Spine Injuries in the Elite Athlete

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Complex Pediatric and Adult Scoliosis Service
Co-Director, Spine Fellowship
Director, Clinical Spine Research
Co-Director, Orthopaedic Clinical Research

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What is our evidence?

How good is it?

…Not very good

Return-to-Play Outcomes After Microscopic Lumbar Diskectomy in Professional Athletes

Robert G. Wiltse, Jr. MD, Robert Harms, lil, David Chang, MD, and Robert G. Wiltse, Jr. MD.

Limitations in our study include that retrospective analysis limits power of conclusions, prospective randomization of treatment may illustrate effectiveness of operative versus nonoperative treatment, and 8 patients were determined to successfully return to sport, but the date of return could not be determined. We also did not calculate information on the durability of the return to play; we know only that each player returned to play at least 1 minute, but not how long.
Results:
• Back and core injuries may represent as many as 12% of all injuries that result in time out of play in the MLB.
• High injury rate likely related to critical role of spine/core in balancing complex combination of upper and lower extremity movements.
• Conservative treatment involving analgesics, rest, and therapy is usually prescribed initially.
• Preemptive spinal and core stabilization will likely help prevent injury.

PREHAB may be KEY!!
The Professional Athlete Spine Initiative: outcomes after lumbar disc herniation in 342 elite professional athletes

Hsu, McCarthy, Savage, Roberts, Roc, Micev, Terry, Gryzlo, and Schafer
The Spine Journal, 2011

Methods:
Retrospective study of 342 professional athletes from four major North American sports from 1972 to 2008 diagnosed with LDH. Functional outcome measured by successful return to play, career games, and years played before and after treatment.

Results:
• Surgical treatment group: 81% RTP for average of 3.3 years after surgery
• No significant difference b/w outcome in surgical and nonoperative cohorts
• Age at diagnosis was negative predictor of career length after injury
• MLB players demonstrated significantly higher return to play rate than those of other sports
• For MLB athletes, lumbar discectomy led to shorter career compared with nonoperative cohort
Great rehabilitation and great physical bodies allow professional athletes undergoing lumbar discectomy to return to sport at a high rate

Robert G. Watkins III
The Spine Journal, 2011


- Does not address why athletes are able to return to play or adequately explain sport specific differences in return to play
- Given that all surgeons involved are reasonably technically well skilled in performing lumbar discectomies, could rehabilitation program and not surgery itself be the determining factor in return to play?
- Study cannot be extrapolated to general population due to distinct bodies of athletes
- “The key to return to play is the rehabilitation and sports-specific training program for these athletes and not whether the patient had surgery or not.”

Subgroup analysis of MLB and NFL athletes who underwent operative and nonoperative treatment for a lumbar disc herniation

<table>
<thead>
<tr>
<th>League</th>
<th>Operative</th>
<th>Nonoperative</th>
<th>p Value</th>
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<tbody>
<tr>
<td>NFL</td>
<td>RTP rate</td>
<td>0.78</td>
<td>0.59</td>
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<td>Games</td>
<td>36</td>
<td>20</td>
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<td>Age (y)</td>
<td>27.5</td>
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<tr>
<td>MLB</td>
<td>RTP rate</td>
<td>0.96</td>
<td>0.97</td>
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<tr>
<td></td>
<td>Games</td>
<td>256</td>
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<td>Years</td>
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<td>Age (y)</td>
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MLB: Major League Baseball; NFL, National Football League; RTP, return-to-play.
Epidemiology of Major League Baseball Injuries
Posner, Cameron, Wolf, Belmont Jr., and Owens
The American Journal of Sports Medicine, 2011

Methods:
Analysis of MLB disabled list from 2002-2008, stratified based on season, month, anatomic zone, injury type, and position (pitcher v. position player)

Results:
• 37% increase in injuries from 2005-2008
• Injury rate decreases from April to September
• Injury rate 34% higher for pitchers than position players
• 11.7% of all injuries were of spine/core musculature
• Pitchers more likely to injure upper extremities, position players lower extremities

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<thead>
<tr>
<th>Body Region</th>
<th>Fielders %</th>
<th>Pitchers %</th>
<th>Overall %</th>
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<tr>
<td>Foot/ankle</td>
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Thoracolumbar Range of Motion in Baseball Pitchers and Position Players
Laudner, Lynall, Williams, Wong, Onuki, and Meister

Methods:
Subjects included asymptomatic pitchers and position players. Active-assisted thoracolumbar flexion, extension, and bilateral ROM were measured in a standing position using inclinometers to compare motion.

Results:
• Pitchers have significantly more rotational ROM to the non-throwing arm side compared to position players
• Pitchers have greater amount of rotational ROM to the non-throwing arm side compared to throwing side
HA1
create clearer chart
Habermann, Alyssa, 10/11/2016
Trunk Axial Rotation in Baseball Pitching and Hitting with Implications about Lumbar Disc Herniations

Fleisig GS, Hsu WK, Fortenbaugh D, Cordover A, Press JM, Andrews JR

Trunk axial rotation = Increased intradiscal pressures

45 deg trunk rotation = 1.5 axial rotation per disc

1Fujii et al 2007, Eur Spine Journal

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| Phases | Kick-off | Step | Arm Contact | Arm Acceleration | Arm Deceleration | Follow-through |

Trunk Axial Rotation in Baseball Pitching and Hitting with Implications about Lumbar Disc Herniations

Fleisig GS, Hsu WK, Fortenbaugh D, Cordover A, Press JM, Andrews JR

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<tr>
<th></th>
<th>Hitters</th>
<th>Batters</th>
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<tr>
<td>Sample size</td>
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<td>33</td>
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<tr>
<td>Axial rotation velocity opening phase before upper trunk (deg/s)</td>
<td>286 ± 83</td>
<td>225 ± 78</td>
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<tr>
<td>Maximum axial rotation before ball release/contact (deg)*</td>
<td>12 ± 3</td>
<td>13 ± 0</td>
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<tr>
<td>Axial rotation velocity rotating upper trunk and declining/groin (deg/s)*</td>
<td>506 ± 81</td>
<td>245 ± 65</td>
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<tr>
<td>Maximum axial rotation after ball release/contact (deg)*</td>
<td>5 ± 3</td>
<td>4 ± 3</td>
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</tbody>
</table>
Outcomes of Lumbar Discectomy in Elite Athletes: The Need for High-level Evidence
Nair, Kahlenberg et al
Clinical Orthopaedics and Related Research, 2015

Methods:
Literature review of articles of lumbar discectomy in the elite athlete population through MEDLINE and EMBASE databases: 1947 - 2013

Results:
- Athletes returning to elite competition after surgery = 75% to 100%
- Higher proportion of baseball players returned to elite competition compared with other athletes
- Reported recovery period after lumbar discectomy = 2.8 to 8.7 months
- Average career length after lumbar discectomy = 2.6 to 4.8 years
- Elite athletes reached average of 64.4% to 103.6% of baseline preoperative stats after lumbar discectomy

Selected Findings from Articles Included in Review

<table>
<thead>
<tr>
<th>Number of patients undergoing lumbar discectomy</th>
<th>Sport</th>
<th>% Returning to sport at 6 months</th>
<th>Mean recovery time (months)</th>
<th>Length of career postoperatively (number of seasons)</th>
<th>Length of career preoperatively (years)</th>
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<tr>
<td>45</td>
<td>NFL</td>
<td>58 (79%)</td>
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<tr>
<td>50</td>
<td>Multiple</td>
<td>67 (89%)</td>
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<tr>
<td>136</td>
<td>NFL</td>
<td>164 (41%)</td>
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<td>55</td>
<td>NBA</td>
<td>67 (61%)</td>
<td>3.3</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>20</td>
<td>Multiple</td>
<td>10 (52%)</td>
<td>3.3</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>25</td>
<td>NFL</td>
<td>70 (79%)</td>
<td>3.3</td>
<td>NR</td>
<td>NR</td>
</tr>
</tbody>
</table>
Lumbar Intervertebral Disk Degeneration in Athletes
Hangai, Kaneoka, Hinotsu, Shimizu, Okubu, Miyakawa, Mukai, Sakane, and Ochiai
The American Journal of Sports Medicine, 2009

Methods: Disc degeneration evaluated using T2-weighted MRI in 308 well-trained university athletes and 71 nonathlete university students (reference group). Self-reported questionnaire concerning low back pain was also conducted.

Results:
- Proportions of participants who had disc degeneration among baseball players and swimmers were significantly higher than among nonathletes
- Significant association between lifetime experience of low back pain and participants with disk degeneration
- Significant linear association between degree of severest low back pain experienced and participants with disc degeneration

Microscopic lumbar discectomy results for 60 cases in professional and Olympic athletes
Watkins IV, Williams, and Watkins III
The Spine Journal, 2003

Methods: Retrospective review of 60 microscopic lumbar discectomies performed on 59 professional and Olympic athletes by senior author between 1984 and 1998

Results:
- All but 7 of 60 patients had returned to their sport
- Average time from surgery to return was 5.2 months (1-15 months)
- Microscopic lumbar discectomy with trunk stabilization rehabilitation program was effective in returning athletes to high level of competition

Return-to-sport rate and average time, by sport

<table>
<thead>
<tr>
<th>Sport</th>
<th>Total surgeries (N)</th>
<th>Return to sport (N)</th>
<th>Return to sport (%)</th>
<th>Average time (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ballet</td>
<td>1</td>
<td>1</td>
<td>100.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Baseball</td>
<td>21</td>
<td>19</td>
<td>90.5</td>
<td>5.3</td>
</tr>
<tr>
<td>Basketball</td>
<td>7</td>
<td>7</td>
<td>100.0</td>
<td>8.0*</td>
</tr>
<tr>
<td>Football</td>
<td>20</td>
<td>15</td>
<td>75.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Hockey</td>
<td>7</td>
<td>7</td>
<td>100.0</td>
<td>6.4</td>
</tr>
<tr>
<td>Olympians</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ski</td>
<td>1</td>
<td>1</td>
<td>100.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Swim</td>
<td>1</td>
<td>1</td>
<td>100.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Water polo</td>
<td>2</td>
<td>2</td>
<td>100.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

*One athlete, 15 months; other six, 6.8 months.
Return to Play After Lumbar Spine Surgery
Cook et al.
Clinics in Sports Medicine, 2016

Results:
- **Microdiscectomy** for lumbar disc herniation has exceptionally favorable outcomes—vast majority of athletes return to play in wide variety of sports with little impact on performance measures
- **Direct pars repairs** equally successful in younger athletes, with high rates of return to play for variety of fixation techniques
- In baseball:
  - Greatest amount of force generated during batting occurs after ball contact and during pitching near front foot contact → greater intradiscal pressures, which may predispose these athletes to either virgin or recurrent lumbar spine injuries
  - 97% successfully return to play at an average of 6.6 months after diagnosis
  - Athletes treated operatively required significantly more time to return to play than those managed conservatively (8.7 vs. 3.6 months, respectively)
  - Pitchers and batters demonstrated significantly poorer performance in certain vital statistical categories postoperatively, whereas the nonoperative cohort returned to play at preoperative performance levels and with longer careers

Return-to-Play Recommendations After Cervical, Thoracic, and Lumbar Spine Injuries: A Comprehensive Review
Huang, Anissipour, McGee, and Lemak
Sports Health, 2015

Methods:
Clinical review of electronic databases and professional orthopedic, neurosurgical, and spine organizational websites from 1980-2015

Results:
- Clinical guidelines have been published for return to play after spine injury, but are almost exclusively derived from expert opinion and clinical experience rather than from well-designed studies
- Recommendations differ and vary depending on anatomic location, type of sport, and surgery performed
- **Universal agreement that athletes should be pain free, completely neurologically intact, and have full strength and range of motion before returning to play after spinal injury**

Does it Matter?
1. Pitcher
2. Batter
3. Infielder
4. Outfielder
Intraop Scope Pictures

Discectomy/Decompression Therapy Protocol

Phase I:
- Lasek Klarenbeck, PT, DPT, OCS

Goals:
1. Improve Neural Mobility
2. Improve flexibility of extremities
3. Establish neutral lumbar spine with extremity motion
4. Assess and improve mobility and strength of cervical and thoracic spine
5. Continue control of pain and inflammation

Precautions:
1. Pain and inflammation controlled
2. Progression relative to soreness protocol
3. Low load high repetitions to improve endurance rather than high load for strength

Treatment:
1. Assess and improve flexibility of lower extremities
2. Assess and correct gait deviations
3. Assess and improve Multifidus contraction timing and endurance in neutral spine
4. Symptom-free neural mobilization
5. Unloaded trunk ROM exercises: quadruped & supine pelvic rocking, pelvic clocks
6. Aerobic conditioning: bicycle (upright or recumbent), Upper Body Ergometer, treadmill
7. Commence balance activities
8. Progress spinal stabilization as able to incorporate UE motion into flexion, hip fall outs, heel slides, walk outs, kick outs, cycles, dying bug, bridging
9. Closed chain lower extremity progressions: wall slides, squats, sit to squat, anterior lateral lunges

Criteria for Progression:
1. Aerobic tolerance to 30 mins/day
2. Static balance with proper form >30 seconds each leg

Phase III:
- 4-8 weeks

Goals:
1. Advanced stability and trunk control
2. Progress strengthening and flexibility in functional postures and movement patterns
3. Commence introduction to sports specific movement patterns low levels, shorter time periods
4. Begin guidelines in attached table

Precautions:
1. Pain and inflammation controlled
2. Progression relative to soreness protocol

Phase IV:
- Ronald A. Lehman, Jr., MD
- LaRae Klarenbeck Mitchell, PT, DPT, OCS
Incidence and etiology of Lumbar Spondylolysis: review of the literature
Sakai, Sairyo, Suzue, Kosaka, Yasui
Journal of Orthopaedic Science, 2010

Methods:
Literature review of lumbar spondylolysis focusing on
1) Incidence in various ethnic groups distributed by sex, familiar occurrence, and concurrence of relevant diseases
2) Incidence in relation to sports practiced by patients

Results:
• Higher incidence in male (7.9%) than female (3.9%) subjects
• Higher incidence in white populations than black populations
• High incidence of lumbar spondylolysis among family members of affected individuals
• Incidence for Japanese rugby and judo players: 20%
• Incidence for Japanese professional soccer and baseball players: 30%

Athletic Participation in Children with Symptomatic Spondylolysis in the New York Area
Ladenhauf, Fabricant, Grossman, Widmann, and Green
Journal of the American College of Sports Medicine, 2013

Methods:
Retrospective evaluation of 127 athletically active patients with symptomatic spondylolysis presenting pediatric orthopedic surgeons

Results:
• Most common location of spondylolysis: L5 (74%)
  - 43.6% bilateral
• Most common athletic activities associated with spondylolysis: soccer (19.3%), basketball (17.2%), lacrosse (9.4%), and baseball (8.9%)
Spondylolysis/Spondylolisthesis

- Extension/loading of spine, most common = L5
- Symptoms of Chronic LBP, increased with extension, sometimes relieved with flexion
- Leg pain as slip progresses, pinches nerve root
- Progression most common at 10-14 years of age.

- Spondylolysis: defect without translation
- Spondylolisthesis: defect with translation forward
200 Adolescents with Low Back Pain
188 negative by Xray; 12 unclear findings
48.5% with active spondylolysis on MRI

SPECT - Helpful

Spondylolysis/Spondylolisthesis

- **Treatment**
  - Minimal chance of defect healing in college age group.
  - Maybe age < 20 years with surgery.
  - Treat symptoms the same as any other back injury.
  - Most athletes recover with rehab.
  - Surgery is last resort. Requires fusion in most cases.
  - Questionable chance of return to sport.
20 yo Div I Collegiate Gymnast

Pars Fracture

- Refractory to:
  - TLSO
  - Activity Modification
  - Mediations
  - 12 months
- Responded to:
  - Pars Injection

MIS Approach

Intraoperative Microscope Pictures

Implants

Compression
Spondylolysis Repair

- Healthy disc on MRI
- Younger patient less than 20
- Pedicle screw rod hook technique most stable construct

Spondylolysis/listhesis PT Protocol

Edward R Colens, PT, DPT, OCS
Advanced Clinician Orthopedic Physical Therapy
New York Presbyterian Hospital
Columbia University Medical Center

Kathleen M. Murphy, PT, DPT, OCS
Head Physical Therapist
New York Presbyterian Hospital
A Lack of Data

- Studies historically use Disabled List as data source
- Studies show 7.6-13.7% of all DL placements are due to back/spine injuries, yet few studies have effectively evaluated these injuries
- No studies have reported the epidemiology, treatment, return to play, or associated injuries with spinal injuries such as LDH and spondylolysis in elite baseball

Recent Research Proposal

- Goal: improve the understanding of the incidence, optimal treatment, and outcomes of LDH and spondylolysis in both Major and Minor League Baseball players
- Use HITS database to:
  1. Report the injury incidence/amount of time on DL with spondy
  2. Report return to play rate with performance metrics
  3. Analyze associated injuries to the spine, such as additional herniations, stress fractures, annular tears and muscle injuries, for associations with spinal injuries
Methods:
Systematic review of the literature reporting the outcomes of cervical spine surgery in high-level athletes (majority of which were NFL players)

Results:
- Most studies suggest return to play is safe for athletes who are asymptomatic after anterior cervical discectomy and fusion for cervical radiculopathy due to disc herniation.
- Surgical treatment may provide a higher rate of return to play for these athletes than nonsurgical treatment.
- Return to play after cervical spinal cord contusion may be possible in asymptomatic patients.
- Cervical cord signal changes on MRI may not be an absolute contraindication for return to play in neurologically intact patients.
- Cervical contusions secondary to cervical stenosis may be associated with a worse outcome and a higher recurrence rate than those secondary to disc herniation.
Cervical Spine Injuries in the Athlete
Shroeder and Vaccaro

- Sports most commonly associated with cervical spine injuries vary depending on region
- United States: American football, wrestling, gymnastics
- Cervical spine injuries in athletes not necessarily the result of substantial spine trauma; chronic conditions increase risk for cervical spine injury even after minor trauma
- Athletes often able to return to play after cervical spine injury if potential for substantial re-injury is minimized

Preop T2 MRI –21 yo Div I Wrestler

Several “Stingers” Profound Weakness

Couldn’t hold finger clasp

Prestige Surgical Technique

Decompress disc herniation
Postop Cervical Arthroplasty
Returned to Div I Wrestling

Outcome
1. Strength returned to normal immediately postop
2. Received a call 6 months postop from Team Physician
3. 18-3, qualified for Nationals - Division I and needed Spine clearance

When Can’t an Athlete Return to Play?
Return to Play in Athletes Receiving Cervical Surgery: A Systematic Review
Molinari, Pagarigan, Dettori, Molinari Jr., and Dehaven
Global Spine Journal, 2016

Methods:
Literature review of return to competitive athletic completion after cervical spine surgery (including articles published up to August 19, 2015): 7 on professional athletes and 2 recreational athletes

Results:
- 75% of professional athletes returned to their respective sport following surgery for mostly cervical herniated disk
- 76% of recreational athletes age 10 to 42 years RTP in a variety of sports following surgery for mostly herniated disks
- Most professional football players and baseball pitchers returned to their respective sport at their pre-surgery performance level

Frequency of return to play for professional athletes by sport

<table>
<thead>
<tr>
<th>Professional sport</th>
<th>Return to play</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rugby</td>
<td>74% (14/19)</td>
</tr>
<tr>
<td>Football(^a)</td>
<td>73% (48/66)</td>
</tr>
<tr>
<td>Wrestling</td>
<td>100% (9/9)</td>
</tr>
<tr>
<td>Baseball</td>
<td>88% (7/8)</td>
</tr>
</tbody>
</table>

\(^a\)Includes one collegiate-level football player.
Absolute Cervical Contraindications for Contact Sports

- Upper Cervical Instability
- Upper Cervical (Occiput, C1, C2) fusion
- Subaxial Cervical instability
- Central Stenosis with cord signal change
- Multilevel Surgical or Congenital fusion
- Acute (unstable) Cervical Fracture
- Spear Tackler’s Spine (Torg, et. al., 1993)

Return to Play Absolute Contraindications

1. Two episodes of transient quadraparesis
2. Signs of myelopathy, cord signal changes
3. Continued neck pain and neurologic deficit
4. C1-C2 fusion, 3 level fusion
5. C1-C2 instability, ligamentous injury

Where do we go from Here?

Develop Criteria
- Injuries based upon sport
- Stratified by location/position
- Recognizing varying disability based on level of activity & goals

Mandatory:
1. Ability
2. Affable
3. Available

Establish Best Practice Guidelines (BPG)
- Diagnosis of Injury
- Nonoperative treatment
- Therapy
- "Sport Hardening"
- Operative Intervention
- High Performance
- Professional
- Sport Specific
- Return to Play/Sport
**Multidisciplinary Approach**

**Personnel**
- Spine Surgeon(s)
- Sports Surgeon(s)
- Physiatrist(s)
- Physical Therapy (Protocols)
- Occupational Therapy
  - "Sport Hardening"
- Athletic Trainers
- Mid-Level Providers
- Foot and Ankle
- Upper Extremity
- Radiology
- Neurology (concussion protocol)

**Capital Equipment**
- Imaging
  - MRI (+/- dynamic)
  - EOS
- Injection Suite
- Xray
- Ultrasound
- Functional Assessment
- Sports Simulators
- Athletic Training Facility
- Operative Suite(s)
- Aesthetic Facility/Office

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**Unified Approach to the Athlete**

*If you build it, they will come.*

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**Thank You!**

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Complex Pediatric and Adult Scoliosis Service  
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