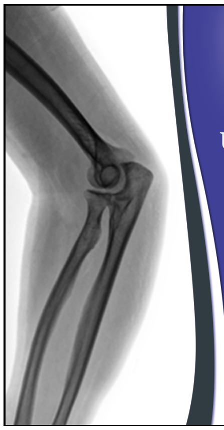

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Ulnar Collateral Ligament Reconstruction in the Throwing Athlete . . . Current Concepts in 2017

Michael G. Ciccotti, MD
The Everett J. and Marian Gordon Professor of Orthopaedics
Chief, Division of Sports Medicine
Director, Sports Medicine Fellowship and Research
Rothman Institute at Thomas Jefferson University
Head Team Physician, Philadelphia Phillies

ROTHMAN INSTITUTE | MAJOR LEAGUE BASEBALL

Elbow Injuries in Professional Baseball: Epidemiology from the Major League Baseball Injury Surveillance System

Michael G. Ciccotti MD
Keisha Pollock PhD
Michael C. Ciccotti MD
John D'Angelo BA
Christopher Ahmad MD
Dave Altchek MD
James Andrews MD
Frank Curriero PhD

AJSM, 2017

Epidemiology of Professional Baseball Elbow Injuries

Table 1:

Level of Play	N (%)	Age Mean (Std)	Days Missed Mean (Median)	Required Surgery	Re-Injury
Minor	2,753 (81.2%)	22.8 (3.2)	27.9 (13)	487 (17.7%)*	61 (2.2%)*
Major	637 (18.8%)	28.9 (3.9)	27.8 (12)	122 (19.2%)*	19 (3.0%)*
Total	3,390				

*Percent calculated within Level of Play

Epidemiology of Professional Baseball Elbow Injuries

Minor & Major League	Frequency	Requiring Surgery	Days Missed Non-Surgery
Event Position	N (%)	N (%)	Mean (Median)
Pitcher (Defense)	1129 (33.3%)	386 (34.2%)	32.0 (20.5)
Position Player (Defense)	316 (9.3%)	64 (20.3%)	17.1 (9.0)
Base Runner (Offense)	24 (0.7%)	3 (12.5%)	13.5 (4.0)
Batter (Offense)	437 (12.9%)	8 (1.8%)	4.1 (2.0)
Not Classified	1,484 (43.8%)	148 (10.0%)	27.6 (15.0)

Epidemiology of Professional Baseball Elbow Injuries

Table 3:

SMDCS		Diagnosis Type: Ligament	Tendon	Nerve	Bone	Misc
Ligament	-UCL	730	0	0	0	0
	-Other	116	0	0	0	0
Tendon	-Medial	0	272	0	0	0
	-Lateral	0	96	0	0	0
	-Other	0	255	0	0	0
Nerve	-Ulnar	0	0	224	0	12
	-Other	0	0	24	0	0
Bone	-Post Imping	0	0	0	0	93
	-Fracture	0	0	0	38	0
Cartilage		0	0	0	0	13
Loose Body		0	0	0	89	0
Misc	-Buritis	0	43	0	0	0
	-Contusion	0	0	0	0	724
	-Infection	0	0	0	0	1
	-Other	5	0	0	1	654
Total		851	666	248	128	1,497

Epidemiology of Professional Baseball Elbow Injuries

Table 5:

	Surgery								
	Minor League			Major League			Minor & Major League		
Diagnosis Type	No	Yes	%Yes*	No	Yes	%Yes*	No	Yes	%Yes*
Ligament	430	290	59.5%	62	69	56.6%	492	359	60.0%
Tendon	474	25	5.1%	153	14	11.5%	627	39	6.4%
Nerve	177	21	4.3%	45	5	4.1%	222	26	4.3%
Bone	38	60	12.3%	13	17	13.9%	51	77	12.6%
Misc	1,147	91	18.8%	242	17	13.9%	1,389	108	17.7%
Total	2,266	487		515	122		2,781	609	

Predictable Series of Events in Throwers

- Progressive osseous changes
- Peri-elbow muscle weakness
- Peri-elbow Soft Tissue contracture
- Flexor-Pronator Strain in Late Cocking/Acceleration/Follow-thru phases of throwing
- *UCL* injury can occur

General population is not routinely exposed to this "cascade of events"... but throwers are!

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UCL Injury

HOW DO YOU *FIX* THAT?

. . . Techniques of Treatment

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Treatment of UCL Injury

- **Nonoperative**
- **Repair**
- **Reconstruction**

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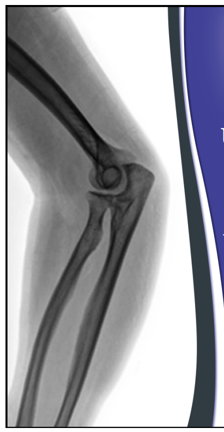

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Ulnar Collateral Ligament Reconstruction in the Throwing Athlete . . . Amateur to Professional: Current Concepts Review

Edward Chang, MD,
Christopher Dodson, MD,
Michael G. Ciccotti, MD

JAAOS, 2016

Figure-of-8 Technique

Table 1. Clinical Outcomes using the Figure-of-Eight Technique

Author	Total No. of patients in study	No. Patients with UCL Reconstruction (No. available for follow-up)	Mean Age (Range) (yrs.)	Sport	FPM approach	Obligatory UNT (type if performed)	Technique	Complications (type)	Reoperation (type)	No. (%) of Excellent Results on Conway Scale
Jobe	16	16	25.3 (20-31)	14 baseball, 2 javelin	Detachment	Yes (submuscular)	Classic Jobe	5 (ulnar neuropathy)	2 (revision ulnar nerve procedures)	10/16 (63%)
Conway	71	56	23.7 (15-24)	52 baseball, 3 javelin, 1 tennis	Detachment	Yes (submuscular)	Classic Jobe	16 (15 ulnar neuropathies, 1 hematoma)	9 (revision ulnar nerve procedures)	38/56 (68%)
Andrews	72	12 (9)	NR	9 baseball	Elevation	Yes (subcutaneous)	ASMI modification	1 (ulnar neuropathy)	None	7/9 (78%)
Azar	91	78 (59)	21.6 (15-39)	85 baseball, 3 football, 1 wrestling, 1 tennis	Elevation	Yes (subcutaneous)	ASMI modification	8 (4 graft site complications, 1 superficial wound infection, 1 ulnar neuropathy, 1 stiffness, 1 posteromedial osteophyte)	2 (1 arthroscopic lysis of adhesion, 1 arthroscopic posteromedial debridement)	48/59 (81%)
Thompson	83	83 (33)	24.3 (NR)	78 baseball, 2 javelin, 1 football, 1 platform diver, 1 softball	Split	No	Modified Jobe	8 (4 ulnar neuropathies, 2 palmar cutaneous neuropathy, 1 FPM re-tear, 1 hematoma)	4 (1 revision FPM repair, 3 arthroscopic posterior debridements)	26/28 (93%)
Petty	31	31 (27)	17.4 (15-19)	27 baseball	Elevation	Yes (subcutaneous)	ASMI modification	3 (2 ulnar neuropathies, 1 wound hematoma)	None	20/27 (74%)
Cain	1281	1266 (733)	21.5 (14-59)	1213 baseball, 15 javelin, 13 football, 9 softball, 7 tennis, 4 cheerleading, 2 wrestling, 2 soccer, 2 gymnastics, 1 pole-vault	Elevation	Yes (subcutaneous)	ASMI modification	148 (121 ulnar neuropathy, 27 graft site complication)	62 (53 arthroscopic posteromedial debridements, 9 revision UCL reconstructions)	610/733 (83%)
Dugas	120	120	21.7 (NR)	120 baseball	Elevation	Yes (subcutaneous)	ASMI modification	25 (ulnar neuropathy)	8 (2 UCL revision reconstructions, 6 additional elbow procedures)	105/120 (88%)

NR= not reported, UCL= ulnar collateral ligament, FPM= flexor-pronator mass, UNT= ulnar nerve transposition

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Figure-of-8 Technique

- 8 studies evaluating Figure-of-8 Techniques
- Total of 1,645 patients
- Baseball primary sport
- Mean age = 17.4-25.3 yrs
- 63-93% excellent on Conway Scale
- Most common complication = ulnar neuropathy
- 79 reoperations (4.8%)

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Docking Technique

Table 2. Clinical Outcomes using the Docking Technique

Author	Total No. of patients in study	No. Patients with UCL Reconstruction (No. available for follow-up)	Mean Age (Range) (yrs.)	Sport	FPM approach	Obligatory UNT (type if performed)	Technique	Complications (type)	Reoperation (type)	No. (%) of Excellent Results on Conway Scale
Rohrbough	36	36	23.0 (15-57)	33 baseball, 1 lacrosse, 1 tennis, 1 golf	Split	No (subcutaneous)	Docking	2 (1 ulnar neuropathy, 1 wound hematoma)	1 (arthroscopic posteromedial debridement)	33/36 (92%)
Dodson	100	100	22.9 (16-43)	96 baseball, 2 football, 2 tennis	Split	No (subcutaneous)	Docking	3 (2 ulnar neuropathies, 1 stiffness)	None	90/100 (90%)
Paletta	25	25	24.5 (19-27)	25 baseball	Split	No (subcutaneous)	4-strand Docking	2 (1 ulnar neuropathy, 1 ulnar bridge fracture)	None	23/25 (92%)
Koh	20	20 (19)	21.7 (17-25)	20 baseball	Split	No (subcutaneous)	Docking or 3-strand Docking	1 ulnar neuropathy	1 (ulnar nerve transposition)	18/19 (95%)
Bowers	21	21	20.0 (16-27)	21 baseball	Split	No (subcutaneous)	3-strand Docking	None	None	19/21 (90%)

UCL=ulnar collateral ligament, FPM= flexor-pronator mass, UNT= ulnar nerve transposition

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Docking Technique

- 5 studies evaluating Docking Techniques
- Total of 202 athletes
- Baseball primary sport
- Mean ages = 20.0-24.9 yrs
- 90-95% excellent on Conway Scale
- Most common complication = ulnar neuropathy
- 2 reoperations (1%)

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Alternate Techniques

Table 3. Clinical Outcomes using other Techniques

Author	Total No. of patients in study	No. Patients with UCL Reconstruction (No. available for follow-up)	Mean Age (Range) (yrs.)	Sport	Flexor-pronator mass approach	Obligatory ulnar nerve transposition (type if performed)	Technique	Complications (type)	Reoperation (type)	No. (%) of Excellent Results on Conway Scale
Savoie	60	NA (all repair)	17.2 (14-22)	51 throwing athletes, 5 cheerleading, 2 basketball, 2 gymnastics	Split	No	Bone tunnels or suture anchors	6 (3 ulnar neuropathies, 2 superficial wound infections, 1 stiffness)	2 (1 Arthroscopic debridement, 1 superficial irrigation and debridement)	51/60 (85%)
Dines	22	22	20.1 (16-24)	20 baseball, 1 football, 1 hockey	Split	No (subcutaneous)	Dane TJ	4 (2 stiffness, 1 ulnar neuropathy, 1 posteromedial osteophyte with ulnar neuropathy)	3 (2 lysis of adhesions, 1 arthroscopic posteromedial debridement)	19/22 (86%)
Hechtman	34	34	18.7 (15-23)	34 baseball	Split	No (subcutaneous)	Hybrid	1 (ulnar neuropathy)	None	29/34 (85%)
Kodde	20	20	22 (18-35)	6 javelin, 4 gymnastics, 3 judo, 3 handball, 2 baseball, 1 swimmer, 1 horseman	Split	No (NR)	Interference screw	1 (ulnar neuropathy)	None	18/20 (90%)
Savoie	123	123 (116)	20.4 (14-32)	Baseball, softball or javelin	Split	No (subcutaneous)	Ulnar: bone tunnel or interference screw Humerus: Docking or Jobe	7 (3 ulnar neuropathies, 2 superficial wound complication, 1 ME fracture, 1 FPM tear	1 (ulnar nerve transposition)	93/116 (80%)

UCL=ulnar collateral ligament, FPM= flexor-pronator mass, UNT= ulnar nerve transposition, ME=medial epicondyle, NA=not applicable

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Alternate Techniques

- 5 studies evaluating Alternate Techniques
- Total of 259 patients
- Baseball primary sport
- Mean age = 17.2-22.0 yrs
- 80-90% excellent on Conway Scale
- Most common complication = ulnar neuropathy
- 6 reoperations (2.3%)

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Systematic Reviews

Table 4. Summary of Systematic Reviews

Author	Number of Studies	Level of Evidence	No. of UCL reconstructions	Mean Age (Range) (yr)	Sport	FPM approach	UNT type (if performed)(%)	Graft Fixation	Complications (type) (%)	Reoperation rate	Overall (%) of Excellent Results on the Conway Scale
Purcell	4	Level III (4)	253	23.1 (15-57)	NR	Detachment (22%), elevation (31%), split (47%)	Submuscular (22%), subcutaneous (37%)	Figure-of-8 (86%), Docking (14%)	NR	NR	NR
Vitale	8	Level III (8)	405	22.5 (15-43)	Baseball (88%)	Detachment (17%), elevation (16%), split (67%)	Submuscular (15%), subcutaneous (32%)	Figure-of-8 (62%), Docking (33%), modified Docking (5%)	Overall (10%): ulnar neuropathy (6%), superficial infection, tightness or graft harvest tenderness (1%), post-operative paresthesia (1%), other (2%)	NR	83%
Watson	14	Level III (3), Level IV (11)	1368	21.7 (17.4-24.3)	NR	Detachment (5%), elevation or split (95%)	Submuscular (5%), subcutaneous (74%)	Figure-of-8 (83%), Docking (12.1%), modified Docking (3.4%), interference screw (1.5%)	Overall (17%): ulnar neuropathy (12.9%)	Overall (6.7%)	Overall: 78.9%, Classic Jobe (66.7%), modified Jobe/ASMI (77.3%), interference screw (90%), Docking (90.4%), modified Docking (91.3%)

UCL= Ulnar Collateral Ligament, NR= not reported, FPM=flexor-pronator mass, UNT=ulnar nerve transposition

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Systematic Reviews

- 3 Systematic Reviews evaluating retrospective, cohort studies with minimum 1 yr F/U
- 79-83% overall excellent results
- 10% complication rate
- Improved results with:
  - Muscle-splitting
  - Abandoning ulnar nerve transposition
  - ? Docking technique
- Inconsistency in levels of competition (selection bias)

Purcell, Matava, Wright Clin Orthop 2007
Vitale, Ahmad AJSM, 2008
Watson, McQueen, Hutchinson AJSM 2013

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Biomechanical Studies

Table 5. Summary of Biomechanical Studies

Author	No. of specimens	Mean age (range) (yr)	Matched or unmatched elbows	Graft used	Graft fixation	Testing device	Style of testing	Results	Fixation failure
Mullen	14	64 (48-81)	NR	Palmaris	Jobe	MTS frame	Submaximal	Increased instability found at 120° flexion	1 ulnar tunnel fracture
Ahmad	10	43 (26-60)	Yes	Palmaris	Interference screw	MTS frame	Submaximal, load to failure	Ultimate moment (N-m): Native- 34.29 Reconstructed- 30.55	6 graft rupture, 2 ulnar tunnel fracture, 1 graft slippage, 1
Armstrong	40	73 (63-80)	No	Palmaris	Jobe, Docking, interference screw, endobutton	MTS frame	Load to failure	Peak load (N): Native 142.5 Docking -53.0 Endobutton 52.5 Interference screw 41.0 Jobe- 33.3	Docking: suture failure, Endobutton: suture failure Jobe: suture failure, Interference screw: tendon pull-out,
Paletta	33	54 (NR)	No	Palmaris	Jobe, Docking	MTS frame	Load to failure	Ultimate moment (N-m): Native: 18.8 Docking: 14.3 Jobe: 8.9	Docking: 12 suture failure, 2 tunnel fracture Jobe: 11 suture-tendon interface failure, 2 tunnel fracture, 1 suture failure
McAdams	16	72 (NR)	Yes	Palmaris	Docking, interference screw	MTS frame	Cyclical loading	No significant difference in valgus angle found at 1000th cycle	Docking: 2 suture-bone interface Interference Screw: 1 tendon rupture
Large	20	76 (62-92)	Yes	Hamstring allograft	Jobe, interference screw	MTS frame	Submaximal, load to failure	Ultimate moment (N-m): Jobe: 22.7 Interference screw: 13.4	Jobe: 3 epicondyle fracture, 1 ulnar tunnel fracture Interference screw: 7 graft pullout, 1 humeral fracture
Ciccotti	20	79 (69-86)	Yes	Palmaris	Jobe, Docking	4-degree of freedom loading system	Submaximal, load to failure	Ultimate moment (N-m): Native: 14.9 Jobe: 8.0 Docking: 8.2	Jobe: 7 ulnar tunnel fracture, 2 midsubstance tear, 1 suture pullout Docking: 4 suture pull-out, 4 ulnar tunnel fracture, 1 midsbstance tear, 1 humeral tunnel fracture

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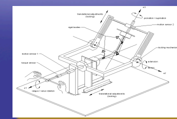
Biomechanical Studies

- 7 Biomechanical Studies comparing the Native UCL to various Recon Techniques
- Testing ranging from Instrom to unique 4-deg of freedom device
- Valgus load/Cyclical loading/ Kinematic Coupling
- Jobe, Docking, Interference Screw and Endobutton with comparable load to failures
- Valgus profiles of Recon Techniques similar to Native UCL at crucial mid-range



Mullin et al JSES 2002
Ahmad et al AJSM 2003
Armstrong et al JSES 2005
Paletta et al AJSM 2006
Large et al JAANA 2007
McAdams et al JSES 2007
Ciccotti et al AJSM, 2009

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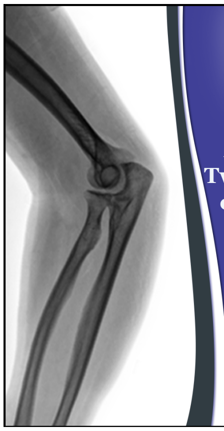

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A Quantitative Evaluation of Two Reconstructive Techniques of the Elbow Ulnar Collateral Ligament

Christopher Spagnola,
John Thinnes,
Monish Romani,
Sorin Seigler,
Michael G. Ciccotti

AAOS, AOSSM Specialty Day
AJSM, 2008

Materials & Methods

- 12 pairs of fresh frozen cadaver elbows
- Potentiometers
- Torque sensors
- 3-Degree of Freedom Loading Device
- Opto-electrical Tracking System for Anterior band of UCL

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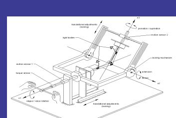
Materials & Methods

- Tested at 30, 60, 90, 110 degrees
- UCL loaded to failure at 80 deg.
- Reconstruction - Jobe/Docking on each pair of elbows
- Testing repeated



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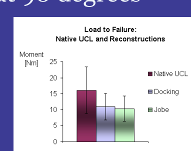
Conclusions

- Load to Failure:
  Native UCL > Jobe, Docking
  Jobe = Docking
- Flexibility of Native UCL, Jobe, Docking all similar at 90 degrees (throwing position)



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Sports Specific Outcome Measures

- The ability to return and sustain pre-injury level of play may *not* be as high as thought
  - Cohen, Sheridan, Ciccotti et al (Sports Health, 2011)
- The use of sports specific performance metrics after UCL Recon is more precise
- Current data is conflicting
  - Erickson, Cole, Romeo et al (AJSM, 2014)
  - Makhni, Lee, Ahmad et al (AJSM, 2014)
- Further research with sports specific metrics is essential

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MAJOR LEAGUE BASEBALL

MLB Elbow Study Group

Education & Research UCL

- I - Epidemiology of Elbow Injuries in Professional Baseball
- II - Epidemiology of UCL Injury in Professional Baseball
- III - Biomechanical Evaluation of Throwing in Normal and UCL Reconstructed Players
- IV – Prospective Evaluation of Outcome after Elbow Surgery in Professional Baseball using a Validated Scoring System
- V – Players' Perspective of UCL Reconstruction in Professional Baseball
- VI – Media Perspective of UCL Reconstruction in Professional Baseball
- VII - Risk Factors for UCL Injuries in the Professional Pitcher: A Prospective Study

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Education & Research UCL

- I – Comparison of Surgical Techniques for UCL Reconstruction in Throwers
- II - Stress Ultrasound Evaluation of Medial Elbow Instability in a Cadaveric Model
- III – Stress Ultrasonography in MLB Baseball Pitchers: 10 Yr Prospective Study
- IV – Early Anatomic Changes of the UCL by Stress Ultrasound in Young Pitchers
- V – MRI Findings Associated with Posteromedial Impingement in Throwers
- VI –Biomechanical Cadaveric Evaluation of the Native UCL, Modified Jobe and Docking Reconstructions
- VII – Biomechanical Cadaveric Comparison of UCL Graft Fixation at 30 vs 90 Deg
- VIII – Return to Play in Professional Baseball Players after Elbow Surgery
- IX - Prospective Evaluation of Outcome after UCL Reconstruction in Baseball using a Validated Scoring System
- X – Epidemiology of Elbow Injuries in Professional Baseball
- XI – Epidemiology of UCL Injury in Professional Baseball
- XII – Biomechanical Evaluation of Throwing in Normal and UCL Recon Players
- XIII – Risk Factors for UCL Injuries in the Pro Pitcher: A Prospective Study

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Current Treatment Guidelines

- Current research indicates increased return to play, particularly in overhead athletes, with respect to UCL reconstruction modifications:
  - *muscle splitting approach*
  - *minimal handling of the ulnar nerve*
- No optimal UCL Recon technique identified:
  - *Modified Figure-of-8 and Docking most common*
  - *Systematic Reviews suggest Docking with lower complication rates and increased RTP – but NOT statistically significant*
  - *Previously, no prospective, matched comparison of the two techniques*

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Current Treatment Guidelines

- Patient specific protocol:
  - Confirm UCL injury
  - Create ulnar and distal medial epicondylar tunnels
  - Harvest graft
  - If graft >/= to 15cm, then Modified Jobe Technique
  - If graft < 15cm, then Docking Technique
- Prevailing literature indicates both techniques result in reliable outcomes
- Further research with sports specific metrics is essential
- We are currently performing a . . .

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Prospective, Randomized Comparison of the Modified Jobe and Docking Techniques for Reconstruction of the Ulnar Collateral Ligament

Michael C. Ciccotti MD
Daniel Mizrah, MD
Adam Zoga, MD
Levon Nazarian, MD
Michael G. Ciccotti MD

In Progress

Summary

- UCL injury is epidemiologically a big deal . . . *particularly in baseball*
- Nonop treatment should be considered . . . *particularly for proximal partial injury*
- UCL Repair may be indicated in younger athletes . . . *with no attritional/degenerative changes*

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Summary

- UCL Repair with Augmentation has been proposed . . . *but follow up continues and precise indications are being determined*
- UCL Reconstruction remains the standard of operative treatment . . . *with comparable outcomes for Modified Jobe and Docking*
- Outcomes and Return-to-Prior Level must all be determined . . . *for optimal care*

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Future Directions

- Evaluation of all levels of baseball players (professional, collegiate, high school and youth)
- Consider other factors that may lead to apparent "epidemic" of UCL injuries
- Identify methods of precisely determining the degree of UCL injury
- Determine long term outcomes of treatment using sports specific metrics

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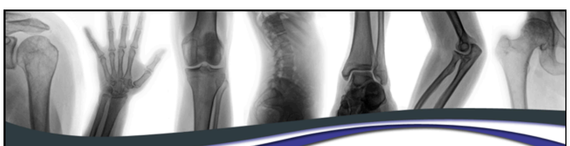

THANK YOU.

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