Arthroscopic Rotator Cuff Repair

A Systematic Review of Overlapping Meta-Analyses

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Abstract

Background: Rotator cuff tears are a common pathology, with an increasing number of repairs being performed arthroscopically. The purpose of this study was to systematically review the results in the current meta-analyses on arthroscopic rotator cuff repair, looking specifically at double-row repair compared with single-row repair, at whether platelet-rich plasma should be used adjunctively at the time of the surgical procedure, and at the effects of early-motion compared with late-motion rehabilitation postoperatively.

Methods: MEDLINE, Embase, and the Cochrane Library were screened for meta-analyses on arthroscopic rotator cuff repair. The levels and quality of the evidence were assessed, and the clinical outcomes were evaluated. A significant result was defined as $p < 0.05$.

Results: Twenty-four meta-analyses were identified, with 10 meta-analyses on double-row repair compared with single-row repair, 7 meta-analyses on platelet-rich plasma compared with a control, and 7 meta-analyses on early motion compared with late motion. Studies found a significant result in terms of reduced retear rates and/or increased tendon-healing rate for double-row repair (6 of 10 studies; $p < 0.05$), without a clinically important improvement in functional outcomes (0 of 10 studies). There was a favorable outcome when using platelet-rich plasma in small-to-medium tears in terms of a reduced rate of retear (4 of 4 studies; $p < 0.05$). However, in the 1 study in which platelet-rich plasma was stratified into pure platelet-rich plasma and platelet-rich fibrin matrix preparation, there was a significantly lower retear rate for tears of all sizes with platelet-rich plasma and not with platelet-rich fibrin ($p < 0.05$). Range of motion was shown to be significantly better with early motion (5 of 6 studies; $p < 0.05$) in the majority of the meta-analyses, without an increased risk of retear (6 of 6 studies; $p > 0.05$).

Conclusions: The highest Level of Evidence and the highest-quality studies all supported the use of double-row repair, adjunctive platelet-rich plasma, and early-motion rehabilitation postoperatively in arthroscopic rotator cuff repair.

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

Rotator cuff tears are a common pathology, with 250,000 to 300,000 rotator cuff repairs being performed annually in the United States, and an increasing number of these are being performed arthroscopically[1,2]. However, within arthroscopic rotator cuff repair, there is still a lack of consensus as to the optimal surgical technique, use of adjuvant biologics, and postoperative rehabilitation, and the topic has

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remained controversial. Multiple high-quality meta-analyses on double-row repair compared with single-row repair, on whether platelet-rich plasma should be used adjunctively at the time of the surgical procedure, and on the effects of early-motion compared with late-motion rehabilitation postoperatively have been published in recent years, with conflicting conclusions[3-5].

Double-row repair was developed following the initial failure rates of single-row repair and is theoretically advantageous because of the restoration of the native anatomic footprint of the rotator cuff[3,6]. Biomechanical studies have shown that double-row repair has increased mechanical strength, has decreased gap formation, has improved tendon-to-bone contact, and has increased footprint coverage. However, there is still controversy as to whether this translates to better functional outcomes and lower retear rates[6-12].

Platelet-rich plasma is plasma with an increased concentration of platelets and growth factors that can be used either as an isolated therapy or as an adjunct to the surgical procedure. Platelet-rich plasma was initially used in cardiac surgery, but has been increasingly used to enhance tendon-healing in many areas of orthopaedics over the past 20 years. Despite the fact that many clinical and in vitro studies on rotator cuff healing have been encouraging, some studies still refute its efficacy[13-16]. Additionally, platelet-rich plasma has remained difficult to assess because of differences in preparation methods, leading to debate over whether there is a superior preparation method.

Rehabilitation is an important aspect of arthroscopic rotator cuff repair, but protocols have not been standardized and are often based on surgical preference, rather than scientific evidence[17]. Traditionally, there has been prolonged immobilization postoperatively, out of concern for tendon-healing, and, although the rate of postoperative stiffness is lower with arthroscopic techniques, it is still problematic. Recent studies have suggested that early motion may lead to improved range of motion and decreased stiffness[18]. However, there is concern that this can lead to increased retears from mobilization before the rotator cuff tendon is healed adequately.

Meta-analyses amalgamate the results in the literature in a standardized fashion; however, these results can offer conflicting information due to differences in authors' methodologies. Therefore, the purpose of this study was to systematically review the results in the current meta-analyses in arthroscopic rotator cuff repair to ascertain whether there was a consensus on double-row repair compared with single-row repair, on whether platelet-rich plasma should be used adjunctively at the time of the surgical procedure, and on the effects of early motion compared with late motion postoperatively. The outcomes from this study will help to guide surgeons on the best treatment options for patients on the basis of the highest levels of current evidence.

Materials and Methods

Search Strategy

A systematic review of the MEDLINE, Embase, and Cochrane Library databases was performed by 2 independent reviewers based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines in February 2017, with a senior author resolving any differences[19]. The following algorithm was used for the search: ((meta-analysis) OR (meta analysis) OR systematic review)) AND ((prp//) OR (platelet rich plasma) OR (platelet-rich plasma) OR (single row) OR (double row) OR (early motion) OR (late motion) OR (rehabilitation)) AND ((arthroscopic rotator cuff repair) OR (arthroscopy rotator cuff repair)). No time limit was given with respect to publication date, to include all relevant publications. The titles and abstracts were screened using specific inclusion and exclusion criteria, and full texts of potentially relevant studies were then reviewed. The references of all publications found in the search results were screened for additional articles not identified through our electronic search.

Inclusion and Exclusion Criteria

The inclusion criteria were that the study was a meta-analysis on arthroscopic rotator cuff repair, it was published in a peer-reviewed journal, it was written in English, and the full text of the study was available. The exclusion criteria were a Level of Evidence poorer than II and reported data that were not pooled.

Data Analysis

The Level of Evidence was evaluated on the basis of previously published criteria by the Oxford Centre for Evidence-based Medicine[20]. The methodological quality of evidence was evaluated using the Assessing the Methodological Quality of Systematic Reviews (AMSTAR) scale. AMSTAR is a scale used to assess the quality of meta-analyses, with a score of 0 to 4 representing low quality, a score of 5 to 8 representing moderate quality, and a score of 9 to 11 representing high quality[21].

The data of each meta-analysis were then extracted using a standardized data sheet consisting of a predetermined list of the information that we required. Each meta-analysis was categorized into one of the following subgroups: double-row repair compared with single-row repair, platelet-rich plasma compared with no platelet-rich plasma, and early motion compared with late motion. These subgroups were evaluated with respect to the rates and significance of their outcomes: retear rate; tendon-healing rate; and functional outcomes including the University of California at Los Angeles (UCLA) shoulder score[22], the American Shoulder and Elbow Surgeons (ASES) score[23], and the Constant score[24]. Range of motion was evaluated for studies examining rehabilitation protocols.

Statistical Analysis

All statistical analysis was performed using a commercially available statistical

software package (SPSS version 22.0 [IBM]). Descriptive statistics were calculated for each study and quantitative statistical parameters were analyzed using SPSS version 22.0 (IBM). Results were classified on whether they were significant in favor of 1 group or neutral when no significance was found. The methodological quality of evidence was measured and the mean was calculated. The results in the tables were organized in descending order of quality based on the Level of Evidence, methodological quality of evidence, number of included patients, and number of included studies; these rankings were used to find the best evidence when no consensus was reached. A significant result was defined as $p < 0.05$.

Results

The literature search revealed 189 total studies and 149 studies after the duplicates were removed. Twenty-four meta-analyses were identified (Fig. 1), overall with 11,518 overlapping patients, with 10 meta-analyses on double-row repair compared with single-row repair, 7 meta-analyses on platelet-rich plasma compared with a control, and 7 meta-analyses on early motion compared with late motion.

Double-Row Repair Compared with Single-Row Repair

There were 10 meta-analyses on double-row repair compared with single-row repair (Level I: 4, Level II: 6), with 4,789 overlapping patients (range, 303 to 807 patients) and 15 unique clinical trials[25-34]. The mean methodological quality of evidence score was 9 (7 high quality, 3 moderate quality). Table I shows the study characteristics and reported clinical outcomes.

Retear rates were reported in 7 of 10 meta-analyses, with rates ranging between 13% and 27% for double-row repair and between 17% and 43% for single-row repair[26,27,29,30,32-34]. The majority of the studies (4 of 7) showed a significantly lower rate of retear in double-row repair ($p < 0.05$), including the 2 Level-I studies[23,25,27,29]. The study with the highest Level of Evidence and methodological quality of evidence showed that double-row repair resulted in a significantly lower retear rate ($p < 0.05$)[26]. One study showed a significantly lower rate of retear in single-row repair ($p < 0.05$)[29].

Tendon-healing rates were reported in 5 of 10 meta-analyses, with rates in 4 studies ranging between 65% and 78% for double-row repair and between 46% and 83% for single-row repair[26,29,31,34] and rates in 1 study[25] not listed but calculated as significant. The majority of the studies (3 of 5) showed a significantly higher rate of tendon-healing in double-row repair ($p < 0.05$), including the 2 Level-I studies with the highest methodological quality of evidence[23,24,32]. One study showed a significantly higher rate of tendon-healing in single-row repair ($p < 0.05$)[29].

All of the included studies measured functional outcomes in the form of the UCLA shoulder score, the ASES score, and the Constant score. Double-row repair was shown to have a significantly improved UCLA score (5 of 10 studies) and a significantly improved ASES score (2 of 10 studies) ($p < 0.05$)[25-27,29,31,32]. No study showed an improved Constant score for

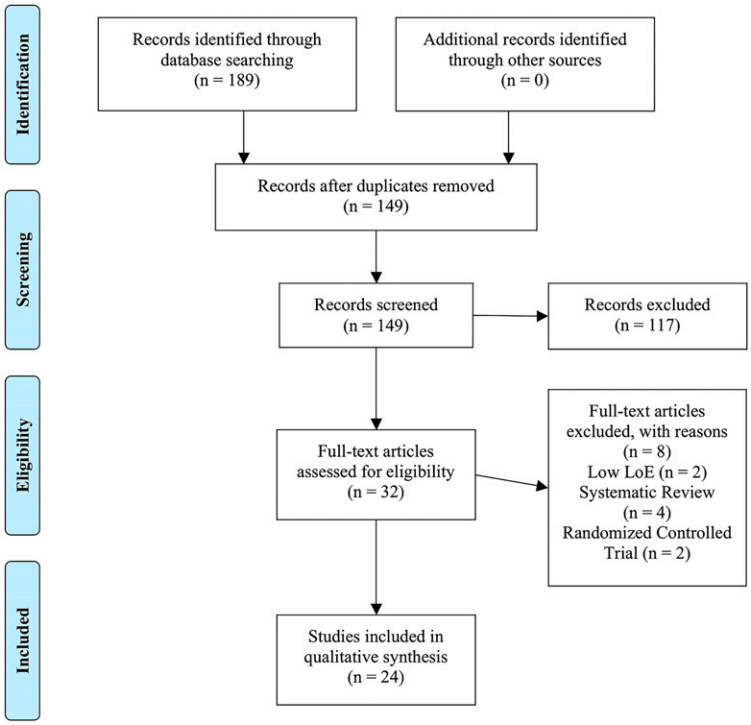

Fig. 1

PRISMA study selection flow diagram. LoE = Level of Evidence.

TABLE I Meta-Analyses Comparing Double-Row Repair and Single-Row Repair*

Study	LOE	Methodological Quality of Evidence	No. of Patients	No. of Included Studies	Retear Rate	Tendon-Healing Rate	Scores		
							UCLA	ASES	Constant
Chen[25] (2013)	I	10	506	6	NR	NR†	DRR‡	NS	NS
Zhang[26] (2013)	I	10	454	8	20% vs. 42%‡	78% vs. 63%‡	DRR‡	DRR‡	NS
Millett[27] (2014)	I	9	567	7	14% vs. 26%‡	NR	DRR‡	NS	NS
Sheibani-Rad[28] (2013)	I	9	349	5	NR	NR	NS	NS	NS
Ying[29] (2014)	II	10	807	7	27% vs. 17%§	73% vs. 83%§	DRR‡	NS	NS
Shen[30] (2014)	II	9	428	6	18% vs. 31%‡	NR	NS	NS	NS
Perser[31] (2011)	II	9	303	5	NR	69% vs. 57%	DRR‡	NS	NS
Xu[32] (2014)	II	8	651	9	24% vs. 40%‡	NR	NS	DRR‡	NS
DeHaan[33] (2012)	II	8	446	7	27% vs. 43%	NR	NS	NS	NS
Prasathaporn[34] (2011)	II	8	308	5	13% vs. 32%	65% vs. 46%‡	NS	NS	NS

*LOE = Level of Evidence, NR = not reported, and NS = nonsignificant. †The specific value was not reported, but the authors calculated it to be significant. ‡Significant in favor of double-row repair (DRR). §Significant in favor of single-row repair.

either treatment. No outcome was improved in any other functional measure for single-row repair (the UCLA shoulder score, the ASES score, and the Constant score).

Platelet-Rich Plasma Compared with No Platelet-Rich Plasma

There were 7 meta-analyses on platelet-rich plasma compared with no platelet-rich plasma (1 Level-I meta-analysis and 6 Level-II meta-analyses), with 4,037 overlapping patients (range, 303 to 1,147 patients) and 18 unique clinical trials[35-41]. The mean methodological quality of evidence score was 9.3 points (all high-quality). The majority of studies pooled mixed preparation methods; however, 1 study subdivided into pure platelet-rich plasma and the platelet-rich fibrin matrix preparation[36]. Table II shows the study characteristics and reported clinical outcomes.

The overall retear rates were reported in all meta-analyses, with rates ranging between 15% and 29% with platelet-rich plasma and between 25% and 38% with no platelet-rich plasma[35-41]. The Level-I meta-analysis and 1 Level-II study were the only studies that showed an overall significantly lower rate of retear with platelet-rich plasma ($p < 0.05$), and the rest of the included meta-analyses found no difference in overall tears when using platelet-rich plasma[35,36]. When analyzing small-to-medium tears (1 to 3 cm), there was a significantly lower rate of retear in all studies (4 of 4) when using platelet-rich plasma ($p < 0.05$)[35,36,38,41]. Additionally, 1 study found that there was a significantly lower rate of retear when subdividing into pure platelet-rich plasma and the platelet-rich fibrin matrix preparation ($p < 0.05$)[36]. In the study in which platelet-rich fibrin matrix was evaluated by itself, there was no

TABLE II Meta-Analyses of Outcomes with and without Platelet-Rich Plasma (PRP)*

Study	LOE	Methodological Quality of Evidence	No. of Patients	No. of Included Studies	Retear Rate	Scores		
						UCLA	ASES	Constant
Cai[35] (2015)	I	9	303	5	15% vs. 30%†	NS	NS	NS
Hurley[36] (2018)	II	10	1,147	18	17.2% vs. 38.3%†	PRP†	NS	PRP†
Zhao[37] (2015)	II	10	444	8	26% vs. 28%	NS	NR	NS
Vavken[38] (2015)	II	9	778	13	13% difference	NR	NR	NR
Warth[39] (2015)	II	9	597	11	29% vs. 37%	NS	NS	NS
Li[40] (2014)	II	9	417	7	27% vs. 25%	NS	NS	NS
Zhang[41] (2013)	II	9	351	7	19% vs. 27%	NS	NS	NS

*LOE = Level of Evidence, NS = nonsignificant, and NR = not reported. †Significant in favor of PRP.

TABLE III Meta-Analyses Comparing Early Motion and Late Motion*

Study	LOE	Methodological Quality of Evidence	No. of Patients	No. of Included Studies	Retear Rate	Range of Motion			ASES
						3 Months	6 Months	12 Months	
Kluczynski[17] (2015)	I	8	353	4	14% vs. 11%	NR	NR	NR	NR
Chen[42] (2015)	II	10	348	4	18% vs. 10%	NR	EM†	EM†	EM†
Chang[43] (2015)	II	9	482	6	NS	EM†	EM†	EM†	NR
Riboh[44] (2014)	II	9	451	5	16% vs. 20%	EM†	NS	NS	NR
Chan[45] (2014)	II	9	345	4	NS	NS	NR	NR	NS
Shen[46] (2014)	II	9	265	3	17% vs. 15%	NR	EM†	NS	NS
Huang[47] (2013)	II	8	448	6	23% vs. 13%	NR	EM†	EM†	NR

*LOE = Level of Evidence, NR = not reported, and NS = not significant. †Significant in favor of early motion (EM).

significant difference in the retear rate in tears of any size ($p > 0.05$)[36].

The majority of studies measured clinical outcomes in the form of the UCLA shoulder score, the ASES score, and the Constant score. The UCLA shoulder score and the Constant score were improved only with pure platelet-rich plasma in 1 study[36], when subdividing into pure platelet-rich plasma and the platelet-rich fibrin matrix preparation ($p < 0.05$), but not in any other functional outcome measures (6 studies) in any other study for platelet-rich plasma (the UCLA shoulder score, the ASES score, and the Constant score)[35,37-41].

Early-Motion Compared with Late-Motion Rehabilitation

There were 7 meta-analyses on early motion compared with late motion (Level I: 1, Level II: 6), with 2,692 overlapping patients (range, 265 to 482 patients) and 8 unique clinical trials[17,42-47]. The mean methodological quality of evidence score was 8.9 (5 high quality, 2 moderate quality). Table III shows the study characteristics and reported clinical outcomes.

Retear rates were reported in all meta-analyses, with rates ranging between 14% and 23% with early motion and between 10% and 20% with late motion[17,42-47]. No single study showed a significant difference in retear with either rehabilitation protocol.

Range of motion was reported in all studies, but with varying time points between 3, 6, and 12 months[17,42-47]. Range of motion was shown to be significantly better ($p < 0.05$) with early motion in the majority of the meta-analyses at 3 months (2 of 3 studies), 6 months (4 of 5 studies), and 12 months (3 of 5 studies)[17,42-47]. The study with the highest methodological quality of evidence showed at all 3 follow-up intervals that early motion significantly improved the range of motion ($p < 0.05$)[42]. The only Level-I study did not evaluate range of motion[17]. Three meta-analyses showed the functional outcomes in the form of the ASES score, with 1 study showing a significant outcome in favor of early motion ($p < 0.05$), although this did not reach clinical importance[42,45,46].

Discussion

This current study reviewed the clinical results of meta-analyses on the comparison between double-row repair and single-row repair, on whether platelet-rich plasma should be used adjunctively at the time of the surgical procedure, and on the effects of early motion compared with late motion postoperatively in arthroscopic rotator cuff repair. The advantage of a systematic review of meta-analyses is that it provides a guide to navigate through the discrepancies in the current best available evidence to optimize treatment recommendations.

Although the individual meta-analyses based on recent clinical trials offer conflicting information, this is due to the different methodologies and search criteria[3,4]. All of the current meta-analyses on arthroscopic rotator cuff repair were conducted between 2011 and 2018, which has contributed to the volume of available studies as multiple authors published their research simultaneously. Despite differences in the meta-analysis designs, our review found that there was a consensus with regard to most of the outcomes measured.

The results of our study show evidence of the superiority of double-row repair in terms of healing and retear, as the majority of the studies showed that double-row repair resulted in a significantly lower rate of retear and an increased rate of tendon-healing, including all 3 Level-I studies evaluating this outcome[25-27]. Those that did not generally still showed a trend toward significance in favor of double-row repair, and only 1 study showed that single-row repair resulted in a lower retear rate and a higher tendon-healing rate[29]. The differences in tear sizes included in each study may have confounded the outcomes, as several authors have shown that the improvement in retear and tendon-healing rates is greater in larger tears than in small-to-medium tears[25,26,29].

Although it had been proposed that double-row repair would lead to

improved functional outcomes due to the increased mechanical strength, decreased gap formation, and improved tendon-to-bone contact, the 2 techniques were shown to have similar functional outcomes[25-34]. The UCLA shoulder score was shown to be significantly higher in half of the meta-analyses in favor of double-row repair, including 3 of 4 Level-I studies; however, none of them reached clinical importance[48]. The cost-effectiveness of double-row repair depends on the cost differences in each institution, as this is variable. A recent cost-benefit analysis by Genuario et al. found that, if the increase in the cost for double-row repair was less than $287 for small-to-medium tears and less than $352 for larger tears compared with the cost of single-row repair, then double-row repair would represent a cost-effective alternative for arthroscopic rotator cuff repair[49].

Our study found that the current evidence suggests that platelet-rich plasma may be a beneficial adjunct to arthroscopic rotator cuff repair. There was only 1 Level-I meta-analysis[35], which showed that platelet-rich plasma significantly reduced the risk of retear in all arthroscopic rotator cuff repairs, and only 1 other study found a significant difference in retear rate[36]. The discordance between the results can be explained by considering the different platelet-rich plasma preparations as a confounding factor, as only 1 study stratified the results by the preparation method[36]. Hurley et al. stratified their results into pure platelet-rich plasma and platelet-rich fibrin matrix preparation[36]. Although they are both processed from autologous blood, they differ as platelet-rich fibrin matrix is collected without anticoagulant and it forms a clot that must be sutured at the time of the surgical procedure. Hurley et al. found that platelet-rich plasma reduces the retear rate and improves functional outcomes and pain scores, but platelet-rich fibrin matrix does not have any benefit[36]. Clinical benefits were only seen in patient function in 1 study, and this may be a result of the difference in the retear rate[36]. A recent cost-benefit analysis[50] found that platelet-rich plasma is not cost-effective overall in arthroscopic rotator cuff repair as it would require a 9.1% reduction in retears (based on a $750 estimated platelet-rich plasma cost), but the current meta-analyses show that this threshold is reached in small-to-medium tears and thus may result in overall reduced health-care costs[36]. Platelet-rich plasma requires further study as to optimal dosing and preparation, as recent clinical studies have shown differences between the application of leukocyte-rich and leukocyte-poor platelet-rich plasma, and there is limited current evidence on which preparation method is superior.

Early motion postoperatively was shown to yield a significantly better range of motion at 3 to 6 months in the majority of the studies and at the 12-month follow-up in a lesser proportion of studies[42-44,46,47]. However, this did not translate into improved functional outcomes, as only 1 study showed a significant improvement in the ASES score, which did not reach clinical importance[42]. Questions remain as to whether this translates to an earlier return to work or sport as none of the current meta-analyses investigated this. Although there has been a concern that earlier movement would lead to a higher retear rate, it has been shown in all of the current meta-analyses that early motion did not increase the risk of retear[17,42-47]. However, some authors have suggested that the risk of retear is dependent on the tear size, with larger tears being at an increased risk for retear when using early motion rehabilitation, but small-to-medium tears having a lower risk for retear with early-motion rehabilitation[17,42]. The current meta-analyses have shown that early motion may be the best protocol for arthroscopic rotator cuff repair because of the ability to regain range of motion at an earlier stage without an increased risk of retear.

The search criteria were limited to MEDLINE, Embase, and the Cochrane Library, with only English articles included. As this is a systematic review, all of the limitations in the included studies are present in this study, including the differences in the search methodology. As the included meta-analyses overlapped and included the same randomized controlled trials, it was only possible to assess qualitative statistics. There were a multitude of confounding factors throughout the studies that may have affected the results. First, patient factors can be a deciding factor in choosing treatment and the included populations were heterogenous. Patient age, chronicity of the tear, and other demographic characteristics can play a role in the outcome. However, the majority of the included studies had homogenous outcomes, indicating uniform results across the studies. In double-row repair compared with single-row repair, only 1 study examined arthroscopic rotator cuff repairs with consistent rehabilitation methods. The surgical technique, such as the number of anchors placed on each row, also varies between the included randomized controlled trials. In the studies examining platelet-rich plasma and rehabilitation, the lack of consistency in operative methods and whether the repair is double-row or single-row can affect the results. In the studies using platelet-rich plasma, there was no consistency in the volume used or the preparation method, and only 1 study subgrouped platelet-rich plasma preparation methods on the basis of the preparation method[36]. Overall, subgroup analysis comparing small-to-medium tears and larger tears is necessary as the tear size has been shown to be influential on the clinical outcomes.

In conclusion, there is a large volume of meta-analyses in the literature on arthroscopic rotator cuff repair, and although the majority reached a similar outcome, there were some discrepancies. Although results were conflicting, the highest Level of Evidence and the highest-quality studies all point toward supporting the use of double-row repair for a reduced risk of retear and a higher tendon-healing rate, but this did

not lead to improved functional outcomes. There is strong, high-level evidence showing that adjunctive platelet-rich plasma reduced retears, but the platelet-rich fibrin preparation did not lead to a decreased retear rate. Early-motion rehabilitation improved range of motion at follow-ups of 3, 6, and 12 months in the majority of the studies, including the meta-analyses with the highest levels and quality of evidence. This was achieved without an increased risk of retear, suggesting that early-motion rehabilitation may be ideal to restore patients' functional range of motion earlier.

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