Figure 1 (A) Coronal slide of T2-weighted MRI image demonstrating (A) ulnar collateral ligament hyperintensity and (B) radiologic posteromedial impingement in two professional MLB pitchers.

from 2005 – 2017 for MRI images of their pitching elbow. Publically available databases were queried to exclude pitchers with injury prior to earliest elbow MRI. Three blinded reviewers, reviewed all MRI studies independently to evaluate for presence of chondral damage of the joint, loose bodies, UCL heterogeneity or tear, flexor pronator mass defect, and signs of posteromedial impingement. Binary imaging findings were related to future placement on the disabled list (DL) for elbow complaints and future elbow surgery.

Results: A total of 41 pitchers had asymptomatic MRI imaging with no prior DL placement. Average age of pitchers was 28.9 ± 4.6 and average career games was 115.0 ± 132.8. For players who eventually went on the DL, there were a statistically greater number of players with heterogeneous signal of the ulnar collateral ligament ($P = .021$), humeral sided partial tearing of the ulnar collateral ligament ($P = .031$), and posteromedial impingement ($P = .004$) on pre-injury MRI in comparison to players that remained healthy. Pitchers that were placed on the DL spent an average of 123.1 ± 69.7 days only due to elbow-related injuries. Pitchers with UCL heterogeneity were associated with reduced career strike zone percentage, innings pitched, and fastball percentage.

Conclusion: This study demonstrates that UCL heterogeneity, posterior medial impingement and humeral-sided partial tears are correlated with future placement on the DL in MLB pitchers. In addition, asymptomatic posteromedial impingement may be a precursor to future surgery. Overall, this data may prove useful for coaches, trainers and team physicians to appropriately risk stratify new players and establish preventative algorithms to prevent the overall impact of these elbow injuries (Fig. 1).

Paper #11   RISK FACTORS FOR ULNAR COLLATERAL LIGAMENT INJURY IN PROFESSIONAL AND AMATEUR BASEBALL PLAYERS: A SYSTEMATIC REVIEW WITH META-ANALYSIS

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Background: Ulnar collateral ligament injury (UCLI) risk factors are unclear despite increasing injury rates.

Hypothesis/Purpose: Summarize UCL injury risk factors across professional and amateur baseball players.

Study Design: Systematic review and meta-analysis

Methods: A computer-assisted search of four databases was performed utilizing keywords related to UCLI risk factors. The *Preferred Reporting Items for Systematic Reviews and Meta-Analyses*

(PRISMA) guidelines were utilized for study methodology. Odds ratio and 95% confidence interval (CI) were calculated for dichotomous outcomes, while mean differences and 95% CI were calculated for continuous outcomes using a random effects model. Risk of bias of the included studies was assessed using the modified Downs & Black grading tool.

Results: Of the 1255 identified studies, 13 qualified for inclusion. Greater shoulder internal rotation (IR) range-of-motion (ROM) at 90° abduction in the non-dominant (ND) arm demonstrated *strong evidence* as a significant risk factor for UCLI ($P < .001$) when compared to a control group [mean difference 6.2 (95% CI: 3.8 to 8.6). Mean pitching fastball ($P = .0003$) [mean difference 0.6 (95% CI: 0.29 to 1.00), changeup ($P = .03$) [mean difference 0.49 (95% CI: 0.04 to 0.94), curveball ($P = .01$) [mean difference 0.78 (95% CI: 0.18 to 1.38), and overall ($P < .001$); [mean difference 0.90 (95% CI: 0.86 to 0.94); $I^2 = 0\%$] pitching velocity; as well as fewer years of player experience ($P < .00001$) [mean difference -1.19 (95% CI: -1.41 to -0.96), less humeral retrotorsion in the ND arm ($P = .0009$) [mean difference 5.4 (95% CI: 2.2 to 8.5), and greater absolute side-to-side differences in retrotorsion ($P = .006$) [mean difference 6.2 (95% CI: 1.83 to 10.68) were all *moderate evidence* risk factors when compared to control groups. *Strong evidence* suggests total ROM arc in 90° abduction in dominant arm was not a risk factor for UCLI ($P = .81$) [mean difference -1.0 (95% CI: -9.4 to 7.3); $I^2 = 81\%$].

Conclusions: Greater ND shoulder IR ROM and less humeral retrotorsion (in professional and amateur players), as well as pitching velocity (in professional players) demonstrated strong to moderate evidence as risk factors for UCLI. Dominant arm total arc of motion, external, or internal ROM were not risk factors for UCLI. Standardized collection and reporting of risk factors is recommended to more clearly elucidate definitive risk factors for UCLI.

Clinical Relevance: Clinicians should consider educating coaches, parents, and players of the potential risk of increased pitching velocity relative to incidence of UCLI. Clinicians should also consider assessment of ND shoulder internal ROM and humeral retrotorsion relative to UCLI risk, but also realize UCLI are multi-factorial and simply focusing on ROM/torsion is not the key to prevention of these injuries.

What is Known About the Subject: UCLI and subsequent UCL surgery prevalence is increasing at all levels of baseball. Many risk factors have been described across various levels of evidence without a systematic consensus of the published literature.

What this Study Adds to Existing Knowledge: To our knowledge, this is the first systematic review with meta-analysis of published risk factors for UCLI. We stratify UCLI risk factors into significant and non-significant risk factors. Additionally, we utilize risk of bias assessment to provide evidence-based strength of evidence for the included recommendations (e.g. strong, moderate, limited, very limited and conflicting evidence).

Paper #12   REVERSE SHOULDER ARTHROPLASTY WITH AND WITHOUT CONCOMITANT LATISSIMUS DORSI AND TERES MAJOR TRANSFER FOR SHOULDER PSEUDOPARALYSIS WITH TERES MINOR DYSFUNCTION: A PROSPECTIVE, RANDOMIZED INVESTIGATION

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Table 1 Comparison of outcome scores pre-operatively and at one-year follow-up

| | Pre-Operative | | | | | | | | | One-Year | | | | | | | | |
| | RSA + Transfer | | | RSA Only | | | | | RSA + Transfer | | | | RSA Only | | | | |
	N	Med	Q1	Q3	N	Med	Q1	Q3	P-value†	N	Med	Q1	Q3	N	Med	Q1	Q3	P-value†
DASH Score (0-100)	15	62.5	45.5	79.5	12	53.1	46.0	70.4	0.3929	13	18.8	13.4	31.3	8	19.4	12.7	29.1	0.9423
ASES (0-100)	12	37.4	26.9	53.2	12	41.4	29.1	51.8	0.5832	12	87.6	77.4	92.9	9	80.3	78.3	88.3	0.4312
ADLER (0-30)	15	16.0	13.0	22.0	12	17.0	9.0	22.0	1.0	13	27.0	26.0	30.0	9	28.0	20.0	30.0	0.6101
SST (0-12)	15	3.0	1.0	4.0	12	4.0	2.5	5.0	0.1665	13	8.0	7.0	10.0	9	9.0	8.0	11.0	0.4167

†Wilcoxon rank-sum test was used for continuous non-normally distributed data to determine statistical significance between groups.
N = sample size, Med = median, Q = quartile

Introduction: Reverse shoulder arthroplasty (RSA) can restore active elevation in a cuff-deficient, pseudoparalytic shoulder. However, RSA alone does not restore active external rotation, which is impaired in patients with teres minor dysfunction. Persistent teres minor dysfunction, following RSA, has been associated with diminished functional outcomes and patient satisfaction, stemming from an inability to control spatial positioning of the arm. To address this concern, latissimus dorsi and teres major tendon transfers have been performed concurrently with RSA to restore both active elevation and external rotation. This is the first prospective, randomized investigation comparing RSA with and without concomitant tendon transfer.

Methods: Twenty-eight eligible patients with concurrent shoulder pseudoparalysis and teres minor dysfunction were randomized into the treatment (RSA with transfer) or comparison (RSA without transfer) group and followed to one year after treatment. The primary outcome measure was the Activities of Daily Living and External Rotation (ADLER) Score. Secondary outcome measures included Disabilities of the Arm, Shoulder and Hand (DASH) Score, American Shoulder and Elbow Surgeons (ASES) Score, and Simple Shoulder Questionnaire (SST).

Results: The gender distribution, body mass index (BMI), and age of the groups were similar. There was no difference in complication rates between the two groups. There was no significant difference in the ADLER, DASH, ASES, or SST between the groups pre-operatively or at one-year follow-up. (Table 1)

Conclusion: Based on the ADLER, DASH, ASES, and SST results at one-year, there did not appear to be a difference in functional outcome or satisfaction between patients with concomitant shoulder pseudoparalysis and teres minor dysfunction who underwent RSA with or without LD and TM transfer.

Paper #13   IMPACT OF SCAPULAR NOTCHING ON REVERSE TOTAL SHOULDER ARTHROPLASTY OUTCOMESâ5 YEAR MINIMUM FOLLOW-UP

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Introduction: Scapular notching is a well-documented phenomenon that occurs following reverse total shoulder arthroplasty (rTSA). Its frequency has been reported to occur variably with rates between 7% and 96% within the orthopedic literature. The impact of scapula notching on clinical outcomes is controversial as previous studies have differed in their determination of a significant effect on outcomes. Mallon et al[1] performed a power analysis on previous rTSA outcome studies and determined that four of the five largest rTSA outcome studies that concluded scapular notching did not have an impact on clinical outcomes were underpowered. The purpose of this study was to conduct a sufficient statistically powered analysis to definitively quantify the impact of scapular notching on rTSA clinical outcomes.

Methods: 247 patients who underwent rTSA utilizing the Equinoxe (Exactech, Gainesville, FL) rTSA system for a diagnosis of either cuff tear arthropathy or osteoarthritis in the setting of a rotator cuff tear and had greater than 5-years follow up were evaluated. Revision cases and fracture rTSA were excluded. Outcome metrics evaluated included the Simple Shoulder Test (SST), University of California Los Angeles (UCLA), American Shoulder and Elbow Surgeons (ASES), Shoulder Pain and Disability Index (SPADI) and Constant scores. Active abduction, flexion, external and internal rotation were also measured. The study patients were stratified according to the presence or absence of scapular notching at latest follow up. A two-tailed, unpaired t-test was utilized to compare the preoperative and postoperative outcomes as well as the pre- to post- operative improvements between the notching and no notching cohorts. A value of $P < .5$ was considered significant.

Results: The 247 patients were evaluated at a minimum of 5 year and an average follow-up of 7.3 ± 1.3 years. Stratification of the patients according to the presence of inferior scapular notching at latest follow-up revealed that 39 (16%) patients had notching and 208 (84%) patients did not. Of the patients with scapular notching the average grade of notching according to the Nerot classification was 1.7 ± 0.8 (eighteen grade 1, fourteen grade 2, seven grade 3). Comparison of preoperative outcome scores and range of motion between the notching and no notching cohorts failed to demonstrate

Table 1 Post-operative outcomes stratified according to notching. Active internal rotation (IR) is reported as a scaled number. Active flexion, abduction and external rotation (ER) are reported as degrees

	SST	Constant	ASES	UCLA	SPADI	Flexion	Abduction	IR	ER
No notching	9.6 ± 2.8	66.2 ± 14.6	79.9 ± 20.1	29.4 ± 6	26.5 ± 27.7	131 ± 28	114 ± 28	4.5 ± 1.7	32 ± 20
Notching	8.1 ± 3.7	56.3 ± 17.7	68.2 ± 26.8	25.1 ± 7.8	41.1 ± 39.6	118 ± 38	96 ± 31	4.5 ± 1.9	30 ± 20
P-value	**.0047**	**.0002**	**.0018**	**.0001**	**.0074**	**.0131**	**<.0001**	.9951	.6111

Table 2 Pre- to post- operative improvement stratified according to notching

	SST	Constant	ASES	UCLA	SPADI	Flexion	Abduction	IR	ER
No notching	6.1 ± 3.3	31.2 ± 16.6	44.1 ± 20.5	15.4 ± 6.5	55.8 ± 6.5	34 ± 45	31 ± 40	1.4 ± 2.2	14 ± 25
Notching	5.2 ± 3.7	23.4 ± 15.4	34.2 ± 27.2	34.2 ± 27.2	44.6 ± 36.8	24 ± 42	40 ± 38	1.1 ± 2	14 ± 24
P-value	.2261	**.0422**	.0501	**.0238**	.0919	.3674	.1706	.4930	.930