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Thermal-Assisted Capsular Shrinkage of the Glenohumeral Joint in Overhead Athletes: A 15- to 47-Month Follow-up

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Study Design: Descriptive postoperative follow-up research.
Objectives: The purpose of this investigation was to describe the return-to-competition rate and functional outcome of overhead athletes following arthroscopic thermal-assisted capsular shrinkage (TACS).
Background: Traditional open procedures to correct instability in overhead athletes, such as capsulolabral repairs and capsular shifts, have produced less-than-favorable results, which have led to the development of TACS. Currently there are no long-term follow-up studies documenting the efficacy of this procedure in groups greater than 31 subjects or for a time period greater than 27 months.
Methods and Measures: Two hundred thirty-one consecutive overhead athletes who due to symptoms of hyperlaxity had previously undergone a TACS procedure from 1997 to 1999 were selected for inclusion in the study. During a 1-month period, 130 of these athletes (mean age ± SD, 24 ± 6 years; 113 male, 17 female) were contacted by phone for follow-up at a mean of 29.3 months postoperatively (range, 15.4-46.6 months). Of the 130, 105 participated in baseball (80 pitchers), 14 in softball, 4 in football (quarterbacks), 4 in tennis, and 3 in swimming. Fifty-four (42%) subjects were professional, 49 (38%) collegiate, 16 (12%) high school, and 11 (8%) recreational athletes. One hundred twenty-three of the 130 (95%) underwent 1 or more concomitant procedure(s) at the time of TACS. Most commonly performed were labral debridements (69%), rotator cuff debridements (65%), and superior labral repairs (35%). Subjects who returned to competition were retrospectively evaluated using a modified Athletic Shoulder Outcome Rating Scale to subjectively assess pain, strength and endurance, stability, intensity, and performance. Overall results were based on a 90-point scale with scores of 80 to 90 representing excellent, 60 to 79 good, 40 to 59 fair, and less than 40 poor results.
Results: One hundred thirteen out of 130 subjects (87%) returned to competition. Mean (±SD) time from surgery to return to competition was 8.4 ± 4.6 months. Mean outcome score for all subjects was 79/90; 75 (66%) subjects had excellent, 24 (21%) good, 11 (10%) fair, and 3 (3%) poor result. The mean outcome score for males was 80/90 and for females was 70/90.
Conclusions: The majority of overhead athletes (87%) successfully returned to competition following a TACS procedure with good-to-excellent long-term outcomes (88%). Based on the results of this study, TACS of the glenohumeral joint is a viable option for overhead athletes with pathological instability. *J Orthop Sports Phys Ther 2003;33:455–467.*

Key Words: *acquired laxity, baseball, rehabilitation, shoulder, shoulder instability*

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The overhead athlete applies large forces upon the shoulder during the act of throwing and various other overhead sports. These high forces occur at angular velocities up to 7200°/s.[5] In addition, the overhead thrower exhibits excessive shoulder range of motion and soft tissue flexibility. In this population, Wilk et al[32] reported the average (±SD) shoulder external rotation at 90° of shoulder abduction to be 129° ± 9°. As a result of the excessive joint forces, angular velocities, and range of motion, shoulder injuries are common in the overhead athlete.

One of the most common pathologies treated by the sports medicine team in the overhead athlete is anterior microinstability.

These patients often exhibit mild pathological hyperlaxity, without gross instability, due to the extreme forces observed at excessive ranges of motion during overhead athletics. This microinstability in overhead athletes has been referred to as acquired laxity.[32,33] Based on the authors' experience, this often presents itself clinically as rotator cuff tendonitis, or may lead to further injuries such as labral pathologies, posterior-superior glenoid impingement (internal impingement), and rotator cuff tearing.[32,33] Thus, during athletic competition, the thrower's shoulder needs to be ''loose enough to throw, but stable enough to prevent symptomatic humeral head subluxations.''[32] Wilk et al[32] have referred to this as the *thrower's paradox*.

The surgical treatment for pathological microinstability in the overhead thrower's shoulder has been difficult and the long-term outcomes have been fair to poor.[3,12,15,17,20,22-24,29] Open surgical stabilization procedures have resulted in range-of-motion complications and a low return to competition.[3,12,15,17,22–24,29] Early outcome reports using the Bristow procedure by Lombardo et al[15] report a mean 11° loss of shoulder external rotation with 0% of overhead athletes returning to play at a mean follow-up of 17 months, while Torg et al[29] report 16% of athletes returned to throwing at a mean follow-up of 47 months. Using the capsular shift procedure, Rubenstein et al[24] reported a mean 2° loss of shoulder external rotation with 46% of professional baseball pitchers having excellent results at a mean follow-up of 39 months. Also using the capsular shift procedure, Bigliani et al[3] reported a mean loss of 7° of external rotation with only 50% of throwers returning to competition at a mean of 48 months.

Functional results using an open capsulolabral repair procedure have also been reported. Rowe et al[22] report 33% of throwers returning to their original level of competition at a mean follow-up of 72 months, while Rowe and Zarins[23] report 50% of patients returning to pitching at a mean follow-up of 48 months. Jobe et al[12] report 32% of patients not achieving full motion with a 13° mean loss of shoulder external rotation and 72% of overhead athletes returning to competition at a mean of 39 months. Similarly, Montgomery and Jobe[17] report a 1° mean loss of shoulder external rotation with 75% of baseball position players and 69% of pitchers returning to competition at a mean of 27 months.

Recently, physicians have turned their attention to arthroscopic procedures for the overhead athlete. The loss of motion, capsular scarring, and postoperative pain following arthroscopic procedures may be much less than for open procedures. Pagnani et al,[20] using an arthroscopic anterior capsulolabral repair procedure, reported a 4% decrease in external rotation with 50% of patients exhibiting loss of motion and 67% of overhead athletes returning to competition at a mean of 67 months.

The use of arthroscopic thermal energy to shrink the glenohumeral joint capsule has recently been suggested as a surgical option to treat the overhead athlete with shoulder instability while minimizing postoperative loss of motion.[4,7-9,18] Thermal energy, in the form of heat, has been used in medicine dating back to Hippocrates. The authors of the current study[34] have previously discussed the basic science and clinical application of thermal-assisted capsular shrinkage (TACS) of the glenohumeral joint capsule. Since the 1990s, thermal energy has been used to modify capsular tissue in orthopedics[4,7-9,18] and may be applied using 2 types of probes: the Holium:YAG laser and the radiofrequency heat probe. Both methods of thermal delivery have been shown to achieve similar and predictable amounts of capsular shrinkage in the cadaveric and ovine model, depending on the temperature settings.[19,27,28] The monopolar radiofrequency probe has recently gained popularity due to its ability to preset a specific temperature, which initiates the connective tissue's response to heat while avoiding tissue necrosis. The unwinding of collagen's triple helix configuration has been observed near 60°C to 65°C with tissue necrosis occurring at temperatures greater than 80°C.[9,18,34] This unwinding turns the collagen bonds into a gel-like substance, resulting in collagen shrinkage[9,18] and an overall decrease in glenohumeral translation.[27,28]

The use of TACS of the glenohumeral joint capsule to correct shoulder instability appears to be declining due to recent studies reporting poor outcomes.[13,30] However, several authors have reported 82% to 93% return to competition following TACS procedures in the overhead athlete,[14,16,25] although initial studies have documented results for only a limited number of patients over a short period of time. Savoie and Field[25] compared the outcomes of 30 patients undergoing an arthroscopic monopolar TACS versus 27 patients with arthroscopic capsular shift procedures at a mean follow-up of 27 months. Eighty-eight percent of athletes undergoing the TACS procedure returned to competition compared to an 82% return of those undergoing the capsular shift. Lyons et al[16] performed a 2-year follow-up of 27 patients undergoing TACS using a laser probe. The authors report that 86% of athletes returned to their previous level of competition.

Furthermore, Levitz et al[14] compared 2 groups of overhead athletes diagnosed with internal impingement. The first group consisted of 51 athletes undergoing traditional rotator cuff debridement, labral debridement, and superior labral (SLAP) lesion repair. The second group consisted of 31 athletes undergoing the same traditional procedure with the addition of TACS. Mean time of follow-up was 2 years. The authors report that 80% of the athletes in group 1 returned to competition at a mean of 7.2 months, while 93% of athletes returned to competition in group 2 at a mean of 8.4 months.

Although the initial reports of the previous studies indicate enhanced results in athletics when compared to the open procedures, each of the studies reported on a small sample of patients (between 26 and 31 subjects) with a short duration of follow-up (range, 20-30 months).[14,16,25] Furthermore, the poor results of recent follow-up reports have included a wide variety of patients with various ages, activities, pathologies, and types of instability.[13,30] Therefore, the purpose of this study was to describe the functional outcome and return-to-competition rate in a group of overhead athletes with acquired laxity who have undergone TACS using the monopolar radiofrequency heat probe.

METHODS

Subjects

Two hundred thirty-one total overhead athletes underwent arthroscopic TACS of the glenohumeral joint by senior author JRA between 1997 and 1999.[34] Indications for patients to undergo the TACS procedure included symptoms of pathological acquired laxity without gross instability, signs of internal impingement on clinical examination,[14] persistent shoulder pain and loss of function, and failure of a nonoperative rehabilitation program for at least 3 months.[32] Only patients classified as overhead athletes were included for follow-up. These included baseball, softball, and tennis players, as well as swimmers and football quarterbacks. Subjects with history of traumatic shoulder dislocation were excluded from follow-up. Of the 231 consecutive patients undergoing TACS, 130 subjects fulfilling all inclusion criteria (113 male [87%], 17 female [13%]) were contacted during a 1-month period.

Mean (±SD) age of patients at time of surgical intervention was 24 ± 6 years (range, 15.3-49.1 years). One hundred five (81%) were baseball players, 14 (11%) softball players, 4 (3%) tennis players, 4 (3%) football quarterbacks, and 3 (2%) swimmers. Eighty (76%) of the 105 baseball players were pitchers. Fifty-four (42%) of patients were professional athletes, 49 (38%) collegiate athletes, 16 (12%) high school athletes, and 11 (8%) recreational athletes. Recreational athletes were defined as having frequent participation in overhead athletic competition of at least 1 time per week. Mean (±SD) years of competition in the patients overhead sport at the time of surgery was 16 ± 6 years.

Surgical Procedure

Examination and documentation of range of motion and stability were performed preoperatively under anesthesia by an orthopedic surgeon. Diagnostic arthroscopy was then performed to document any pathological intra-articular findings. All surgical procedures were performed by senior author JRA.

Any intra-articular pathology involving the labrum, rotator cuff, articular surface, or biceps tendon was addressed prior to capsular shrinkage. Once any other pathology had been addressed, the monopolar radiofrequency probe was used to shrink the inferior capsule from around the 6-o'clock position to the posterior band of the inferior glenohumeral ligament. The probe was then used to shrink from the posterior band of the inferior glenohumeral ligament to the posterior capsule. The anterior capsule was then shrunk from the 6-o'clock position up to, and including, the anterior band of the inferior glenohumeral ligament. The TACS procedure was performed utilizing the paintbrush method.[34]

One hundred twenty-three (95%) of the 130 patients had concomitant procedures performed at the time of thermal heat probe application. Procedures performed at a frequency of greater than 1% are listed in Table 1. The procedures most commonly performed included labral debridement (69%), rotator cuff debridement (65%), and superior labral tear (SLAP type II) repair (35%). One hundred nine (96%) of the 113 male overhead athletes underwent a concomitant procedure at the time of TACS, while only 14 (81%) of the 17 female athletes had concomitant surgeries.

Postoperative Rehabilitation

The rehabilitation program following thermal capsular shrinkage of the shoulder follows several key rehabilitation guidelines as described by Wilk et al[34] and can be found in Table 2.

Immediately following surgery, a standard sling was worn during the first 1 to 2 weeks for comfort and an immobilizer (with arm at the side of the body without abduction pillow) to restrict shoulder motion was worn while sleeping for the first 2 weeks. Immediate motion was performed, but no stretching. Active-assisted flexion range of motion was allowed to be performed with a wand or L-bar to approximately 70° the first week and 90° by the end of week 2.

TABLE 1. Concomitant procedures performed at the time of thermal application.

Procedures	Patients (n)	Patients (%)
Labral debridement	90	69
Rotator cuff debridement	84	65
SLAP type II repair*	45	35
Subacromial decompression	22	17
Anterior Bankart repair	10	8
Rotator cuff repair	4	3

* Repair of a superior labral lesion.

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TABLE 2. Rehabilitation program following thermal-assisted anterior capsulorrhaphy for individuals with acquired laxity.[34]

Phase 1: Protection Phase (Day 1 to Week 6)

Goals:
- Allow soft-tissue healing
- Diminish pain and inflammation
- Initiate protected motion
- Retard muscular atrophy

Weeks 0-2
- Sling use for 7-10 d
- Sleep in sling/brace for 14 d

Exercises:
- Hand-gripping exercises
- Elbow and wrist range of motion (ROM) exercises
- Active ROM cervical spine
- Passive- and active-assisted shoulder ROM exercises:
  - Elevation to 75°-90° (flexion to 70° week 1, flexion to 90° week 2)
  - Internal rotation (IR) in scapular plane at 30°-45° abduction (45° by week 2)
  - External rotation (ER) in scapular plane at 30°-45° abduction (25° by week 2)
  - No aggressive stretching
- Rope and pulley (shoulder flexion) active-assisted ROM
- Cryotherapy to control pain (before and after treatment)
- Submaximal isometrics (ER, IR, abduction, flexion, extension)
- Rhythmic stabilization exercises at 7 d
- Proprioception and neuromuscular control drills

Weeks 3-4
- Shoulder ROM exercises (passive ROM, active-assisted ROM, active ROM):
  - Elevation to 125°-135°
  - IR, in scapular plane, full motion (60°-65°)
  - ER, in scapular plane 45° by week 4
  - At week 4, begin ER-IR at 90° abduction
  - ER at 90° abduction to 45°-50°
  - No extension
  - No aggressive stretching
- Shoulder strengthening exercises:
  - Active ROM program (begin at week 3)
  - Initiate light isotonic program (use 0.45 kg [1 lb] at week 4)
  - ER-IR exercise tubing (0° abduction)
  - Continue dynamic stabilization drills
  - Scapular strengthening exercises
  - Biceps-triceps strengthening
  - Proprioceptive neuromuscular facilitation D2 flex-ext manual resistance (limited ROM)
  - Emphasize ER strengthening and scapular musculature
- Continue use of cryotherapy and modalities to control pain

Weeks 5-6
- Continue all exercises listed above
- Progress ROM to the following:
  - Elevation to 160° by week 6
  - ER at 90° abduction (75°-80°) by week 6
  - IR at 90° abduction (60°-65°) by week 6
- Initiate Throwers Ten strengthening program
- Continue emphasis on ER and scapular muscles

Phase 2: Intermediate Phase (Weeks 7-12)

Goals:
- Restore full ROM (week 8)
- Restore functional ROM (weeks 10-11)
- Normalize arthrokinematics
- Improve dynamic stability, muscular strength

Weeks 7-8
- Progress shoulder ROM to the following:
  - Elevation to 180°
  - ER at 90° abduction to 90°-100° by week 8
  - IR at 90° abduction to 60°-65° by week 8
- Continue stretching program:
  - May become more aggressive with ROM progression and stretching
  - May perform joint mobilization techniques
- Strengthening exercises:
  - Continue Throwers Ten program
  - Continue manual resistance, dynamic stabilization drills
  - Rhythmic stabilization drills
  - Initiate plyometrics (2-handed drills)

TABLE 2. Rehabilitation program following thermal-assisted anterior capsulorrhaphy for individuals with acquired laxity.[34] (continued)

Phase 2: Intermediate Phase (Weeks 7-12) (continued)

Weeks 9-12
- Progress shoulder ROM to the overhead athlete's demands
  - Gradual progression from weeks 9 to 12
  - Continue stretching into ER
  - ER at 90° abduction to 110°-115° by weeks 10-12
  - Continue stretching program for posterior structures (IR, horizontal adduction)
- Strengthening exercises:
  - Progress isotonic program
  - Continue Throwers Ten program
  - May initiate more aggressive strengthening
    - Push-ups
    - Bench press (do not allow arm below body)
    - Latissimus pull-downs (in front of body)
    - Single-hand plyometrics throwing (initiate 14-18 d following the introduction of 2-hand plyometrics)
    - Plyoball wall drills

Phase 3: Advanced Activity and Strengthening Phase (Weeks 12-20)

Goals:
- Improve strength, power, and endurance
- Enhance neuromuscular control
- Functional activities

Criteria to enter phase 3:
- Full ROM
- No pain or tenderness
- Muscular strength 80% of contralateral side

Weeks 12-16
- Continue all stretching exercises
  - Self capsular stretches, active ROM, passive stretching
- Continue all strengthening exercises
  - Throwers Ten program
  - Progress isotonics
  - Plyometrics
    - 2-hand drills progress to 1-hand drills
    - Throwing into plyoback 0.45-kg (1-lb) ball (week 13)
    - Neuromuscular control-dynamic stabilization drills

Weeks 16-22
- Initiate interval sport program (throwing, tennis, swimming, etc.) week 16
- Progress all exercises listed above
- May resume normal training program
- Continue specific strengthening exercises
- Progress interval program (throwing program to phase 2) weeks 22-23

Week 22
- Progress to phase 2 interval throwing program or sport-specific training
- Continue isotonic strengthening
- Continue flexibility and ROM
- Continue plyometrics

Phase 4. Return to Activity Phase (Week 26)

Goals:
- Gradual return to unrestricted activities
- Maintain static and dynamic stability of shoulder joint

Criteria to enter phase 4:
- Full functional ROM
- No pain or tenderness
- Satisfactory muscular strength (isokinetic test)
- Satisfactory clinical exam

Exercises:
- Continue maintenance for ROM (stretching)
- Continue strengthening exercises (Throwers Ten)
- Gradual return to competition
  - Progress throwing program to game situations (months 6-7)

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Active-assisted shoulder internal rotation (IR) and external rotation (ER) range of motion was performed in the scapula plane at 30° of shoulder abduction to approximately 25° of ER and 45° of IR by the end of week 2. Excessive external rotation, elevation, and shoulder extension were avoided. Immediate motion was utilized to stimulate the proliferation of collagen tissue and to assist in collagen synthesis, organization, alignment, and strength.[1,6,36] Thus, gradual progressive applied loads were allowed to stimulate collagen tissue, but we caution against overly aggressive stretching.[34]

At week 3, IR and ER was performed at 45° of shoulder abduction. ER was allowed to approximately 30° and IR was performed to touch the side of the body. Active-assisted flexion range of motion was progressed past 90° during week 4. At week 5, we allowed shoulder IR and ER to be performed at 90° abduction. Range of motion was progressed cautiously during the first 6 to 8 weeks secondary to the reduced tensile properties of the collagen tissue.[7-9,19] Our goal was to have 75° of ER at 90° of shoulder abduction at week 6, and 90° by week 8. Shoulder flexion should be to 180° by week 8. Shoulder motion, with the arm at 90° of abduction, was gradually progressed from 90° of ER to approximately 115° of ER by week 12 as the tensile properties of the collagen tissue returned.[19] Full motion was achieved through the use of manual stretches as well as functional activities such as plyometric drills. The rate of progression utilized is based on the author's clinical experience and was continuously adjusted based on assessment of range of motion and capsular end feel at end range of motion.[34] For example, a patient with sufficient motion and a soft end feel was progressed slower than a patient with a hard end feel and restricted motion.[34]

Strengthening was also performed immediately after surgery through the use of isometric exercises. Isometrics for shoulder flexion, extension, abduction, IR, and ER were performed in midrange and were performed submaximally for coactivation of the glenohumeral joint dynamic stabilizers. At approximately 10 to 14 days postoperatively, a light isotonic program was initiated using exercise tubing and active range of motion as described by Wilk et al[34] and outlined in Table 2. Early proprioceptive exercises, such as active joint repositioning in restricted ranges of motion, were performed. At week 5, the athlete was progressed to a full isotonic strengthening program for the entire upper extremity, such as the Throwers Ten Program.[31,33,34] Emphasis was placed on external rotation and scapular strengthening utilizing sidelying external rotation, prone rowing, and prone horizontal abduction exercises. Isotonic exercises were progressed by 0.45 kg (1 lb) every 7 to 10 days. Furthermore, neuromuscular control drills such as proprioceptive neuromuscular facilitation patterns, manual resistance external rotation with rhythmic stabilizations, and wall stabilization drills with manual perturbations were performed as described by Wilk et al.[34]

Plyometrics were begun at approximately 8 weeks postoperatively utilizing 2 hand drills and restricted amounts of motion. After 10 to 14 days of 2-hand drills, plyometric exercises were progressed to include 1-hand drills. An aggressive strengthening program using machine resistance, such as seated bench press, seated rowing, and latissimus dorsi pulldowns, was allowed beginning postoperative week 12, although in a restricted range of motion.

A gradual return to overhead sports through an interval sport program was allowed beginning week 16, as described by Reinold et al.[21] Criteria to begin an interval sport program consisted of no pain or tenderness, full range of motion and flexibility, satisfactory clinical examination including stability testing, and sufficient strength based on isokinetic testing.[21,33,34] Isokinetic strength values at 180°/s should include a ratio of external rotation peak torque to body weight from 18% to 23%, a ratio of external rotation to internal rotation from 66% to 76%, and a ratio of external rotation to abduction from 67% to 75%.[21,33,34]

Modifications to the rehabilitation program were made based on concomitant procedures performed at the time of thermal application. Rehabilitation of the patient with a SLAP repair incorporates an initial slower rate of progression to allow the healing of the repaired tissues.[34] The rehabilitation progression was based on the number of anchors involved in the labral repair. If 1 anchor was used, the isolated TACS program was followed. If 2 or more anchors were used, a slower rehabilitation program was followed due to the tenuous nature of the repair.[34] The patients wore a sling and limited range of motion to below 90° for the first 4 weeks, gradually progressing to achieve full range of motion at the same time frame as required by an isolated TACS program. No isolated biceps brachii contractions were allowed for 6 to 8 weeks following surgery due to the anatomical attachment of the long head of the biceps at the repair site of the superior labrum.

Rehabilitation following TACS with concomitant subacromial decompression followed a slightly faster rate of progression due to the increased amount of inflammation, bleeding, and subsequent scar tissue formation in the subacromial space.[34] Full passive range of motion was achieved between 4 to 6 weeks versus achievement at 8 weeks with the isolated TACS procedure, although isotonic and functional exercise progressions did not differ.

Follow-up

Over a 1-month period, 130 (56%) of 231 patients were contacted by phone. This phone call follow-up occurred at a mean (±SD) of 29.3 ± 8.7 months (range, 15.4-46.6 months) following the surgery. Evaluation was conducted using the Modified Athletic Shoulder Outcome Scale as described by Tibone and Bradley.[26] The authors developed this scale to provide a means to accurately measure functional outcomes in overhead athletes, using a different set of parameters than scales commonly used for general orthopaedic patients. Although no validity and reliability testing has yet been performed on this scale, the authors report several deficiencies in commonly used outcome scales that may yield higher results than the athlete's actual performance outcome. Thus, the Athletic Shoulder Outcome Scale was developed to address these deficiencies and to provide a standardized outcome scale for overhead athletes for long-term outcome studies.

The scoring used by Tibone and Bradely[26] featured a 100-point scale with 10 points devoted to objective range of motion measurements of the dominant shoulder in comparison to the nondominant shoulder. Full scoring of range of motion (10/10 points) was originally considered to be shoulder flexion and external rotation equal to that of the contralateral shoulder. We chose to modify this scale by eliminating this component due to the range of motion discrepancies that exist between the dominant and nondominant shoulders in overhead athletes,[32] thereby making a comparison between shoulders invalid and unreliable as originally described.

The modified form combined reports of pain level (10 points), strength and endurance (10 points), stability (10 points), intensity (10 points), and performance (50 points) on a 90-point scale (see Appendix). The overall results were rated as excellent (80-90 points), good (60-79 points), fair (40-59 points), or poor (less than 40 points) based on the original description by Tibone and Bradely.[26]

RESULTS

One hundred thirteen (87%) of 130 athletes returned to competition at the same level or higher. Mean (±SD) time to return to competition following surgery was 8.4 ± 4.6 months. Mean scores of the modified Athletic Shoulder Outcome Scale are listed in Table 3. Mean (±SD) overall score was 79 ± 14.5 out of a possible 90 points. Seventy-five (66%) athletes reported excellent, 24 (21%) good, 11 (10%) fair, and 3 (3%) poor outcomes.

Analysis of outcomes based on sport showed that: 100% (4/4) of tennis players returned to competition with a mean (±SD) outcome score of 82 ± 8.4 (excellent); 91% (95/105) of baseball players returned to competition with a mean (±SD) outcome score of 81 ± 12.7 (excellent); 71% (10/14) of softball players returned to competition with a mean (±SD) outcome score of 70 ± 22.0 (good); 67% (2/3) of swimmers returned to competition with a mean (±SD) outcome score of 74 ± 22.6 (good); and 50% (2/4) of football quarterbacks returned to competition with a mean (±SD) outcome score of 72 ± 31.2 (good).

TABLE 3. Mean (±SD) outcome scores for the modified Athletic Shoulder Outcome Scale.*

	Points
Pain	8.4 ± 2.3/10
Strength and endurance	8.9 ± 1.8/10
Stability	9.0 ± 2.1/10
Intensity	8.9 ± 1.7/10
Performance (all patients)	43.6 ± 10.7/50
• Number of patients (%) with 50/50 point score	74 (57%)
• Number of patients (%) with 40/50 point score	21 (16%)
• Number of patients (%) with 30/50 point score	6 (5%)
• Number of patients (%) with 20/50 point score	9 (7%)
• Number of patients (%) with 10/50 point score	3 (2%)
• Number of patients (%) with 0/50 point score	0 (0%)
Overall score	79.1 ± 14.6/90

* Modified from Tibone and Bradley.[26]

Comparing outcomes based on the level of competition showed that: 85% (46/54) of professional athletes returned to competition with a mean (±SD) outcome score of 80 ± 13.8 (excellent); 94% (46/49) of collegiate athletes returned to competition with a mean (±SD) outcome score of 78 ± 16.8 (good); 63% (10/16) of high school athletes returned to competition with a mean (±SD) outcome score of 79 ± 13.6 (good); and 100% (11/11) of recreational athletes returned to competition with a mean (±SD) outcome score of 80 ± 8.0 (excellent).

Comparing outcomes between sex showed that: 89% of males returned to competition with a mean (±SD) outcome score of 80 ± 13.2. Conversely, 71% of females returned to competition with a mean (±SD) score of 70 ± 20.7. Of the 7 athletes with an isolated TACS procedure, 5 of the 7 (71%) returned to competition with a mean (±SD) outcome score of 73 ± 14.1 (good). However, 100% (4/4) of male athletes, as compared to 33% (1/3) of female athletes, with an isolated TACS procedure returned to competition.

Comparing outcomes between different concomitant procedures revealed similar results regardless of the procedure performed. Ninety percent of patients who underwent TACS with Bankart repairs returned to competition with a mean (±SD) outcome score of 84 ± 7.2 (excellent); 87% of patients who underwent TACS with labral debridement and rotator cuff debridement returned to competition with a mean (±SD) outcome score of 80 ± 13.1 (excellent); 86% of patients who underwent TACS with subacromial de-

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compressions returned to competition with a mean (±SD) outcome score of 83 ± 10.8 (excellent); and 84% of patients who underwent TACS with SLAP repairs returned to competition with a mean (±SD) outcome score of 79 ± 13.2 (good).

Analyzing the results from year to year (Table 4), outcome scores, percent return, and time to return showed similar results each year, although a trend towards the percentage of patients returning to competition steadily rose from 1997 to 1999, while the time to return to competition showed a steady decrease.

Comparing the outcomes based on the time of follow-up showed consistent results as well. Eighty-six percent (38/44) of athletes with a follow-up of between 15 and 23.9 months returned to competition with a mean (±SD) outcome score of 79 ± 13.5 (good); 93% (52/56) of athletes with a follow-up between 24 and 35.9 months returned to competition with a mean (±SD) outcome score of 78 ± 16.9 (good); and 77% (23/30) of athletes with a follow-up between 36 and 47 months returned to competition with a mean (±SD) outcome score of 83 ± 9.1 (excellent).

No adverse effects were noted in any of the 130 subjects. None of the subjects had surgical complications such as neuropathy or recurrent instability. Of the 17 patients who did not return to competition, 42% were diagnosed with multidirectional instability and 35% had previous surgical procedures on the shoulder. Eighteen percent of patients reported that their inability to return to competition was not related to shoulder outcome.

DISCUSSION

Surgical intervention for shoulder instability in the overhead athlete has evolved dramatically over the past several years. Reports on outcomes of several open surgical procedures have indicated long-term loss of motion complications and poor functional outcomes in the overhead athlete population. The poor objective and functional outcomes associated with open stabilization procedures has facilitated the use of arthroscopy to minimize postoperative loss of motion. Recently the application of thermal energy as a means to selectively shrink the glenohumeral capsule using an arthroscopic procedure has been advocated.[4,7-9,18]

In our current study, we examined the functional outcomes of 130 overhead athletes undergoing TACS at a mean follow-up of 29 months (range, 15-47 months). The results of our study indicate superior outcomes to those which reported using open and arthroscopic stabilization procedures without TACS,[3,12,15,17,20,22-24,29] and similar to those of Savoie and Field,[25] Lyons et al,[16] and Levitz et al,[14] which used TACS. Eighty-eight percent of patients had good-to-excellent results, with 87% returning to the same level of competition at a mean of 8.4 months postoperatively.

A structured postoperative rehabilitation program is vital to the overall outcome following TACS due to the unique properties of thermal-altered collagen tissue. The rehabilitation program utilized in this study is based on the authors' clinical experience of over 700 patients treated with TACS between 1997 and 2003, the effects of mobilization on collagen tissue healing,[1,6,34,36] and the basic science of collagen tissue healing following thermal modification.[7-9,18,19,27-28,34]

The rehabilitation program follows a gradual progression of applied loads on the collagen tissue to restore range of motion as the strength and tensile properties of the collagen tissue gradually returns to the preoperative state. The use of immediate motion is based on the theory that gentle passive motion is beneficial to the restoration of the organization, alignment, and strength of collagen tissue.[1,6,34,36] Several authors have shown a significant decrease in collagen tissue stiffness following thermal modification.[11,19,34] Hecht et al[11] documented a significant reduction in collagen strength of 48% immediately following thermal modification, and a 26% decrease at 2 weeks after surgery, in a study using a bovine model. This was followed by a gradual improvement of the tissue's mechanical properties by 6 weeks postoperatively and a full return of preoperative stiffness at 12 weeks. Similarly, Hecht et al[10] reported a 65% reduction of tissue stiffness at 2 weeks following surgery, and a 20% reduction at 6 weeks postoperatively, with a return to preoperative tissue stiffness at 12 weeks following thermal application in a study using a bovine model. Therefore, passive range of motion is initially performed without stretching, as it is necessary to carefully progress the range of motion

TABLE 4. Outcome trends over time from 1997 to 1999.

	1997 (n = 30)	1998 (n = 56)	1999 (n = 44)	Overall Mean (n = 130)
Percent return to competition	80	87	88	87
Mean time to return to competition (mo)	8.9	8.5	8.2	8.4
Overall outcome score (mean points/90)	82.6	76.7	79.6	79.0

during the first 4 to 6 weeks when collagen tissue may be susceptible to stretch-out due to a decrease in tissue stiffness. As the strength of the collagen returns from 6 to 12 weeks, the patient may be gradually progressed to full shoulder range of motion.

Furthermore, the use of an arthroscopic surgical approach, with minimal surrounding tissue involvement, allows for use of immediate motion without applying deleterious forces to surgically involved tissue. This progression towards early, controlled range-of-motion activities in comparison to the delayed rehabilitation programs used for the previously discussed open and arthroscopic stabilization procedures[3,12,15,17,20,22-24,29] may contribute to the enhanced outcomes observed in overhead athletes following TACS.

Based on our clinical experience and the results of this study, the use of TACS may enhance the functional outcomes in overhead athletes, possibly by minimizing the common postoperative complications often associated with open stabilization procedures such as subscapularis scarring, decreased capsular mobility, and decreased range of motion.

Furthermore, TACS does not appear to be a procedure that is performed in isolation. Ninety-five percent of athletes in our study had a concomitant procedure performed at the time of thermal application. Most commonly performed were rotator cuff debridement, labral debridement, SLAP repairs, and subacromial decompressions. It appears that TACS may be best used to decrease glenohumeral joint translation associated with acquired laxity in overhead athletes, while addressing the associated pathologies of shoulder instability such as labral and rotator cuff lesions.

Toth et al[30] reported the results of TACS in 80 patients with a mean follow-up of 3.3 years. Six surgeons performed TACS using a monopolar device on a variety of patients of various ages, and with various types of instability, dislocation histories, activities, and previous surgeries. The authors noted a 31% failure rate, although the rate of failure increased from 21.7% in patients with concomitant labral repair to 39.2% without a repair. Furthermore, 21.7% of patients with anterior instability failed versus 27.7% with multidirectional instability (MDI) and 80% with posterior instability.

Similarly, Krishman et al[13] reported the results of 86 patients undergoing TACS with a minimal 2-year follow-up. The authors performed the procedure on a variety of patient populations and noted a mean 39.5% failure rate. The rate of failure increased from 30.4% in patients with anterior instability undergoing concomitant Bankart repairs to 33% without the labral repair. Furthermore, 41.6% of patients with posterior instability and 59% of patients with MDI failed the TACS procedure.

The results of the current study as well as with the studies by Toth[30] and Krishman[13] may suggest that concomitant surgeries, such as labral repairs performed at the time of TACS, may enhance surgical outcomes. The variability in failure rates between the current study and those of Toth[30] and Krishnan[13] may, furthermore, be related to the patient populations examined in these studies. The previous authors performed TACS on a wide variety of patient populations with several different pathologies. The TACS procedure may not be the most ideal surgery for patients with posterior and multidirectional instability due to the increased failure rates reported in these populations by Toth[30] and Krishman,[13] but it may enhance the outcome of overhead athletes with acquired glenohumeral laxity as reported in this study. Particularly, 91% of baseball players returned to competition versus 72% of all other overhead athletes.

The possible reasons for this reported high success rate might be due to our patient population of overhead athletes with unidirectional microinstability, the use of the described structured rehabilitation program, close postoperative patient supervision, and a high rate of concomitant procedures. Based on our clinical experience and the results of Toth,[30] Krishman,[13] and the current study, it appears that addressing all of the underlying pathologies with concomitant procedures at the time of thermal application may yield the best outcomes.

In an attempt to identify risk factors associated with poor outcomes following TACS, Anderson et al[2] followed 106 patients undergoing the TACS procedure. The authors reported that 15 (14%) patients failed at a mean of 6.3 months postoperatively. Treatment failure was defined as recurrent dislocations, reoperation, or poor functional outcome score. The authors report that previous surgical procedures (46% of failures) and multiple recurrent dislocations (53% of failures) were significantly associated with poor outcomes. Participation in contact sports and patients with multidirectional instability were also associated with poor outcomes, although not statistically significant. A concomitant procedure at the time of TACS was not associated with poor outcomes.

Of the 130 overhead athletes observed in this study, 13% did not return to competition. Forty-two percent of these athletes exhibited multidirectional instability and 35% had previous surgical procedures to the throwing shoulder, similar to the findings of Anderson et al.[2] It was also noted that 89% of males (80/90) compared to 71% of females (70/90) returned to competition, possibly due to the higher incidence of congenital laxity observed in the female overhead athletes involved in this study. Of the athletes that did not return to competition, 18% report various reasons for not returning to competition that were not associated with shoulder function,

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most commonly graduating from high school or college without the desire to pursue further competition. The most common complaint of athletes not returning to competition was feeling tight and a loss of throwing velocity, although strength and stability were adequate. Based on the experience of the authors, patients undergoing TACS appear to regain their full preoperative range of motion, although clinical subjective assessment of the patient's capsular end feel reveals a firmer end point postoperatively, thus a decrease in the end feel's elasticity. In fact, it has been the author's experience that the patients with the most difficulty returning to competition are those who do not regain full motion, commonly complaining of feeling ''too tight'' when attempting to perform.

At the time of follow-up, no athletes in the current study reported adverse complications from the TACS procedure. In a survey of 379 orthopedic surgeons, Wong and Williams[35] report a 8.3% incidence of recurrent instability and a 1.4% incidence of axillary nerve injury with 95% recovering at approximately 4 months postoperative. Neither recurrent instability nor axillary nerve injury were observed in the current group of overhead athletes.

The results of TACS have been retrospectively studied in this group of 130 overhead athletes using a functional outcome scale. The limitations of the current study involve the retrospective and subjective nature of data collection. Further research regarding the efficacy of this surgical procedure are needed to observe the outcomes of a greater sample of patients at a longer clinical follow-up, including prospective, randomized studies. Inclusion of more detailed objective data is also necessary. Also, the long-term outcome of other patient samples, such as nonoverhead athletes and patients with multidirectional instability, needs to be studied further.

CONCLUSION

Based on the results of the current study, the use of TACS in overhead athletes with acquired laxity who have failed a nonoperative rehabilitation program is an effective method of treating shoulder microinstability. It appears that this surgical technique is more effective than traditional open procedures in returning overhead athletes to competition by using an arthroscopic approach, which may minimize joint scarring and motion loss. TACS is rarely used as an isolated procedure, but, rather, is used to reduce glenohumeral joint translation while addressing associated pathologies to the rotator cuff and glenoid labrum. The use of TACS may be best suited for the patient with mild unidirectional hyperlaxity with concomitant rotator cuff and labral pathology, such as in overhead athletes, rather than for patients with gross instability, recurrent dislocations, previous surgical procedures, or multidirectional instability. Regardless, surgical intervention addressing all underlying pathologies, as well as a well-designed postoperative rehabilitation program based on the basic science of collagen tissue following thermal application, appears to be vital to the final outcome. A gradual progression using immediate passive range of motion while continuously monitoring the patient's progression assures a gradual application of controlled stress on the healing soft tissue and minimizes the loss of motion.

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REFERENCES

1. Akeson WH, Amiel D, Mechanic GL, Woo SL, Harwood FL, Hamer ML. Collagen cross-linking alterations in joint contractures: changes in the reducible cross-links in periarticular connective tissue collagen after nine weeks of immobilization. *Connect Tissue Res.* 1977;5(1):15-19.
2. Anderson K, Warren RF, Altchek DW, Craig EV, O'Brien SJ. Risk factors for early failure after thermal capsulorrhaphy. *Am J Sports Med.* 2002;30(1):103-107.
3. Bigliani LU, Kurzweil PR, Schwartzbach CC, Wolfe IN, Flatow EL. Inferior capsular shift procedure for anterior-inferior shoulder instability in athletes. *Am J Sports Med.* 1994;22(5):578-584.
4. Fanton GS. Arthroscopic electrothermal surgery of the shoulder. *Op Tech Sports Med.* 1998;6:139-146.
5. Fleisig GS, Andrews JR, Dillman CJ, Escamilla RF. Kinetics of baseball pitching with implications about injury mechanisms. *Am J Sports Med.* 1995;23(2):233-239.
6. Frank C, MacFarlane B, Edwards P, et al. A quantitative analysis of matrix alignment in ligament scars: a comparison of movement versus immobilization in an immature rabbit model. *J Orthop Res.* 1991;9(2):219-227.
7. Hayashi K, Markel MD, Thabit G, 3rd, Bogdanske JJ, Thielke RJ. The effect of nonablative laser energy on joint capsular properties. An in vitro mechanical study using a rabbit model. *Am J Sports Med.* 1995;23(4):482-487.
8. Hayashi K, Nieckarz JA, Thabit G, 3rd, Bogdanske JJ, Cooley AJ, Markel MD. Effect of nonablative laser energy on the joint capsule: an in vivo rabbit study using a holmium:YAG laser. *Lasers Surg Med.* 1997;20(2):164-171.
9. Hayashi K, Thabit G, 3rd, Massa KL, et al. The effect of thermal heating on the length and histologic properties of the glenohumeral joint capsule. *Am J Sports Med.* 1997;25(1):107-112.
10. Hecht P, Hayashi K, Cooley AJ, et al. The thermal effect of monopolar radiofrequency energy on the properties of joint capsule. An in vivo histologic study using a sheep model. *Am J Sports Med.* 1998;26(6):808-814.
11. Hecht P, Hayashi K, Lu Y, et al. Monopolar radiofrequency energy effects on joint capsular tissue: po-

tential treatment for joint instability. An in vivo mechanical, morphological, and biochemical study using an ovine model. *Am J Sports Med.* 1999;27(6):761-771.
12. Jobe FW, Giangarra CE, Kvitne RS, Glousman RE. Anterior capsulolabral reconstruction of the shoulder in athletes in overhand sports. *Am J Sports Med.* 1991;19(5):428-434.
13. Krishnan SG, Hawkins RJ, Karas SG, Horan MP, Noonan TJ. Electrothermal arthroscopic shoulder capsulorrhaphy: a minimum two-year follow-up. *Annual Meeting of the American Orthopedic Society for Sports Medicine.* Orlando, FL; American Orthopedic Society for Sports Medicine: 2002.
14. Levitz CL, Dugas J, Andrews JR. The use of arthroscopic thermal capsulorrhaphy to treat internal impingement in baseball players. *Arthroscopy.* 2001;17(6):573-577.
15. Lombardo SJ, Kerlan RK, Jobe FW, Carter VS, Blazina ME, Shields CL, Jr. The modified Bristow procedure for recurrent dislocation of the shoulder. *J Bone Joint Surg Am.* 1976;58(2):256-261.
16. Lyons TR, Griffith PL, Savoie FH, 3rd, Field LD. Laser-assisted capsulorrhaphy for multidirectional instability of the shoulder. *Arthroscopy.* 2001;17(1):25-30.
17. Montgomery WH, 3rd, Jobe FW. Functional outcomes in athletes after modified anterior capsulolabral reconstruction. *Am J Sports Med.* 1994;22(3):352-358.
18. Naseef GS, 3rd, Foster TE, Trauner K, Solhpour S, Anderson RR, Zarins B. The thermal properties of bovine joint capsule. The basic science of laser- and radiofrequency-induced capsular shrinkage. *Am J Sports Med.* 1997;25(5):670-674.
19. Osmond C, Hecht P, Hayashi K, et al. Comparative effects of laser and radiofrequency energy on joint capsule. *Clin Orthop.* 2000;375:286-294.
20. Pagnani MJ, Warren RF, Altchek DW, Wickiewicz TL, Anderson AF. Arthroscopic shoulder stabilization using transglenoid sutures. A four-year minimum followup. *Am J Sports Med.* 1996;24(4):459-467.
21. Reinold MM, Wilk KE, Reed J, Crenshaw K, Andrews JR. Interval sport programs: guidelines for baseball, tennis, and golf. *J Orthop Sports Phys Ther.* 2002;32(6):293-298.
22. Rowe CR, Patel D, Southmayd WW. The Bankart procedure: a long-term end-result study. *J Bone Joint Surg Am.* 1978;60(1):1-16.
23. Rowe CR, Zarins B, Ciullo JV. Recurrent anterior dislocation of the shoulder after surgical repair. Apparent causes of failure and treatment. *J Bone Joint Surg Am.* 1984;66(2):159-168.
24. Rubenstein DL, Jobe FW, Glousman RE, et al. Anterior capsulolabral reconstruction of the shoulder in athletes. *J Shoulder Elbow Surg.* 1992;1:229-237.
25. Savoie FH, 3rd, Field LD. Thermal versus suture treatment of symptomatic capsular laxity. *Clin Sports Med.* 2000;19(1):63-75.
26. Tibone JE, Bradley JP. Evaluation of treatment outcomes for the athlete's shoulder. In: Matsen FA, Fu FH and Hawkins RJ, eds. *The Shoulder: A Balance of Mobility and Stability.* Rosemont, IL: American Academy of Orthopedic Surgeons; 1993.
27. Tibone JE, Lee TQ, Black AD, Sandusky MD, McMahon PJ. Glenohumeral translation after arthroscopic thermal capsuloplasty with a radiofrequency probe. *J Shoulder Elbow Surg.* 2000;9(6):514-518.
28. Tibone JE, McMahon PJ, Shrader TA, Sandusky MD, Lee TQ. Glenohumeral joint translation after arthroscopic, nonablative, thermal capsuloplasty with a laser. *Am J Sports Med.* 1998;26(4):495-498.
29. Torg JS, Balduini FC, Bonci C, et al. A modified Bristow-Helfet-May procedure for recurrent dislocation and subluxation of the shoulder. Report of two hundred and twelve cases. *J Bone Joint Surg Am.* 1987;69(6):904-913.
30. Toth AP, Cordasco FA, Althchek DW, O'Brien SJ. Thermal assisted capsular shrinkage for shoulder instability: minimum two year follow-up. *Annual Meeting of the American Orthopedic Society for Sports Medicine.* Orlando, FL: 2002.
31. Wilk KE, Andrews JR, Arrigo CA, et al. *Preventive and Rehabilitative Exercises for the Shoulder and Elbow.* 6th ed. Birmingham, AL: American Sports Medicine Institute; 2001.
32. Wilk KE, Meister K, Andrews JR. Current concepts in the rehabilitation of the overhead throwing athlete. *Am J Sports Med.* 2002;30(1):136-151.
33. Wilk KE, Reinold MM, Andrews JR. Postoperative treatment principles in the throwing athlete. *Sports Med Arthrosc Rev.* 2001;9:69-95.
34. Wilk KE, Reinold MM, Dugas JR, Andrews JR. Rehabilitation following thermal-assisted capsular shrinkage of the glenohumeral joint: current concepts. *J Orthop Sports Phys Ther.* 2002;32(6):268-292.
35. Wong KL, Williams GR. Complications of thermal capsulorrhaphy of the shoulder. *J Bone Joint Surg Am.* 2001;83-A(Suppl 2, Pt 2):151-155.
36. Woo SL, Matthews JV, Akeson WH, Amiel D, Convery FR. Connective tissue response to immobility. Correlative study of biomechanical and biochemical measurements of normal and immobilized rabbit knees. *Arthritis Rheum.* 1975;18(3):257-264.

Appendix

Modified Athletic Shoulder Outcome Rating Scale*

Name ______ Age ______ Sex ______
Dominant Hand (R) ______ (L) ______ (Ambidextrous) ______
Date of Examination ______ Height ______ Weight ______
Surgeon ______ Date of Surgery ______
Surgery ______
Type of Sport ______
Position Played ______
Years Played ______
Prior Injury ______
Time to Return to Competition ______

Activity Level Preoperative
1. Professional (major league)
2. Professional (minor league)
3. College
4. High School
5. Recreational (full time)
6. Recreational (occasionally)

Activity Level postoperative
1. Professional (major league)
2. Professional (minor league)
3. College
4. High school
5. Recreational (full time)
6. Recreational (occasionally)

Diagnosis
1. Anterior instability
2. Posterior instability
3. Multidirectional instability
4. Recurrent dislocations
5. Impingement syndrome
6. Internal impingement
7. Acromioclavicular separation
8. Acromioclavicular arthrosis
9. Rotator cuff tear (partial)
10. Rotator cuff tear (complete)
11. Labral tear
12. Biceps tendon rupture
13. Calcific tendinitis
14. Fracture

Pain	Points
• No pain with competition	10
• Pain after competing only	8
• Pain while competing	6
• Pain preventing competing	4
• Pain with activities of daily living (ADLs)	2
• Pain at rest	0
Strength/Endurance	
• No weakness, normal competition fatigue	10
• Weakness after competition, early competition fatigue	8
• Weakness during competition, abnormal competition fatigue	6
• Weakness or fatigue preventing competition	4
• Weakness or fatigue with ADLs	2
• Weakness or fatigue preventing ADLs	0
Stability	
• No looseness during competition	10
• Recurrent subluxations while competing	8
• Dead-arm syndrome while competing	6
• Recurrent subluxations prevent competition	4
• Recurrent subluxations during ADLs	2
• Dislocation	0

Intensity	
• Preinjury versus postinjury hours of competition (100%)	10
• Preinjury versus postinjury hours of competition (less than 75%)	8
• Preinjury versus postinjury hours of competition (less than 50%)	6
• Preinjury versus postinjury hours of competition (less than 25%)	4
• Preinjury and postinjury hours of ADLs (100%)	2
• Preinjury and postinjury hours of ADLs (less than 50%)	0
Performance	
• At the same level, same proficiency	50
• At the same level, decreased proficiency	40
• At the same level, decreased proficiency, not acceptable to athlete	30
• Decreased level with acceptable proficiency at that level	20
• Decreased level, unacceptable proficiency	10
• Cannot compete, had to switch sport	0
Total	/90

Overall Results	
Excellent	80-90 points
Good	60-79 points
Fair	40-59 points
Poor	<40 points

* Modified from Tibone and Bradely with permission from the American Academy of Orthopedic Surgeons.[26]

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