Technical Note

Revision Rotator Cuff Repair: A Comprehensive Approach and Stepwise Technique

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Abstract: The indications for and techniques to accomplish revision rotator cuff repair continue to be challenging problems that surgeons face. Complexity of tears, poor tissue quality, retained hardware, and adhesions are routinely encountered during surgical intervention for failed rotator cuff repairs. A successful outcome for any revision rotator cuff repair is determined, in part, by the surgeon's ability to address these intraoperative issues in an optimum manner. The surgical technique described in this article outlines a comprehensive and stepwise approach that can aid the surgeon in developing an effective strategy to accomplish revision rotator cuff repair.

Failure of index rotator cuff repairs to heal is not an uncommon occurrence, with retear rates in published studies ranging from 13.1% to 79%.[1-3] This wide range of retear rates is primarily due to the vast differences in those rotator cuff tears that are being repaired. Most young, active patients with good tissue quality and no muscle atrophy have a much higher repair success rate compared to more elderly patients with relatively poorer tissue quality. The total number of surgical revision procedures for failed index rotator cuff repairs has been steadily increasing over the past 2 decades because of the consistent increase in the volume of index rotator cuff repairs being performed.[1] Failure of rotator cuff repairs to heal may be caused by several different factors such as (1) technical errors; (2) surgical complications; (3) biological mediated failure to heal; (4) patient noncompliance, and (5) traumatic failure.[4] The indications for revision repair are not well defined. With the advancement in reverse shoulder arthroplasty technology along with an improved understanding of the biomechanics of the shoulder, surgeons may opt to transition some of these patients to an arthroplasty procedure. However, when properly indicated, arthroscopic revision of rotator cuff repairs can be performed using more recent surgical techniques and biologic adjuncts that can improve the chances of a successful revision rotator cuff repair and avoid the need for arthroplasty in some patients.

Revision of primary rotator cuff repair failures may be complicated by the presence of relatively poor-quality tissue, glenohumeral and subacromial space adhesions, and retained implants and suture material.[1-3] Surgeons must address these complicating factors to increase the chances for a successful revision outcome. Preoperative clinical and radiographic assessment of rotator cuff tissue quality is often helpful in evaluating a patient for possible revision rotator cuff repair, but this can often be a difficult exercise because of the variability of clinical patient presentation and radiographic ambiguity created from chronic tissue inflammation and degradation. Magnetic resonance imaging assessment of muscle fatty infiltration is strongly correlated with patient age and duration of the rotator cuff detachment and, in severe presentations, negatively correlates with postrepair outcomes. Arthroscopic evaluation of the rotator cuff is a more direct method of assessing the quality and repairability of available tissue. However, in the revision setting, arthroscopic assessment may be challenging because of obscured anatomy and landmarks, as well as the relative immobility of cuff tissue.[5] Identifying all rotator cuff tissue can be difficult in such cases in which this tissue is retracted or

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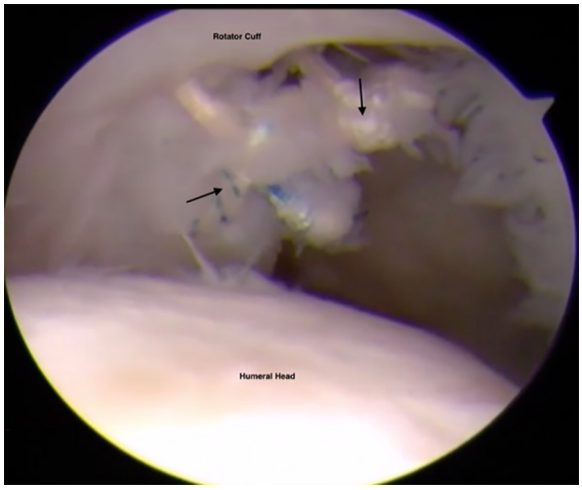

Fig 1. Arthroscopic view from the posterior portal in a right shoulder with the patient in the beach chair position visualizing the failed rotator cuff tear from the glenohumeral joint. The black arrows represent the suture material being visualized from the glenohumeral joint space.

scarred down to the capsule or adjacent bony structures. Thorough examination from within the glenohumeral joint and subacromial space must be completed to accurately identify all potentially repairable rotator cuff tissue. Once recognized, this tissue often requires mobilization to accommodate for cuff reapproximation to the greater or lesser tuberosities in a relatively low-tension state.

Along with developing strategies to effectively address these complicating factors encountered during revision rotator cuff repair, several surgical adjuncts have proven helpful in improving healing rates after rotator cuff repairs. Bone marrow stimulation and bioinductive patches are adjuncts that have the potential to aid in this healing process. Preparing the greater tuberosity using microfracture has been shown to significantly increase rotator cuff tendon after healing.[6] Likewise, rip-stop techniques have been shown in biomechanical and clinical studies to significantly reduce suture cutout.[7]

The surgical technique used for revision repair of a specific rotator cuff tear depends on the unique features of the tear and surgeon preference. The authors present an example of a stepwise arthroscopic surgical approach that addresses a revision rotator cuff repair. In the case presented, a variety of techniques are demonstrated to address the rotator cuff tissue retraction and adhesions that were present. In addition, a double-row rip-stop repair technique[7] was used to strengthen the integrity of the repair construct. Bone marrow stimulation and a bioinductive patch were also added to facilitate healing of the repair.

Surgical Technique

The patient is placed in either the beach chair or lateral decubitus position for revision rotator cuff repairs. The senior author (L.D.F.) prefers using the beach chair position for repair of the rotator cuff. The complete surgical technique is demonstrated in a supplemental video (Video 1). After the induction of anesthesia, the operative arm is prepped and draped in usual sterile fashion. The skin is then marked with a sterile pen to facilitate accurate portal placement. A standard posterior portal is established first using manual distraction of the glenohumeral joint to create maximum space for trocar insertion. Once the posterior portal is established, the arthroscope is inserted to confirm accurate placement. A spinal needle is then used to aid in creating the anterior portal. After these 2 initial portals are made, a diagnostic arthroscopy of the glenohumeral joint is performed viewing from the posterior portal. In the surgical case presented, a failed rotator cuff repair is visualized from the glenohumeral joint (Fig 1). The rotator cuff is retracted and adhered, allowing for visualization of a bare rotator cuff footprint.

After completion of the glenohumeral joint diagnostic arthroscopy, attention is then turned to the subacromial space. The posterior trocar is then removed from the glenohumeral joint and advanced into the subacromial space. Again, a spinal needle is used to aid in establishing a lateral portal. Further visualization of the tear is appreciated from the subacromial space, with sutures noted within the retracted rotator cuff tissue (Fig 2). A grasper is introduced into the lateral portal to check the mobility of the tendon (Fig 3). It is noted that adhesions have formed around the retracted rotator cuff tendon, and the tendons are unable to be advanced to the anatomic footprint. Visualization from the lateral portal is very advantageous and allows for identification of any lamination that might be present on the articular

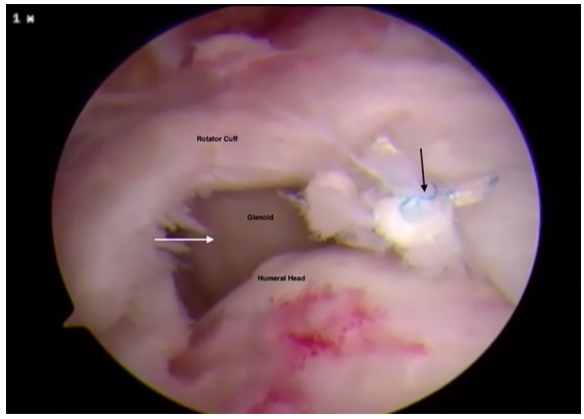

Fig 2. Arthroscopic view from the lateral portal in a right shoulder with the patient in the beach chair position visualizing the failed rotator cuff tear from the subacromial space indicated by the white arrow. The black arrow represents the suture material being visualized from the subacromial joint space.

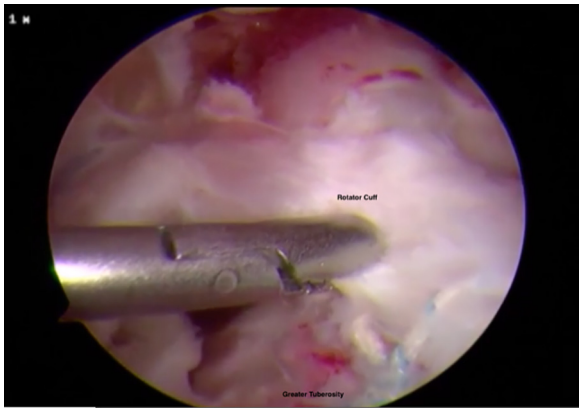

Fig 3. Arthroscopic view from the lateral portal in a right shoulder with the patient in the beach chair position showing an arthroscopic grasper being introduced from the posterior portal into the subacromial space, and a failed attempt is made to mobilize the rotator cuff to the greater tuberosity.

side of the retracted rotator cuff tissue (Fig 4). Suture material should be identified and removed at this time, as necessary. Likewise, retained anchors may require removal from the tuberosity, but the authors do not generally remove previously placed anchors unless they will directly interfere with the planned revision repair or will create a significant, potential impediment to postoperative healing. Suture material is present in the demonstrated case, and a standard scalpel blade is introduced from an accessory lateral portal to section the sutures (Fig 5). An arthroscopic grasper is then used to remove this suture material. Mobilization of the tendon is carried out by releasing adhesions within the subdeltoid space using an arthroscopic shaver (Dyonics Powermax; Smith & Nephew, Watford UK). An anterior interval slide in-continuity is performed as well to improve rotator cuff tendon excursion by releasing the rotator interval capsule and coracohumeral ligament

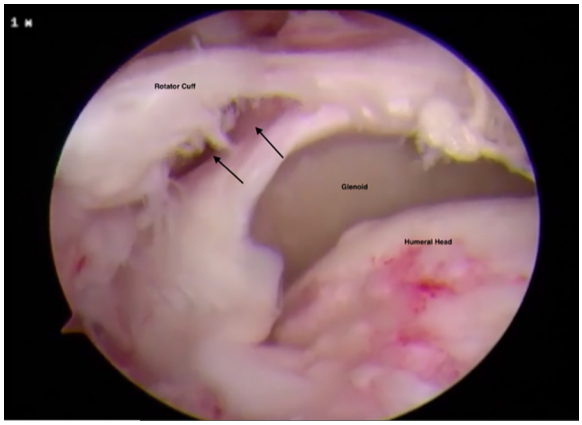

Fig 4. Arthroscopic view from the lateral portal in a right shoulder with the patient in the beach chair position clearly identifies a laminar tear in the rotator cuff indicated by the black arrows.

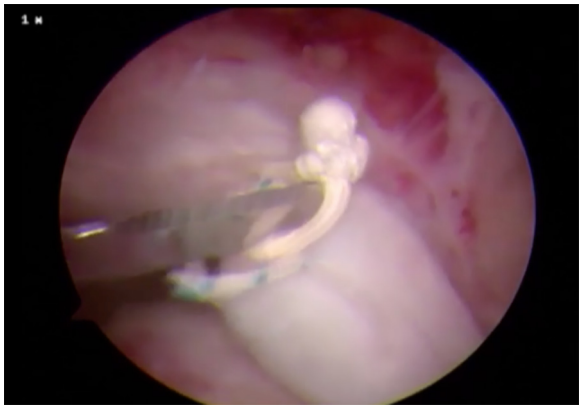

Fig 5. Arthroscopic view from the lateral portal in a right shoulder with the patient in the beach chair position shows a scalpel blade being introduced into the subacromial space from the posterior portal, and suture material is cut to aid in removal.

while preserving the comma tissue (Figs 6 and 7). After additional scar tissue and capsular releases, the rotator tendon tissue, superior capsule, and other laminated rotator cuff tissue can now be adequately mobilized for anatomic footprint coverage (Fig 8).

Attention is then turned to reattaching the rotator cuff tissue to the greater tuberosity with the goal of anatomic reduction in a low-tension state. Two triple-loaded anchors (Healicoil; Smith & Nephew) are chosen for this patient not only because of the number of sutures available per anchor but also on the basis of the fact that this anchor's design allows for venting of marrow elements through the anchor's core as a consequence of the anchor's open internal architecture. These two anchors are inserted into the tuberosity in an orientation that will accommodate suture placement in a double-row rip-stop orientation.[6] The double-row rip-stop results in an interconnected suture construct that

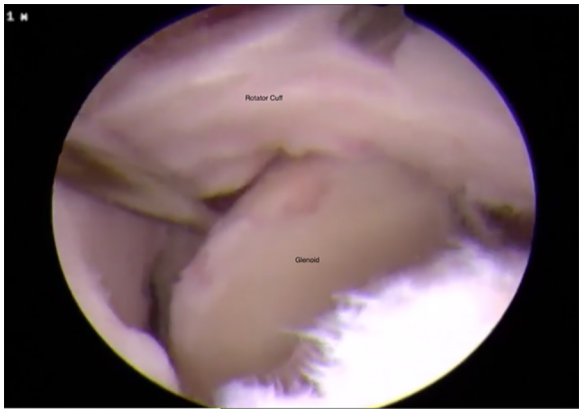

Fig 6. Arthroscopic view from the lateral portal in a right shoulder with the patient in the beach chair position visualizing an arthroscopic shaver being passed from the subacromial space into the glenohumeral joint and used to complete a capsular release

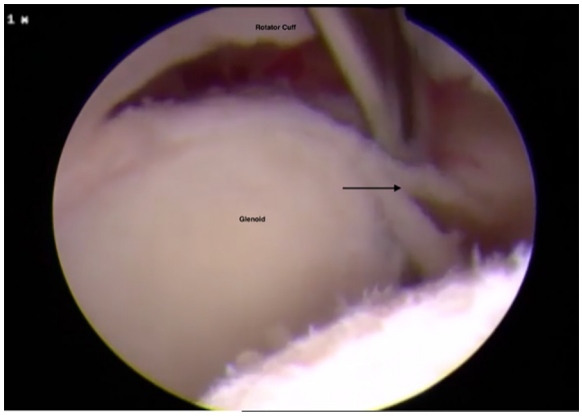

Fig 7. Arthroscopic view from the lateral portal in a right shoulder with the patient in the beach chair position visualizing an arthroscopic shaver being passed from the subacromial space into the glenohumeral joint and used to release the coracohumeral ligament indicated by the black arrow.

aids in the strength of the overall rotator cuff repair. This technique is especially well suited for patients with relatively poor tissue quality, as is often seen in revision rotator cuff repair situations. The additional compressive area created by the double-row rip-stop configuration along with the mattress suture orientation that reduces the chances of more medially placed simple suture cutting out of the tendon decreases the tensile point loads at suture/tendon perforations, thus inhibiting the primary mechanism of repair failure. Thus the mattress sutures within the double-row rip-stop configuration effectively act as a "rip-stop" of the more medially placed simple sutures.

In addition to the venting that was accommodated by the anchors, additional stimulation and perforation of the greater tuberosity cortex was accomplished using

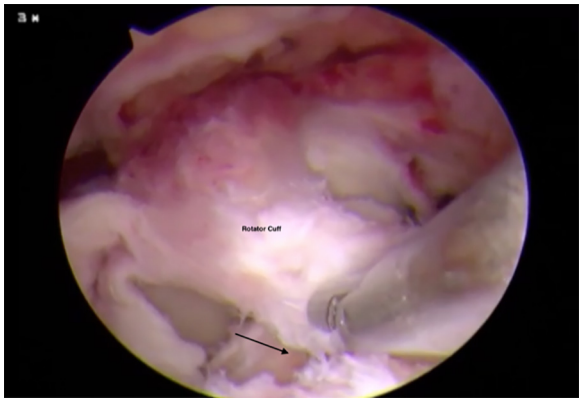

Fig 8. Arthroscopic view from the lateral portal in a right shoulder with the patient positioned in the beach chair position showing an arthroscopic grasper being introduced into the subacromial space; after release of adhesions, the rotator cuff is able to be mobilized to the anatomic footprint indicated by the black arrow.

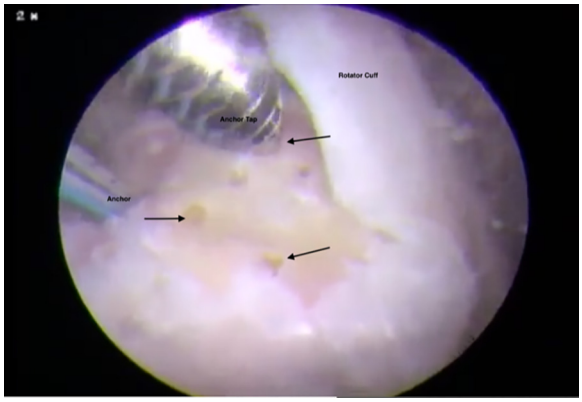

Fig 9. Arthroscopic view from the lateral portal in a right shoulder with the patient in the beach chair position showing an anchor tap being used to stimulate bone marrow on the greater tuberosity in the "Crimson Duvet" technique indicated by the black arrows.

the "Crimson Duvet" technique (Fig 9). The resulting clot is thought to provide additional mesenchymal stem cells and growth factors from the greater tuberosity to aid in the subsequent tendon-to-bone healing. Next, these triple-loaded anchor sutures are passed through the tendon (Fig 10). After the completion of suture passage and knot tying, a bioinductive patch (Regeneten; Smith & Nephew) is inserted from the lateral portal and placed on the superior aspect of the rotator cuff tendon as an adjunct to potentially aid in healing of the revision rotator cuff repair (Fig 11). The patch is then secured via a combination of tendon anchor pins and bone anchors per the manufacturer's recommended protocol. The final repair is then carefully assessed to confirm secure fixation, and the arthroscopy portals are then closed in standard fashion.

The authors individualize postoperative rehabilitation protocols for each patient on the basis of a number

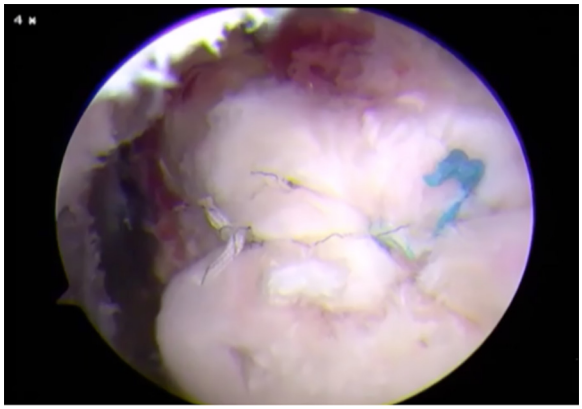

Fig 10. Arthroscopic view from the lateral portal in a right shoulder with the patient in the beach chair position showing tissue fixation using a double-row rip-stop suture configuration and triple-loaded anchors.

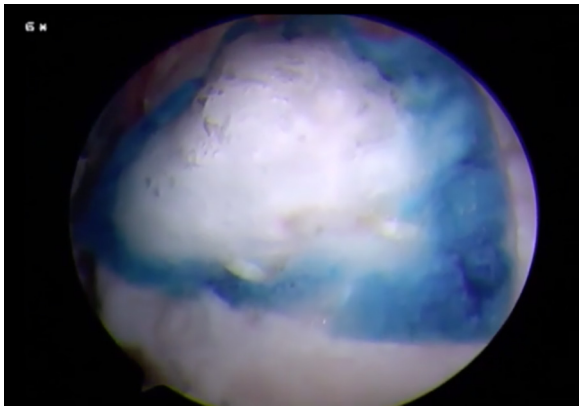

Fig 11. Arthroscopic view from the lateral portal in a right shoulder with the patient in the beach chair position showing a bioinductive patch that was placed on the superior surface of the repaired rotator cuff tendon.

of criteria including the size of the tear and security of the repair construct, along with tendon quality and the surgeon's assessment of an individual patient's likelihood of remaining compliant with restrictions. The patient highlighted in the accompanying video was immobilized for the first 3 weeks, followed by the initiation of passive and active assisted range of motion exercises for the subsequent 5 weeks. Strengthening exercises were then started at 8 weeks after operation and were continued for 6 weeks, after which time the patient was released from the author's care.

Discussion

As the number of rotator cuff repairs increases annually, so does the necessity for revision rotator cuff repair. As such, shoulder surgeons should be well versed in the techniques available to aid in the repair of these often-complex problems. The technique for arthroscopic revision repair was well described by Lo and Burkhart[2] in 14 patients treated arthroscopically, with their patients reporting significant improvements in outcomes scores, forward elevation, and external rotation. Indeed, arthroscopic techniques have many advantages over open revision repair. Arthroscopically, the surgeon can evaluate the glenohumeral and subacromial spaces more thoroughly and, if additional pathology is noted, can address these issues before re-repairing the rotator cuff tendon tear.[2,3]

Revision rotator cuff repairs can be quite difficult to accomplish even in the hands of very experienced surgeons. The elevated risks associated with revision cuff repair are ever-present and none more inherent than the failure of the index repair. Beyond the more mechanical issues of tendon quality, scar, and retraction, patient age and inflammatory factors may significantly impede repair healing. This article describes several different techniques that can be used concurrently to aid in the repair and subsequent healing of these tendons. The rotator cuff tissue can often be of poorer quality than for index repair situations and can also be difficult to identify due to adhesion and scar tissue formation. Once the surgeon has identified the rotator cuff tissue, advancing the tendons to the greater tuberosity can be difficult as well because of retraction and inelasticity. Techniques such as capsular release and anterior/posterior interval slides in selected cases may aid in mobilization of retracted rotator cuff tissue.[3,8] The choice of suture repair construct is also important in revision rotator cuff repair cases because the tissue is often of inferior quality, and the repair has the best chance of healing when reapproximated in a low-tension state. Failure at the suture-tendon interface has been shown to be the primary mode of cuff repair failure.[9] A double-row rip-stop repair technique was used in this specific case to

Table 1. Surgical Pearls and Pitfalls of Revision Rotator Cuff Repair: A Comprehensive Approach and Step-Wise Technique

Pearls
Use of a double-row rip-stop construct allows for an interconnected suture construct that can increase the strength in a revision rotator cuff repair.
It is important to adequately mobilize the rotator cuff to establish a low-tension reapproximation to the greater tuberosity.
Supplementing revision rotator cuff repairs with a bioinductive patch can aid in healing of soft tissue to bone in revision situations.
Bone marrow stimulation at the greater tuberosity can aid in creating an advantageous healing environment for rotator cuff repairs.
Pitfalls
Failure to identify any delaminated tears in the rotator cuff can potentially negatively impact the chances for revision rotator cuff repair healing.
Failure to adequately resect tissue adhesions or mobilize rotator cuff tissue may result in a higher tension repair construct that may contribute to failure of the revision rotator cuff repair to heal after surgery.

Table 2. Advantages and Disadvantages of Revision Rotator Cuff Repair: A Comprehensive Approach and Stepwise Technique

Advantages
Use of a comprehensive approach for revision rotator cuff repairs can allow for greater likelihood for repair healing and can help to avoid the necessity for a more-invasive procedure such as a reverse shoulder arthroplasty.
Following an orderly step-wise approach will allow one to address each component that may complicate revision rotator cuff repairs, thus enhancing the success rate of the repair.
Disadvantages
Failure to identify patients with poor tissue quality can result in failure of the revision rotator cuff repair.
Surgeon experience with complex tears and mobilization of adhered rotator cuff tissue can potentially influence the likelihood of a successful revision.

maximize fixation while, it is hoped, avoiding overtensioning of the tissue. This rip-stop repair technique has been shown in biomechanical studies to significantly reduce suture cutout when compared to single-row techniques.[7]

Providing an optimal biologic environment is desirable to maximize the chances of rotator cuff healing. Bone marrow stimulation and supplemental bioinductive patch use are adjunctive techniques that have the potential to aid in the healing process.[10] The so-called "Crimson Duvet" technique allows for mesenchymal stem cells to be released after mechanical perforation of the bone marrow at the greater tuberosity. These mesenchymal cells have the potential to promote bone to soft tissue healing of the rotator cuff repair via the formation of a biologically active clot at the bone/soft tissue interface.[6] Commonly experienced technique "Pearls and Pitfalls" are shown in Table 1 and the "Advantages and Disadvantages" associated with revision cuff repairs are shown in Table 2.

In conclusion, complicating anatomic factors along with a relatively poor healing environment and reduced tendon durability often result in unique challenges for the surgeon when performing revision rotator cuff repairs. A stepwise approach that minimizes tissue tension and maximizes fixation strength and that also incorporates proven adjunctive techniques[1-4] is important toward the goal of achieving successful outcomes in revision rotator cuff repair surgery.

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