training significantly improved pain (WOMAC) and function (WOMAC)
Foroughi N et al.[162]	Patients with knee OA (n=54)	Strengthening exercise with and without hip abd./hip adduction/knee extension	Strengthening exercise significantly improved pain (WOMAC) and difficulty (WOMAC); there were no significant differences between groups
Glaviano NR et al.[163]	Female patients with chronic PFPS (n=15)	Patterned electrical neuromuscular stimulation (PENS) vs. sham	PENS group had significantly improved pain (VAS) in load testing, with improvement of hip abduction and significant improvement in GMed activation
Kameda M e al.[11]	MPS patients with leg pain or hip pain (n=14)	ASTR or TPI	Combination treatment of ASTR or TPI significantly improved pain (NRS)
	GMedS patients with leg pain or hip pain (n=9)	ASTR or TPI	Combination treatment of ASTR or TPI significantly improved pain (NRS)

OA: osteoarthritis; PFPS: patellofemoral pain syndrome; abd.: abductor; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; VAS: visual analogue scale; NRS: numerical rating scale; ASTR: active soft tissue release; TPI: trigger point injection.

anesthesia or normal saline is effective as TPI for treating MPS[11, 18, 182], which may have little or no results of nerve block

Table 11. Characteristics of surgery-related symptoms related to GMed

Report	Cases	References to GMedS
Iorio R et al.[164]	Patients with postoperative (THA) lateral hip pain (n=24)	24/543 LTP (4.4%)
		Postoperative GTPS in 5% of cases, direct lateral approach
		Postoperative GTPS in 1.2% of cases, posterior approach
Farmer KW et al.[165]	Patients with postoperative TB (n=32)	32 cases of postoperative GTPS among 689 cases of primary THA (4.6%)
Teixeira MJ et al.[166]	Patients with FBSS (n=56)	85% of FBSS cases were complicated with MPS
		MTrPs of GMed was identified in 16% of cases
Matsumoto J et al.[167]	Patients who underwent lumbar surgery (n=74)	20/74 (27%) FBSS patients

GMedS: gluteus medius syndrome; TB: trochanteric bursitis; LTP: Lateral trochanteric pain; GTPS: greater trochanteric pain syndrome; THA: total hip arthroplasty; GMed: gluteus medius; MPS: myofascial pain syndrome; FBSS: failed back surgery syndrome; MTrPs: muscle trigger points.

effects. The appropriate diagnosis to identify the pathology of the pain in terms of muscle sliding or nerve constriction is required in daily clinical practice. Since, both of these pathologies are hypothetically designated as MPS.

Many reports support the association of hip osteoarthritis with GMed dysfunction (Tables 7 and 8). GMed dysfunction possibly exacerbates hip osteoarthritis. THA is an effective treatment strategy for hip osteoarthritis, but THA also involves manipulation of the GMed. It is thus undeniable that this manipulation of GMed is a partial cause of pain or symptom recurrence in THA. Further research is needed on this topic.

Fearon et al. argued that pain itself rather than GMed tendinopathy is the cause of decreased GMed strength[60]. Alleviating pain possibly improves gluteal tendinopathy or hip osteoarthritis, and additional physiotherapy, manual therapy, TPI, and other pain release methods may be important in treatment of hip osteoarthritis. The question remains as to whether hip pain exacerbates GMed dysfunction or whether GMed dysfunction worsens hip articular pressure, hip pain, or prognosis of hip osteoarthritis, or whether these vicious cycles constitute the pathology of hip osteoarthritis. Proper diagnosis and treatment of GMedS could possibly protect the hip from osteoarthritis, and possibly reduce the number of cases of THA. Further study

Table 12. Treatment of surgery-related symptoms related to GMed

Report	Cases	Treatment	Outcomes
Iorio R et al.[164]	Patients with postoperative (THA) lateral hip pain (n=24)	Cs injection	All cases were treated non-surgically
Farmer KW et al.[165]	Patients with postoperative (THA) TB (n=32)	Cs injection	Symptoms resolved in 20/25 patients (80%)
Matsumoto J et al.[167]	Patients with FBSS (n= 20)	Only TPI (n=4) GMed decompression (n=8) Peripheral nerve decompression (n=11) Repeat surgery for lumbar disease (n=6)	FBSS group achieved good results similar to those of the non-FBSS group (RMDQ/JOA) (n=20)

GMed: gluteus medius; THA: total hip arthroplasty; TB: trochanteric bursitis; Cs: corticosteroid injection; FBSS: failed back surgery syndrome; TPI: trigger point injection; RMQ: Roland Morris Disability questionnaire; JOA: Japanese Orthopaedic Association.

is needed.

Knee osteoarthritis is related to GMed and interventions for GMed improved function and pain of knee osteoarthritis and PFPS (Tables 9 and 10). Vasilevska et al. and Grimaldi et al. described GTPS and the iliotibial band[32, 183]. Furthermore, the strength involving the hip abductors improved the prognosis of knee osteoarthritis[184], and thus some part of knee osteoarthritis possibly attributed to GMedS.

In some cases, hip OA is complicated by LDD and treatment is unsuccessful even after surgical intervention. Even the combination of THA and spine surgery could not achieve pain relief but rather reduces activities of daily living of patients. Degenerative hip disease is often accompanied by LDD, and this combination was named hip-spine syndrome[185, 186].

It was demonstrated that GMedS and GTPS elicit both back pain and hip or leg pain and are related to LDD and hip osteoarthritis. This implies that GMedS or GTPS is possibly the main cause of hip-spine syndrome. Proper diagnosis and treatment of GMedS before surgery may decrease postoperative complications.

The prevalence of FBSS is reported to be 10–40%[167, 173, 187]. Most cases of FBSS are complicated by MPS[166]. The fact that most FBSS cases are adequately treated by GMed decompression and nerve decompression[167] might indicate that FBSS is a component of MPS. Proper diagnosis and treatment of MPS and GMedS might decrease the likelihood of FBSS and further research is needed in terms of safety and cost-effectiveness.

The clinical features of GMedS was reviewed in terms of diagnosis and treatment on this article. GMedS is associated with low back pain, leg pain, LDD, and hip osteoarthritis. Moreover, we identified a new treatment strategy for GMedS and GTPS. Proper diagnosis of GMedS may improve LDD and osteoarthritis of the hip and knee, as well as hip-spine syndrome and FBSS. Further research is warranted to clarify these issues.

This research review was conducted by searching for articles using only simple keywords, which may not have captured the full scope of the topic. This may have led to overlooking or not identifying some important factors. Also, the quality of evidence was not assessed in the included articles, and so the reliability of the review may have been lessened by combining certain and uncertain research. There were few reviews on this topic, and this might limit the conclusiveness of our review.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of interest

The authors have no conflicts of interest to declare.

ACKNOWLEDGEMENT

The authors would like to thank Mr. Masakazu Kutsunugi and Dr. Tadashi KOBAYASHI for the advice during the drafting of this manuscript.

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