Arthroscopic rotator cuff repair: Double rows & suture bridge technique

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신 상 진

A. Goals of rotator cuff repairs

1. High initial fixation strength
2. Minimize gap formation
3. Maintain mechanical stability under cycling loading
4. Optimize the biology of the tendon-bone healing

B. Background for double-row rotator cuff repair technique

- Healed rotator cuffs have better function
- Early rotator cuff failures and retears from anchors pulling out of bone, suture failures and knot loosening are somewhat solved due to improvement of anchor and suture materials, and knot tying techniques.
- Despite improved rotator cuff repair techniques, postoperative complications such as the persistent tear rate and structural failure of repaired tendon regardless of open or arthroscopic technique remain remarkably high, suggesting that current repair techniques fail to restore the anatomic contact area in tendon footprint and a sufficient healing environment after repair.
- To improve the healing environment between tendon and bone, new rotator cuff repair techniques have been developed to better restore the supraspinatus footprint.
- The greater the extent to which a given repair covers and secures tendon over the healing zone, the greater the chance for tendon-bone healing.
- In 2002, mini-open roator cuff repair using a 2-row fixation technique revealed good clinical outcomes[3].

C. Different rotator cuff repair techniques

1. Transosseous repairs: sutures are placed directly through transosseous tunnels (Fig. 1A)
2. Single-row repairs: suture anchor placed in a linear fashion (usually 1 to 2 anchors placed laterally) (Fig. 1B)
3. Double-row repairs: configuration of a medial row of suture anchors placed at the articualr

cartilage margin of the anatomic neck and a second more laterally placed row along the tuberosity (Fig. 1C)

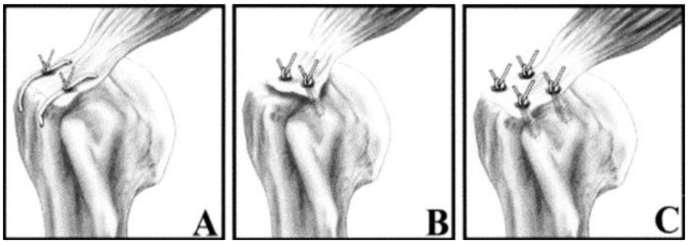


Fig. 1. (**A**) Transosseous repairs (**B**) Single-row repairs (**C**) Double-row repairs

4. Transosseous equivalent repairs (suture bridge technique): use suture anchors to achieve what is considered to resemble biomechanically traditional open transosseous repairs (Fig. 2)
: two traditional suture anchors are used to secure the medial side of the torn tendon. The sutures are placed through the tendon in a horizontal mattress fashion and are not cut. The suture tails are passed through into the Pushlock anchors, which are inserted into the lateral aspect of the footprint. The suture tails are tensioned over the cuff thereby achieving the same purpose as a standard transosseous repair.

Fig. 2. Transosseous equivalent repairs

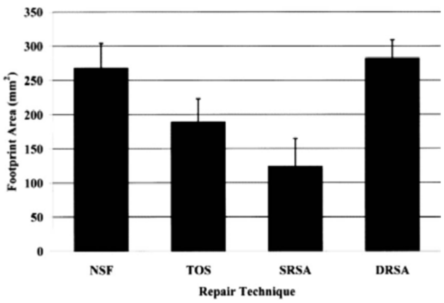
D. Biomechanical studies on different repair techniques

1. Double-row vs Single-row repair
- Double-row repairs had 42% less gap formation, 46% more stiffness, 48% more ultimate load to failure; by increasing the footprint area of repair, theoretically, there may be ab increased rate of repair of the rotator cuff tendon, which may lead to early greater strength[6].
- Double-row repairs configurations were the most successful in restoring the repair footprint[10].

- Double-row repairs showed similar gap formation but significantly higher ultimate tensile load than the three types of single-row fixation stitches[9].
- Double-row repair is significantly more resistant to cyclic displacement than single-row repair in both tension-free and tension repair[12].
- Double-row repairs demonstrated superior resistance to gap formation under static loading as compared with single-row technique[17].
- Single-row repairs with modified suture configurations may lead to comparable results with several double row fixation[8].

2. Transosseous vs Single- row repair
- Transosseous repairs were superior to single-row in ultimate load to failure, interface motion, restoring footprint, and achieving the best pressure on the repair[2].
- Contact area of transosseous technique was 31% greater than that of single row technique[19].

3. Transosseous vs Double-row vs Single-row repair
- High stress concentration in single and double-row techniques at the anchor site[16].
- Double-row technique consistently reproduced 100% of the original supraspinatus footprint, whereas the single-row technique and transosseous simple suture technique reproduced only 46% and 71% of the insertion sites. Double-row technique showed higher initial mechanical strength[11]. (Fig. 3A)
- Double-row repair had highest number of cycles to failure[20]. (Fig. 3B)
- Contact area of double-row technique was 42% greater than that of transosseous technique and 60% greater than that of single-row technique. Average contact pressure of the double-row and single-row technique were 16% and 18% greater, respectively, than that of transosseous technique[19].



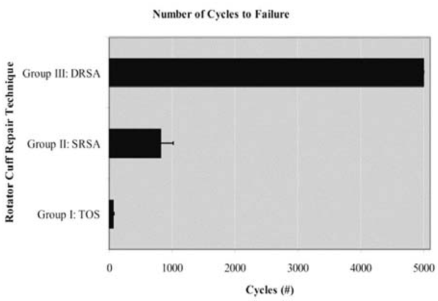


Fig. 3. (**A**) Footprint area for original tendon and each repair technique. (**B**) Number of cycles to failure for each repair technique. NSF: Normal tendon, TOS: Transosseous repairs, SRSA: Single-row repairs, DRSA: Double-row repairs

4. Transosseous equivalent vs Double-row repair
- Transosseous equivalent repair had higher ultimate load and similar initial stiffness and

gap formation compared to double-row repair (Table 1).
- 4 suture bridge transosseous equivalent repair clearly had best contact area and pressure over footprint compared with transosseous equivalent and double row repair[14].
- Transosseous equivalent technique restored to 75% to 150% of the original footprint.
- Suture anchor tension the tendon itself rather than provide a compressive vector over the tendon toward the bony footprint. Suture bridges provide significantly more compression compared with suture anchor techniques[13].
- Yield load for the transosseous equivalent repair was larger than double row technique when allowing for external rotation during load testing. External rotation can accentuate gap formation anteriorly at a repaired rotator cuff footprint. No differences for gap formation, sytiffness, ultimate load to failure and energy absorbed to failure between 2 repairs[15].
- Double-row repair using double anchors had highest ultimate tensile load and smallest gap formation under cycling load compared to transosseous equivalent and single-row technique[8].
- Transosseous equivalent repair had highest ultimate load to failure and were the most resistant to rotational and shear forces and most closely restored the native footprint leading to minimal gap formation[2].

Table 1. mechanical properties of double-row and transosseous equivalent techniques.

	Double row	Transosseous equivalent	P value
Initial stiffness (N/mm)	33.8±15.8	47.5±31.1	.274
Yield load (N)	214.3±31.1	260.3±69.5	.196
Ultimate load (N)	299.2±52.5	443.0±87.8	.029
Gap at ultimate (mm)	3.47±0.78	5.88±3.42	.150
Area (mm^2)	124.2±16.3	63.3±28.5	< .05

E. Clinical outcomes after Double-row rotator cuff repairs

- Similar subjective functional outcomes but better structural outcome (cuff integrity) evaluated using MRI than single row[18].
- 89% of the double-row cuff repairs were intact by US[5].
- Only 11.4% of patients had structural failure[7].
- Double and single-row technique showed similar clinical results, but tendon healing rates were better with the double-row anchorages[1].
- Double-row technique produces a mechanically superior construct compared with the single row method in restoring the anatomical footprint of the rotator cuff, but these mechanical

advantages do not translate into superior clinical performance[4].

F. Disadvantages of double-row repair

- Surgical time, complexity, added cost

G. Conclusion

- Partial thickness and full thickness rotator cuff tear under 12 mm in length: Single-row repair may be sufficient
- Double-row fixation can be used in management of rotator cuff tears and may be mechanically superior to single-row repairs in terms of load to failure, cyclic displacement, and gap formation.
- A double-row technique produces a mechanically superior construct compared with the single-row method in restoring the anatomic rotator cuff footprint, and biomechanical studies show that a double-row suture anchor repair increased the tendon-bone contact area, which may provide a better environment for tendon-bone healing.
- No clinical studies have shown superior results for double-row repairs compared to single-row repairs concerning the failure rate of the reconstruction and the clinical outcome.
- The mechanical advantages of double-row repair evidenced in cadaveric studies do not translate into superior clinical performance when compared with single-row technique.
- Surgeon should choose the best form of fixation for each individual patient.

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