Patella Alta and Distalizing Tibial Tuberosty Osteotomy

AOSSM-AANA Combined 2021 Annual Meeting
Instructional Course
Nashville, TN
July 9, 2021

Andrew J. Cosgarea, MD
Drew Family Professor of Orthopaedic Surgery *in honor of* Alec Cosgarea
Johns Hopkins University
Disclosure

I have no financial conflicts to report. Please see the disclosure listings in the final program.
Recurrent Patella Instability
Surgical Options

Proximal
- Soft Tissue
  - VMO Advancement
  - MPFL Repair
  - MPFL Reconstruction

- Bony
  - Derotation Osteotomy
  - Valgus Osteotomy
  - Trochlear Osteotomy

Distal
- Soft Tissue
  - Galeazzi

- Bony
  - Medialization
    - Elmslie-Trillat

Distalization
Trends in the Popularity of Patellar Stabilization Surgery

Risk of Recurrence = 15-44%
Risk Factors for Recurrent Dislocation

- Retrospective study 40 of 61 pts experienced patellar redislocation within 24 mos
- Patellar Instability Severity Score (0-7):
  - age
  - bilateral instability
  - trochlear dysplasia (2)
  - patella alta
  - TT–TG distance
  - patellar tilt
- Odds ratio for recurrent dislocations = 4.88 (95% CI 1.57–15.17) for pts who scored ≥4 compared to pts who scored ≤3 (p = 0.0064)

What Stabilizes the Patella?

3 Important Factors

- Dynamic Muscle Action
- Passive Soft Tissue Restraints
- Osteochondral Geometry
What Stabilizes the Patella?

- **Passive Soft Tissue Restraints**
  Medial patellofemoral complex: $MPFL$, $MPML$, $MPTL$, $MQTFL$
Bone
Bruise
Medial Patella

Bone
Bruise
LFC
Soft Tissue Restraints

Glide Test

- Measure passive patellar translation and quantify in quadrants
What Stabilizes the Patella?

- **Passive Soft Tissue Restraints**
  Medial patellofemoral complex: 
  *MPFL, MPML, MPTL, MQTFL*

  - **MPFLR** to *restrain* the patella
Isolated MPFLR

- 90 pts underwent isolated MPFLR regardless of TT-TG distance, patellar height and trochlear depth
- Exclusion criteria: grade IV lesions and daily anterior pain as >50%
- 58 underwent MPFL + TTO during the study
- 96% at 1 year and 100% at 2 year follow up had no instability
- 90% at 1 year and 88% at 2 years had returned to sports

“At early follow-up of 1 and 2 years, isolated MPFL reconstruction is an effective treatment for patellar instability…..regardless of bony pathologies, including TT-TG distance, CDI, and trochlear dysplasia.”

Isolated MPFLR

- Prospective comparative study of 42 patients with recurrent instability and TT-TG of 17-20mm
- 18 underwent MPFLR + TTO, 24 isolated MPFLR from 2008-2013
- Mean follow-up 41 months (24-60 months)
- Significantly better Kujala (p=.003), Lysholm (p=.02), IKDC (p=.002) scores in the MPFLR + TTO group

“TTO + MPFLR resulted in better functional outcome scores and patellar kinematics compared with MPFLR in patients with a TT-TG distance of 17 to 20 mm.”

Franciozi et al: Anteromedial Tibial Tubercle Osteotomy Improves Results of Medial Patellofemoral Ligament Reconstruction for Recurrent Patellar Instability in Patients With Tibial TuberosityeTrochlear Groove Distance of 17 to 20 mm. Arthroscopy, 2019
Isolated MPFLR

• Retrospective case series of 239 isolated MPFLR from 2008-2014
• Mean follow-up of 5.8 years (3-9.3 years)
• Ten (4.7%) required revision for recurrent instability
• Risk factors for failure:
  ➢ Patella alta (CDI ≥ 1.3, p=.02)
  ➢ Positive J-sign (p=.04)

“In our practice, bony procedures, such as distalization of the tibial tubercle and trochleoplasty, are performed only in cases of revision for failure in patients with identified failure risk factors, such as a CDI ≥1.3 and a positive J-sign associated with trochlear dysplasia.”
Failure of Isolated MPFLR

- Retrospective review of 26 pts underwent revision MPFLR
- Redislocation was nontraumatic in 69%
- Pts with nontraumatic redislocations showed significantly more anatomic risk factors (ARFs)
  - TT-TG (>20mm)
  - Trochlear dysplasia (B-D)
  - Valgus (>5 degs)
  - Alta (CDI >1.2)
  - Anteversion/torsion
- Strong association between failed MPFLR and anatomic risk factors

What Stabilizes the Patella?

- Osteochondral Geometry
- femoral anteversion, Q-angle, patella alta, trochlear dysplasia, genu valgum, tuberosity lateralization, tibial torsion
Osteochondral Geometry

Abnormal anatomy predisposes to maltracking and instability

- Femoral anteversion
- Trochlear morphology
- Patellar height
- Valgus (tib-fem) alignment
- Tuberosity lateralization
- Tibial torsion

**Patella Alta:** CD Index $A/B \geq 1.2$
Osteochondral Geometry

Abnormal anatomy predisposes to maltracking and instability

- Femoral anteversion
- Trochlear morphology
- Patellar height
- Valgus (tib-fem) alignment
- Tuberosity lateralization
- Tibial torsion

Sagittal engagement: patellotrochlear index A/B > 0.20

30.1 mm
Osteochondral Geometry

Abnormal anatomy predisposes to maltracking and instability

- Femoral anteversion
- Trochlear morphology
- Patellar height
- Valgus (tib-fem) alignment
- Tuberosity lateralization
- Tibial torsion

Sagittal engagement: patellofrochlear index $A/B > 0.20$
Deviation of the patella from the midline of the femoral axis and trochlear groove due to an imbalance of the forces acting on the patellofemoral joint:

1. Muscles
2. Bones
3. Ligaments

“Its all about the balance”
John Fulkerson
Influence of Alta on Tracking

- 12 pts with patella alta were compared to 13 control pts
- Subluxation, tilt, and contact area quantified on axial MR images during quad contraction
- The alta group had greater lateral displacement, tilt and less contact area

“…vertical position of the patella is an important structural variable that is associated with patellofemoral malalignment and reduced contact area…”

Interaction Between Risk Factors

- Alta, TT position & dysplasia each influence patella stability
- Computational reconstruction of in vivo motion studied
  - Alta group (CDI 1.21 - 1.78)
  - Non-alta group (0.80 - 1.18)

Computational models showing lateral patellar maltracking for the combination of patella alta and a lateral tibial tuberosity (TT) position and for a shallow groove without alta.

Interaction Between Risk Factors

Alta group
• Lateral tracking correlated with TT position in extension
• TT-PCL distance accounted for 87% of the variation

Non-alta group
• Lateral tracking correlated with trochlear depth in extension

The influence of lateral position of the TT and trochlear depth on patellar tracking varies with patellar height

Bisect offset index and lateral patellar tilt vs. lateral TT-PCL distance at 0° of knee flexion for knees with patella alta.

What Stabilizes the Patella?

- **Osteochondral Geometry**
  - femoral anteversion, Q-angle, patella alta, trochlear dysplasia, genu valgum, tuberosity lateralization, tibial torsion

- **Osteotomy** to realign malaligned limb
Distalization

**Distalizing Osteotomy**

- Tuberosity shingle transferred distally
- Distal fragment placed into proximal defect
- Allows engagement of patella in trochlea earlier flexion angle
- Can also medialize or anteromedialize
What Stabilizes the Patella?

- Dynamic Muscle Action
  - Rehabilitation
- Passive Soft Tissue Restraints
  - MPFL Reconstruction
- Osteochondral Geometry
  - Osteotomy

Which osteotomy?
Which TTO?

- **Medialization** - lateralized tibial tuberosity
- **Anteromedialization** - lateralized tuberosity and distal patellar lesion
- **Distalization** - patella alta with poor trochlear engagement
AMZ + Distalization
AMZ + Distalization
AMZ + Distalization
AMZ + Distalization
AMZ + Distalization
AMZ + Distalization
MPFLR/TTO
Return to Sports

• Systematic review and meta-analysis of 23 articles with 930 pts (786 athletes) to evaluate return to sport rates
• 61.3% were female, mean age was 21.1 yrs, mean f/u was 3.0 yrs
• Concomitant TTO or trochleoplasty was performed on 10.5% of athletes
• Return to sport rate was 92.8% with 71.3% returning to the same level or greater at a mean of 6.7 mos
• Recurrent instability 1.9%
• Return to sport did not differ significantly in pts undergoing MPFLR (95.4%) vs those with additional osteotomy (86.9%)

MPFLR/TTO
Return to Sports

- Retrospective review of 100 pts undergoing stabilization for recurrent instability
- MPFLR = 71, MPFLR+TTO = 29
- Overall pts reported high return to sport rates (87/89%) and low recurrent dislocation rates (1/71, 1/29)
- Return to same or higher level of sport was greater in MPFLR (85%) vs MPFLR+TTO pts (57%) (P=0.009) and was quicker in MPFLR (8.9 months) vs TTO pts (13.5 mos) (P<0.001)

<table>
<thead>
<tr>
<th></th>
<th>MPFLR</th>
<th>MPFLR+TTO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>71 pts</td>
<td>29 pts</td>
</tr>
<tr>
<td>Recurrent</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>RTS</td>
<td>87%</td>
<td>89%</td>
</tr>
<tr>
<td>RTS same level</td>
<td>85%</td>
<td>57%</td>
</tr>
<tr>
<td>Time to RTS</td>
<td>8.9 mos</td>
<td>13.5 mos</td>
</tr>
</tbody>
</table>

Complications
Osteotomy

- Painful hardware
- Shingle fracture
- Tibia fracture
- Delayed union
- Nonunion
- Wound healing issues
Complications
Distalization
Distalization

Distalizing Osteotomy

• Tuberosity released, transferred distally
• Allows engagement of patella in trochlea earlier
• Distal osteotomy
  – Step cut
  – Converging cut

Complications TTO\textsubscript{d}

- Retrospective review of 153 pts undergoing tuberosity osteotomy (122 TTO, 31 TTO\textsubscript{-d}) for instability or OA
- Clinical and xray follow-up of min 90 days or osseous union
- Complications in 71/153 (46\%) pts
  - Nonunion 2\%
  - Delayed union 23\%

<table>
<thead>
<tr>
<th>Complication</th>
<th>TTO (n = 122)</th>
<th>TTO-d (n = 31)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;1 complication</td>
<td>53 (43)</td>
<td>18 (58)</td>
<td>.145</td>
</tr>
<tr>
<td>Reoperation</td>
<td>31 (25)</td>
<td>7 (23)</td>
<td>.745</td>
</tr>
<tr>
<td>Painful hardware</td>
<td>27 (22)</td>
<td>5 (16)</td>
<td>.463</td>
</tr>
<tr>
<td>Delayed union</td>
<td>22 (18)</td>
<td>13 (42)</td>
<td>.005</td>
</tr>
<tr>
<td>Deep vein thrombosis</td>
<td>4 (3.3)</td>
<td>0 (0.0)</td>
<td>.583</td>
</tr>
<tr>
<td>Wound breakdown</td>
<td>3 (2.5)</td>
<td>0 (0.0)</td>
<td>&gt;.999</td>
</tr>
<tr>
<td>Delayed range of motion</td>
<td>2 (1.6)</td>
<td>1 (3.2)</td>
<td>.496</td>
</tr>
<tr>
<td>Sensory deficit</td>
<td>2 (1.6)</td>
<td>1 (3.2)</td>
<td>.496</td>
</tr>
<tr>
<td>Clinical nonunion</td>
<td>1 (0.8)</td>
<td>2 (6.5)</td>
<td>.105</td>
</tr>
<tr>
<td>Fascial hernia</td>
<td>1 (0.8)</td>
<td>0 (0.0)</td>
<td>&gt;.999</td>
</tr>
<tr>
<td>Hematoma</td>
<td>1 (0.8)</td>
<td>0 (0.0)</td>
<td>&gt;.999</td>
</tr>
<tr>
<td>Quadriceps dysfunction</td>
<td>1 (0.8)</td>
<td>0 (0.0)</td>
<td>&gt;.999</td>
</tr>
<tr>
<td>Tibial fracture</td>
<td>1 (0.8)</td>
<td>0 (0.0)</td>
<td>&gt;.999</td>
</tr>
<tr>
<td>Broken screw</td>
<td>0 (0.0)</td>
<td>1 (3.2)</td>
<td>.203</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Data are shown as n (%). TTO, tibial tuberosity osteotomy; TTO-d, tibial tuberosity osteotomy with distalization.
## Complications of TTOd

### 3.5mm vs 4.5mm Screws

<table>
<thead>
<tr>
<th>Complication</th>
<th>3.5mm x3</th>
<th>4.5mm x2</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delayed union (clinical)</td>
<td>3/41</td>
<td>32/80</td>
<td>0.006</td>
</tr>
<tr>
<td>Delayed union (xray)</td>
<td>3</td>
<td>23</td>
<td>0.054</td>
</tr>
<tr>
<td>Surgery</td>
<td>3</td>
<td>35</td>
<td>0.002</td>
</tr>
<tr>
<td>Screw removal</td>
<td>2</td>
<td>30</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Surgical Recommendations

Medial Soft Tissue Insufficiency - MPFLR to Stabilize

Malalignment - Osteotomy to Realign (and balance)
  a. Increased TT-TG (>15-20mm): Medialization
  b. Increased TT-TG + chondral lesion: AMZ
  c. Patella alta (CD>1.3-1.4): Add Distalization
  d. Trochlear dysplasia: Trochlear Osteotomy
  e. Femoral anteversion: Derotation Osteotomy
  f. Genu valgum: Distal Femoral Osteotomy
Thank you