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Current Concept of Management of Partial-thickness Rotator Cuff Tear

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Most studies on the pathophysiology, natural history, diagnosis by imaging and outcomes after operative or nonoperative treatment of rotator cuff tear have focused on those of full-thickness tears, resulting in limited knowledge of partial-thickness rotator cuff tears. However, a partial-thickness tear of the rotator cuff is a common disorder and can be the cause of persistent pain and dysfunction of the shoulder joint in the affected patients. Recent updates in the literatures shows that the partial-thickness tears are not merely mild form of full-thickness tears. Over the last decades, an improved knowledge of pathophysiology and surgical techniques of partial-thickness tears has led to more understanding of the significance of this tear and better outcomes. In this review, we discuss the current concept of management for partial-thickness tears in terms of the pathogenesis, natural history, nonoperative treatment, and surgical outcomes associated with the commonly used repair techniques.
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Key Words: Rotator cuff; Tear; Partial

Introduction

When compared with a full-thickness rotator cuff tear, a partial-thickness rotator cuff tear has not been much highlighted in the literature. Most studies on the pathophysiology, natural history, diagnosis by imaging and outcomes after operative or nonoperative treatment of rotator cuff tear have focused on those of full-thickness tears, resulting in limited knowledge of partial-thickness rotator cuff tears. However, a partial-thickness tear of the rotator cuff is a common disorder. Sher et al.[1] reported a 20% incidence of partial-thickness tears by magnetic resonance imaging (MRI) in 96 asymptomatic shoulders, and this incidence increases with age. Milgrom et al.[2] studies asymptomatic shoulders by ultrasonography, and found a incidence of full- or partial-thickness tears of 5% to 11% in subjects aged 40 to 60 years, increasing to 80% in patients aged older than 70 years. Moreover, partial-thickness tears can be the cause of significant pain and disability in affected patients. Fukuda[3] reported pain severity in patients with subacromial bursitis and/or partial-thickness tears, and full-thickness tears. Interestingly, more than 70% of patients with the former diagnosis reported 'more than moderate pain' (visual analogue scale score >5), compared with 50% of patients with full-thickness tears.

Recent updates in the literatures show that the partial-thickness tears are not merely mild form of full-thickness tears. Gerber et al.[4] investigated abnormal tendon functions in partial tears using real-time ultrasound. They compared *in vivo* dynamics of normal, repaired, and fully and partially torn supraspinatus tendons, and found that loading of a partially torn supraspinatus tendon resulted in visible intrinsic stretching of the tendon and thinning of the tendon under isometric muscle contraction, similar to full-thickness tears. They concluded that partially torn supraspinatus tendons behave like musculotendinous units with full-thickness tear. Farshad-Amacker et al.[5] also reported that partial tear of the supraspinatus tendon is associated with significant tendon lengthening, suggesting failure incontinuity, and this might be as unfavorable as small full-thickness tear. Andarawis-Puri et al.[6] evaluated the mechanical interactions between the

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supraspinatus and infraspinatus tendons with use of partial-thickness tear models in cadavers. They demonstrated that the partial-thickness tears of the supraspinatus significantly increase in normalized maximum principal strain in the infraspinatus tendon, suggesting that partial tears of the supraspinatus tendon may increase in risk of injury to the infraspinatus tendon.

Over the last decades, an improved knowledge of pathophysiology and surgical techniques of partial-thickness tears has led to more understanding of the significance of this tear and better surgical outcomes. In this review, we discuss the current concept of management for partial-thickness tears in terms of the pathogenesis, natural history, nonoperative treatment, and surgical outcomes associated with the commonly used repair techniques.

Pathogenesis

The pathogenesis related to the development of partial-thickness rotator cuff tears is often classified as intrinsic, extrinsic, or traumatic. Intrinsic tendinopathy, related to changes in cuff vascularity or metabolic phenomenon associated with the aging process, may lead to degenerative tears, which most commonly involving the articular-surface of the rotator cuff.[7-10] Their tendency to involve the articular side of the cuff may be related to tenuous vascularity, particularly with aging. A zone of relative hypovascularity is found on the articular surface of the rotator cuff lateral to the rotator cable, extending to within 5 mm of the cuff insertion.[11,12] Nakajima et al.[13] found that less uniformly arranged composition in the articular side is less tolerant of deformation and shows approximately half the ultimate stress to failure as that of the bursal side. Differential shear stress affecting the layered anatomy of the cuff has been proposed as one mechanism involved in the production of articular-sided tears. Degenerative tears are often associated with extensive lamination and may remain entirely intratendinous.[14]

Extrinsic impingement due to supraspinatus outlet narrowing caused by coracoacromial arch abnormalities can result in cuff irritation and is thought to play a role in many partial cuff tears.[15] Histologic changes have been found on the undersurface of cadaveric acromion specimens with bursal-sided tears but not in those with articular-sided tears.[10] Schneeberger et al.[16] created iatrogenic impingement in rats and found exclusively bursal-sided tears. These results suggest that bursal tears may be more likely to be related to abrasion of the cuff by the acromion, as the extrinsic theory (Fig. 1). However, some authors think that extrinsic impingement due to coracoacromial arch narrowing can lead to partial tears on the articular as well as the bursal surface of the cuff.[17]

Tensile overload of the cuff, due to either a single violent traumatic injury or repetitive microtrauma, may also cause partial cuff injury. On occasion, more than one etiologic factor may be involved, as Pettersson stated already in 1942 that 'even in cases of traumatic rupture—the age distribution indicates that changes in the elasticity and tensile strength are prerequisites for the appearance of the rupture.' (quoted from reference 18).

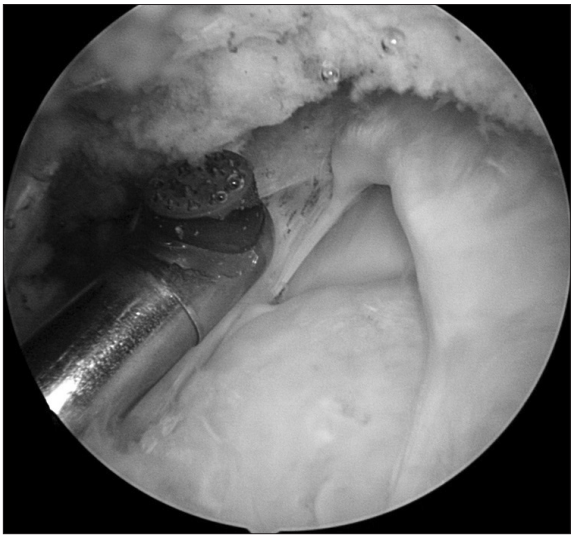

Fig. 1. Arthroscopy viewing from posterolateral portal in subacromial space shows large spurs of anterolateral acromion (indicated by radiofrequency device), protruding just over a bursal-sided, partial-thickness supraspinatus tear. This image suggests close relationship between acromial spur and bursal-sided tear.

Natural History

Many questions about natural history of partial tears remains unclear, such as, (1) Why do some tears become painful or others not?; (2) When do they become painful?; and (3) Do spontaneous healing of tear occur or not? Since the natural history and results of nonoperative treatment of partial tears is not commonly studied, compared with full-thickness tears, most answers could be only speculated from results of full-thickness tears and biomechanical studies.

Yamaguchi et al.[19] compared asymptomatic full-thickness tears with symptomatic ones by ultrasonography, and concluded that symptomatic tears are significantly larger (30%) in tear size than asymptomatic shoulders. In another study, Yamaguchi et al.[20] performed a longitudinal analysis of asymptomatic full-thickness tears by ultrasonography and demonstrated that 51% of the patients became symptomatic over 2.8 years with tear progression in some patients. Biomechanical studies also showed that the maximum strain in abduction of applied at the articular side of the anterior aspect of the supraspinatus tendon and is in favor to posterior extension.[21,22] Therefore, the healing potential of torn rotator cuff tendon is the matter of debate. Yamanaka and Matsumoto[23] reported that 10% of tears completely healed in serial arthrographic evaluations. Maman et al.[24]

recently observed that 9% of tears decreased in tear size on MRI follow-ups, although they questioned the quality of tissues in the tear site. However, others argued the possibility of spontaneous healing. Fukuda[3] reported that histologic section of partial tears showed no evidence of active tissue repair. Safran et al.[25] followed 51 full-thickness tears by ultrasound and found increases in tear size in 49% after mean 29-months. Maman et al.[24] also showed tear progression is more likely to occur in patients with longer than 18 months of follow-up time, suggesting long-term follow-up may reveal tear propagation more frequently. Factors predisposing to tear progression were age of more than 60 years, full-thickness tears (compared with partial tears), and fatty infiltration in their study. Fucentese et al.[26] reported that small and symptomatic, full-thickness rotator cuff tears after nonoperative treatment remained no increase in tear size by MRIs at mean 3.5 years follow-ups with high patients satisfactions. These observations may lend proof to Codman's statement 60 years earlier, 'It is my unproved opinion that many of these lesions never heal, although the symptoms caused by them usually disappear after a few months.'[18] In summary, it appears that some partial tears and small-sized full-thickness tears do not progress in their natural course and nonoperative treatments may yield good outcome in limited time period.

Nonoperative Treatment

Nonoperative treatment should be initial treatment of choice in most partial-thickness tears. The treatment modalities of partial-thickness tear are similar to those of other rotator cuff problems (such as impingement syndrome, and some full-thickness tears), including a rest, activity modification, use of oral analgesics and/or nonsteroidal antiinflammatory drugs, subacromial corticosteroid injections, and physical therapy.

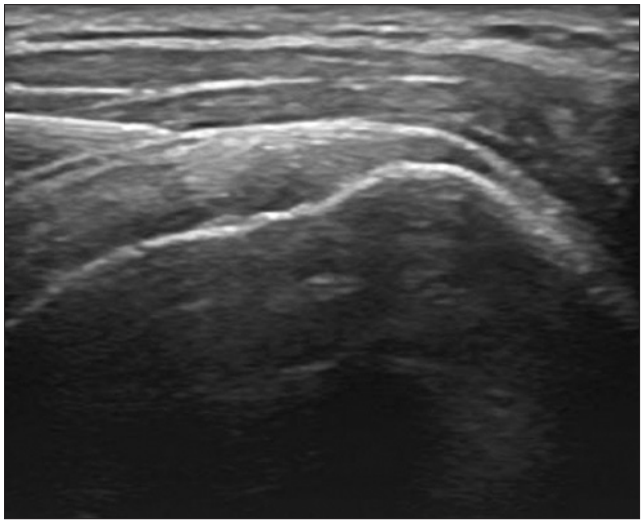

Fig. 2. Ultrasonography-guided, subacromial injection of corticosteroid.

Subacromial injection is effective especially in patients with severe pain and/or subacromial bursal inflammation. Nowadays, an ultrasonography-guided injection is popularizing by shoulder surgeons (Fig. 2). However, corticosteroid-induced adverse effect on the supraspinatus tendon is still a concern.[27] Transient increase in blood glucose levels over a few days in diabetic patients is not uncommon.[28] Moreover, recent systematic review showed that there was no evidence to support the use of subacromial injections in the treatment of rotator cuff disease. Under these circumstances, Min et al.[29] recently studied the utility of alternative injections into the subacromial space. They evaluated the efficacy of subacromial injection of nonsteroidal antiinflammatory drug (NSAID) (ketorolac), compared with corticosteroid (triamcinolone) in subacromial impingement syndrome. Interstingly, an injection of ketorolac resulted in greater improvements in clinical scores at 4 weeks follow-up, suggesting it can be a good alternative, especially in patients that corticosteroid use is not appropriate for, such as patients with diabetes or history of multiple uses of corticosteroid during a short period of time.

A physical therapy is also important, as Kuhn[30] reported in his systematic review that exercise has statistically and clinically significant effects on pain reduction and improving function, and supervised exercise was not different than home exercise programs. However, there is no consensus on an optimal exercise program to treat patients with rotator cuff disease. Therefore, based on the above-metioned review, Kuhn et al.[31] developed a physical therapy program and assessed its effectiveness in full-thickness tear, their protocol was effective in 75% of patients followed up for 2 years. All of these results can be applied the treatment strategy in partial-thickness tears.

However, there are no standardized, long term follow-up studies evaluating the clinical outcomes of patients with partial-thickness tears treated nonoperatively. Therefore, some issues still need to be further studied in the future, such that how the natural course of articular or bursal sided tears is different from each other, which tears progress to full-thickness tears, or how the tear extent of partial tears (*i.e.* tears greater than 50%-thickness) affect the results of nonoperative treatment and indication of surgical repair. We recently evaluated outcomes of nonoperatively-treated, symptomatic partial-thickness tears of 54 patients. Our treatment consisted of NSAIDs medication, an ultrasonography-guided subacromial injection, and a home-based exercise. In our seires, nonoperative treatment was effective in 80% of patients followed for mean 23 months. Higher pain level and greater percentage-thickness tears were associated with failure of nonoperative treatment (unpublished data).

Operative Treatment

Currently, there is not a consensus on an indication of surgi-

cal intervention for the patients with a symptomatic, partial-thickness tear. Objective data to guide clinical decision-making for the treatment of partial-thickness tears have been lacking. Therefore, most of the surgeons combine clinical and radiological criteria to decide whether the patient would benefit from a surgical intervention or whether rather a conservative approach should be employed first. Generally, if the patients are not satisfied with their outcomes after 6 months of dedicated nonoperative treatment, operative intervention can be considered.[32] Most authors recommended repair of tears involving 50% or more of the tendon thickness. Relative indications for repair may be acute traumatic tears, bursal-sided tears, and tears in young and active patients.

Historically, surgical interventions moved from tear debridement with or without acromioplasty into tear repair with or without acromioplasty. Cordasco et al.[33] performed tear debridement and acromioplasty in large series (107 tears) with Ellman[34] grade 1 or 2, and reported good clinical outcomes at 2- to 10-years follow-up. However, they found unsatisfactory results in higher grade, bursal-sided tears. Kartus et al.[35] reported

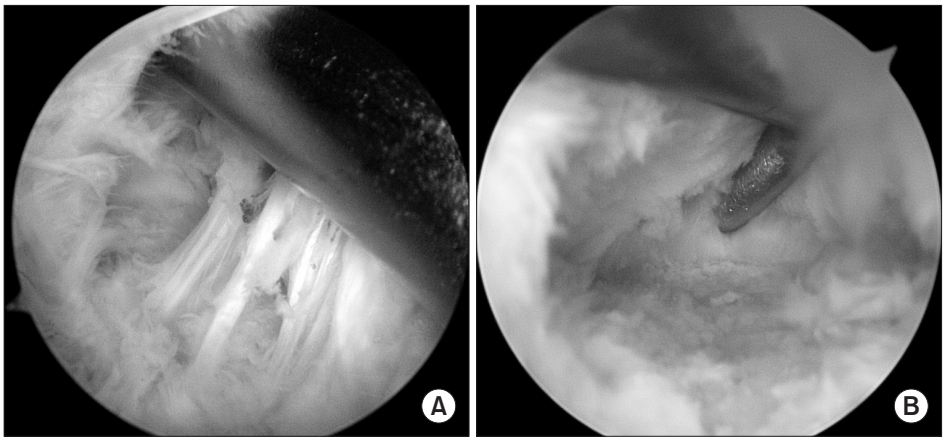

Fig. 3. Arthroscopy viewing from posterolateral portal in subacromial space showing only partially remained bursal-sided, supraspinatus tendon with poor tendon quality (A), compared with robust remnant articular-sided tendon in bursal-sided partial supraspinatus tear in another patient (B).

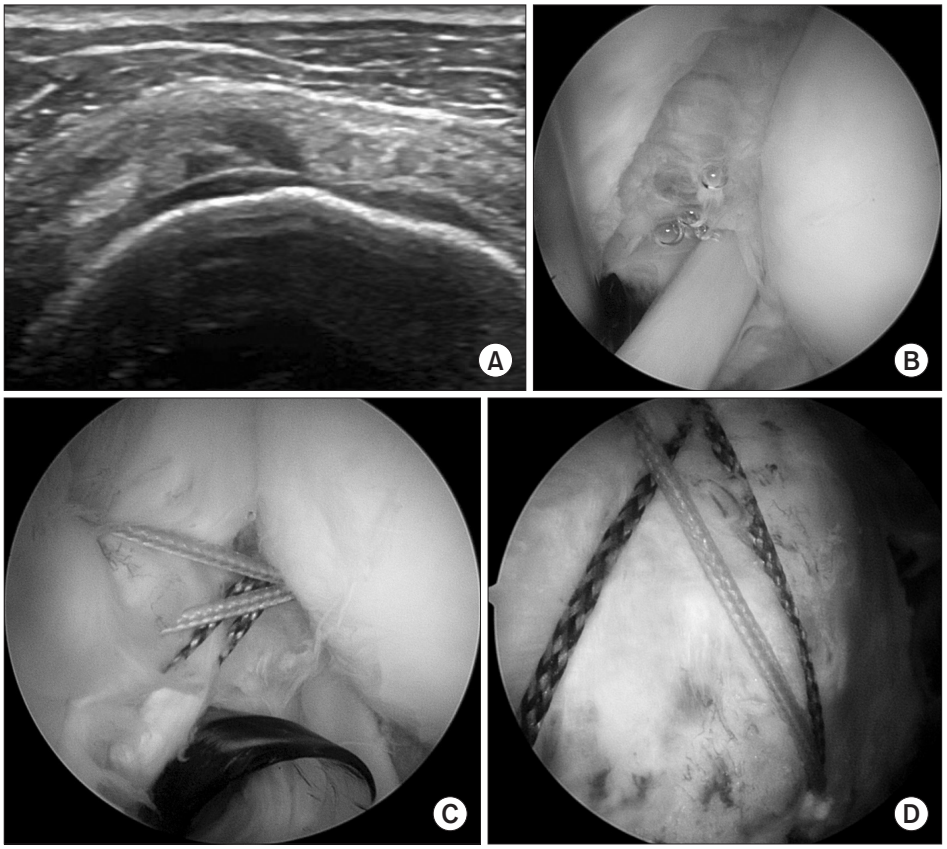

Fig. 4. Articular-sided, partial supraspinatus tendon tear of 60-year-old male patient. Preoperative ultrasonography shows articular-side tear, just posterior to the biceps tendon (A), which was confirmed by arthroscopy in the glenohumeral joint (B). Arthroscopic transtendon repair using suture bridge technique was performed (C, D).

long-term results (mean 101 months) of 26 patients after tear debridement and acromioplasty. They observed tear progression to full-thickness tear in 9 patients, and stated that tear debridement and acromioplasty appears not to protect the rotator cuff. Weber[36] compared tear debridement with mini-open repair in patients with Ellman[34] grade 3 tears. They noted 18% reoperation rate, including progression to full-thickness tears in debridement group, and concluded that repair yielded superior results in their study. Strauss et al.[37] also reported in their systematic review that debridement of partial-thickness tears of less than 50% of the tendon's thickness with or without acromioplasty results in 6.5% to 34.6% incidence of progression to full-thickness tears despite good to excellent, clinical results. All of these studies may indicate the role of surgical repair in partial-thickness tears. Similarly, the biomechanical data regarding differential shear stress and tear propagation provide a mechanical rationale for repair of partial-thickness tears. Mazzocca et al.[38] showed increased tendon strain pattern return to near-intact states with *in situ* tendon repair. Recently, Gerber et al.[4] demonstrated that the successfully repaired group restored tendon biomechanics, similar to normal tendons.

Literaturally, many repair techniques has been reported with or without surgical outcomes. They can be divided into three categories according to the preservation of the remaining tendon tissue; (1) tear completion and repair (conversion to full-thickness tear and repair), (2) transtendon repair preserving intact portion of partial-thickness tear, and (3) *in situ* repair of only torn tendon portion. Decision on preservation of the remained tendon may depend mostly on the surgeon's preference and the quality of residual intact tendon (Fig. 3). Advocates for tear completion and repair have argued the quality of residual intact tendon. Yamakado[39] reported histopathologic degeneration in 93% of macroscopically intact residual tendon in partial articular supraspinatus tendon avulsion lesions. They inferred that the transtendon technique leaves not only degenerative but also potentially thin fibers at the repair site, which may compromise the repair. However, tear completion may place the repair at greater risk of retear. In studies evaluating repair integrity, tear completion and repair yielded 11.9% retear rate,[40] while there were no retear in transtendon repair techniques in articular-sided partial-thickness tear groups.[41,42] On the other hand, advocates for transtendon repair technique (Fig. 4) presumed that intact residual tendon may protect the repaired tendon as an internal splint, possibly facilitating faster rehabilitation than tear completion

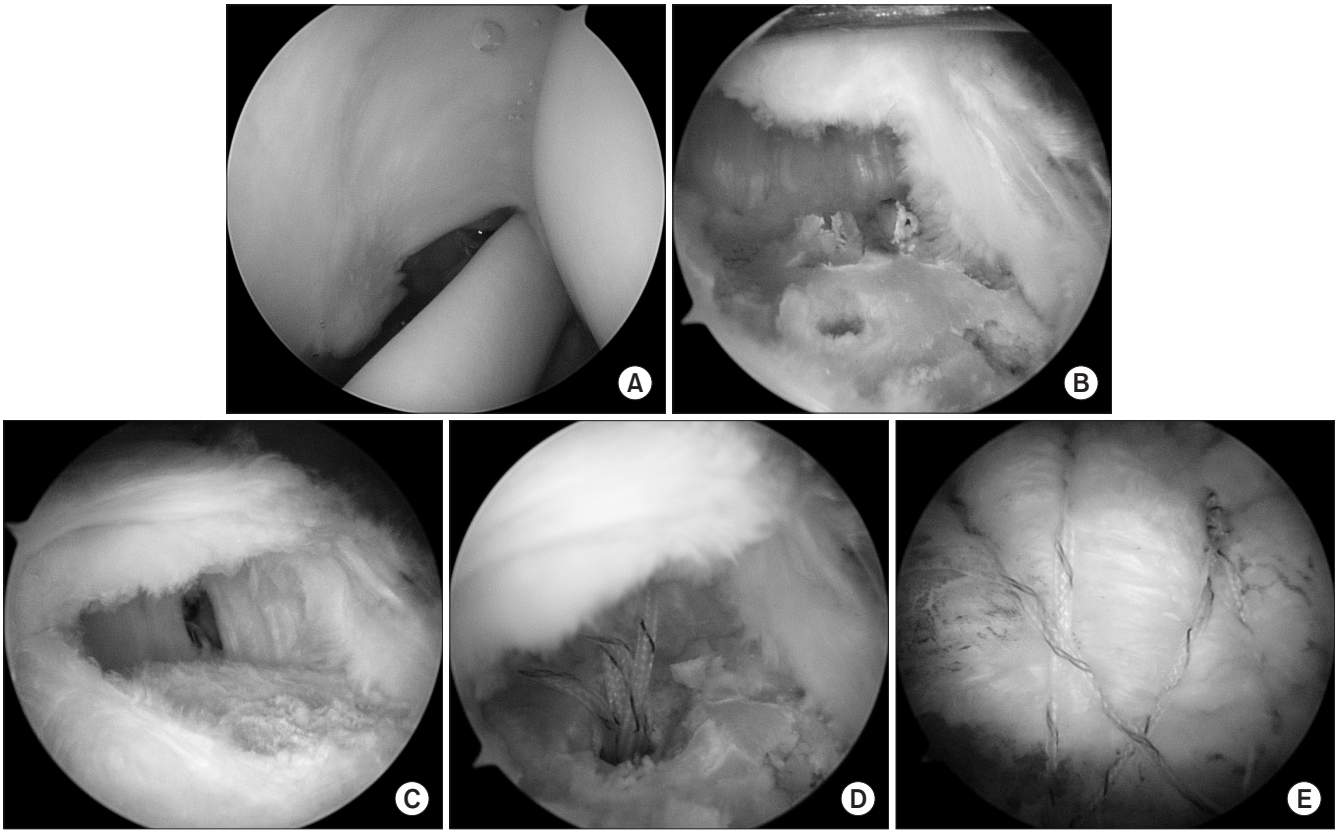

Fig. 5. Bursal-sided, partial supraspinatus tendon tear of 58-year-old female patient. Arthroscopy shows intact articular-side supraspinatus tendon in the glenohumeral joint (A) and high grade, bursal-sided partial tear (B). Arthroscopy from bursal side showing small window (less than 5 mm) made in the robust medial footprint of the supraspinatus tendon (C), suture passing through full-layer of the tendon (D) and final repair with suture bridge technique (E).

technique. However, transtendon technique may result in tension mismatching on the repair between repaired tendon portion and intact tendon.[43] Despite several theoretical advantages and disadvantages, clinical results of both techniques in articular-sided partial-thickness tears were favorable in the systematic review.[37] With the level 1 evidence, Shin[44] reported good clinical outcomes with no difference between both techniques, and showed slow recovery until 3 months in transtendon group and a trend of higher retear in tear completion group (2/24 patients vs. 0/24 patients, respectively), as expected.

Outcomes after surgical repair for bursal-sided partial-thickness tear are also favorable in the literature. Tear completion and repair technique in bursal tears is more familiar to shoulder surgeons because of technical similarity to repair of full-thickness tear. As such, Peters et al.[45] compared outcomes after tear completion and repair in bursal-sided tears with repair of small full-thickness tears, and showed no difference in clinical scores and retear rates. The preservation of the residual intact tendon is also the issue in bursal-sided tears. Yoo et al.[46] first described the technique of arthroscopic full-layer repair for bursal-sided tear to minimize damage to intact articular tendon ('window technique', Fig. 5). By using this technique, Koh et al.[47] showed good clinical outcomes with 88% intact repaired tendon in 38 patients at minimum 2 years of follow-up. Kim et al.[48] also described surgical technique preserving intact articular tendon with modification of suture bridge repair in bursal-sided tears. Kim et al.[43] also introduced *in situ* repair technique only repairing torn bursal flap tear without sutures passing the intact tendon. However, this technique has disadvantage in that simple repair of retracted bursal tendon may result in a remaining intratendinous tear.[43] Oh et al.[49] reported good clinical outcomes with 10.5% retear rate with *in situ* repair technique in 31 bursal-sided tears (including 11 repairs with tear completion and repair). In contrast to articular-sided tears, we are not aware of any study comparing results of different repair techniques in bursal-surface tears. The superiority of these techniques in terms of clinical and structural outcome needs to be further studied in the future. Recently, a systematic review revealed that for high-grade lesions including articular- and bursal-sided tears, the data support arthroscopic tear completion and repair, and transtendon repairs, with both techniques providing a high percentage of excellent results.[37] On the other hand, surgical outcomes of intratendinous cuff tear are rarely reported. Uchiyama et al.[50] reported that open repair of torn tendon provided good clinical results at mean 8 years of follow-up. They confirmed the intratendinous tear through longitudinal split of the supraspinatus tendon in the area of softening, fraying, edema and redness, and performed excision of the tear and repair. A similar finding can be observed by arthroscopy in a typical case (Fig. 6).

Knowledge of factors affecting outcomes after repair of

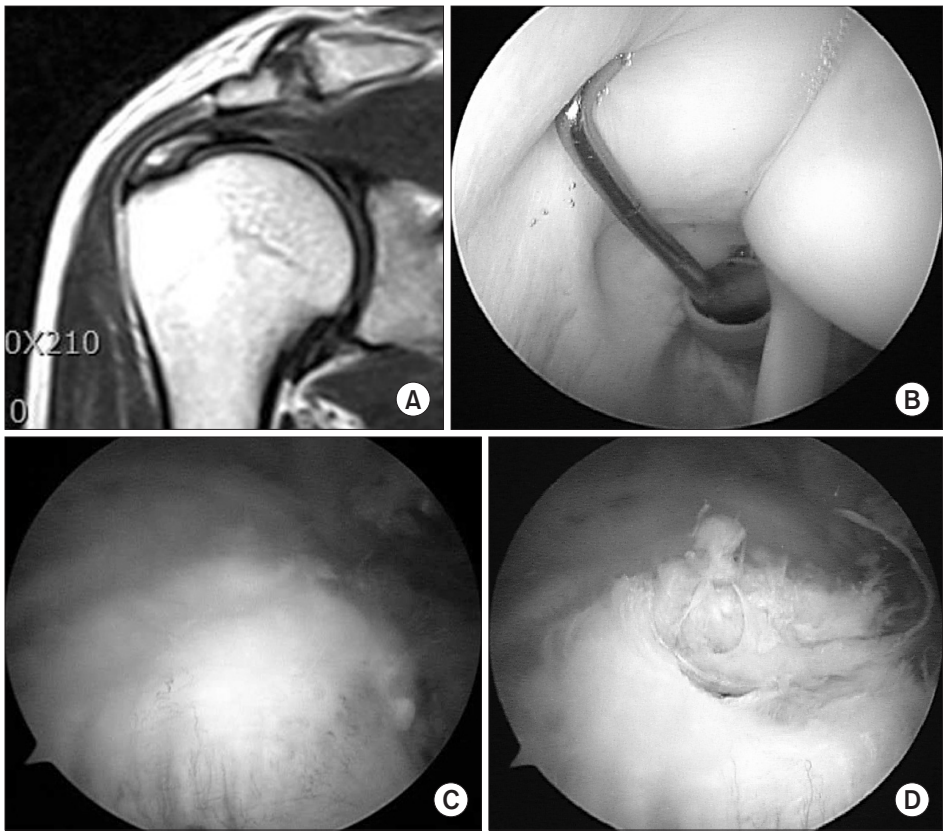

Fig. 6. Intratendinous, partial supraspinatus tendon tear of 40-year-old-aged male patient. Preoperative magnetic resonance imaging (T2-weighted, coronal view) shows high-signal intensity within the supraspinatus tendon with intact continuity of articular- and bursal-side tendon (A), which were confirmed by arthroscopy from the glenohumeral joint (B) and subacromial space (C). At probing and shaving, the red-yellowish, granulation tissues were found, suggesting degenerative, intratendinous tear of the supraspinatus tendon (D). Arthroscopic repair was performed after tear completion.

partial-thickness rotator cuff tears are limited. In terms of tear size, Tauber et al.[51] reported no difference in clinical outcomes after repair between grade 2 and 3 tear groups. Castagna et al.[52] reported residual pain after transtendon repair was related to the amount of tendon retraction (12.7 mm with pain versus 5.7 mm without pain). Age may be related to repair integrity. Kamath et al.[40] showed retear group was older than intact group (62 versus 51 year-old ages, respectively) after tear completion and repair. Some authors compared surgical results between articular- and bursal-sided tears. Park et al.[53] reported no difference of clinical outcomes in both tears after tear debridement and acromioplasty. Recently, Kim et al.[54] reported no differences of clinical outcomes and structural integrity in both tear groups after repair.

Conclusion

The partial-thickness rotator cuff tear is a common condition, causing pain and disability in the affected patients. However, the natural history of partial-thickness tears and their contribution to clinical symptoms remain poorly characterized, and outcomes after standardized, nonoperative treatment need to be further studied. Furthermore, a consensus on clear indication of nonsurgical or surgical treatment for symptomatic, partial-thickness tears is still lacking. High grade tears that not responded nonoperative care may be indicated for surgical repair. Regardless of the surgical technique, the current repair methods yield good clinical outcomes and repair integrity in the literature.

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