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Biomechanical Function of the Ligamentum Teres in Hip Rotational Range of Motion and Femoral Head Position

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DISCLOSURES

- **Dr. Michael Banffy, MD**
  - AOSSM: Board or committee member
  - Arthrex, Inc: Paid presenter or speaker
  - Stryker: Paid consultant
- **Michelle H. McGarry, MD**
  - Subchondral Solutions: Stock or stock Option
- **Thay Q. Lee, MD**
  - ASES: Board or committee member
  - Arthrex, Inc: Research support
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  - Journal of Shoulder and Elbow Surgery: Editorial or governing board

BACKGROUND

- Precise function of the **ligamentum teres (LT)** of the hip has yet to be completely elucidated.
  - Vascular support for developing femoral head
  - Distribution of synovial fluid
  - Proprioception and nociception of the hip joint [1,2,3]
  - **Secondary stabilizer** of the hip
    - Position of flexion and ER [2]
    - Particularly important in hip dysplasia and capsular insufficiency [5]
    - LT shifts anteroinferior with flexion/abduction, acting as a "sling" against anteroinferior translation of the femoral head [7]

- Tears of the ligamentum teres are commonly seen at arthroscopy, occurring in 8 to 51% of cases [6,8]
  - Commonly associated with FAI [7,9]

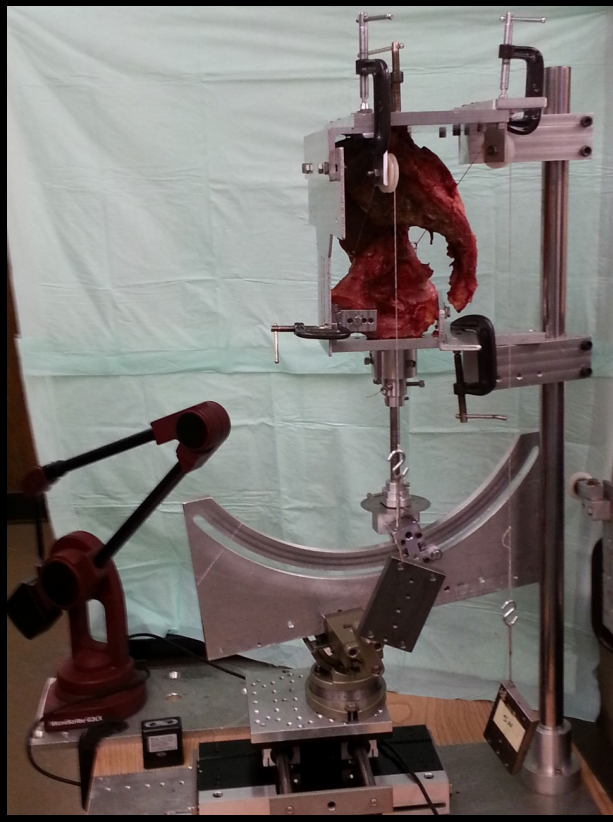
PURPOSE

- The purpose of this study was to determine the role of the LT in limiting hip rotational motion and its effect on femoral head position.

- **Hypothesis**: Sectioning of the LT would result in increased rotational motion, and lead to a positional shift of the femoral head.

METHODS

- Six cadaveric hemi-pelvises were mounted in a custom testing system as described by Jackson et al.[4]
  - 3 coordinate points were marked with screws in the ilium and femur to allow consistent digitized landmarks
  - A 2x2 cm hole was created in the quadrilateral plate to evaluate for an intact LT. This created a vented state. A 10 N axial force was applied across the joint to offset the loss of the suction seal effect.
  - Tested after exposure through quadrilateral plate. Testing repeated after sectioning of the LT through the quadrilateral plate.



- Rotational Motion:
  - Maximum IR internal and ER external rotation were measured with 3Nm of applied torque. Measurements were performed at 0°, 30°, 60°, and 90° of flexion as well as 20° of abduction with neutral flexion.
- Extension and Abduction Motion:
  - Maximum extension and abduction was measured at 10 Nm of applied torque.
- Femoral head position:
  - Position of the femoral head geometric center was measured at maximal IR and ER using digital capturing with MicroScribe 3DLX (Revware, Raleigh, NC) and Rhinoceros software (Robert McNeel & Assoc., Seattle, WA).

- *Statistical Analysis:*
  - The mean of the two trials used for analysis. A paired student t-test was performed to analyze the difference between the LT exposed and LT transected states. The statistical significance was set at a p value of <0.05.

RESULTS

- 2 female, 4 male hemi-pelvises
- Mean age 79.7 yr

Maximum hip extension and abduction (mean +/- SD)

Motion	LT intact (°)	LT Transected (°)	Difference	P value
Extension	15.0 ± 5.0°	16.1 ± 4.6°	+ 1.1°	0.14
Abduction	52.6 ± 5.8°	52.6 ± 6.1°	0°	0.83

RESULTS

Total Rotational Motion (IR + ER) (mean +/- SD)

Position	LT Exposed (°)	LT Transected (°)	Difference (°)	P value
0° Flexion 0° Abduction	45.3 ± 8.6	46.8 ± 8.0	1.5 ± 0.7	0.09
30° Flexion 0° Abduction	57.2 ± 5.7	61.2 ± 4.9	4.0 ± 1.0	**0.01**
60° Flexion 0° Abduction	60.5 ± 4.3	64.2 ± 3.1	3.7 ± 1.3	**0.04**
90° Flexion 0° Abduction	55.0 ± 6.1	60.5 ± 5.0	5.5 ± 1.5	**0.02**
0° Flexion 20° Abduction	57.2 ± 5.4	58.8 ± 5.8	1.6 ± 1.1	0.19

RESULTS

Maximum Internal Rotation (mean +/- SD)

Position	LT Exposed (°)	LT Transected (°)	Difference (°)	P value
0° Flexion 0° Abduction	22.4 ± 4.3	22.7 ± 4.6	0.3 ± 0.7	0.72
30° Flexion 0° Abduction	28.5 ± 2.9	29.5 ± 3.3	1.0 ± 0.5	0.12
60° Flexion 0° Abduction	30.7 ± 3.1	32.0 ± 3.0	1.3 ± 0.4	**0.03**
90° Flexion 0° Abduction	24.6 ± 3.5	27.0 ± 3.9	2.4 ± 0.6	**0.01**
0° Flexion 20° Abduction	18.5 ± 3.8	20.2 ± 3.8	1.7 ± 0.8	0.09

Maximum External Rotation (mean +/- SD)

Position	LT Exposed (°)	LT Transected (°)	Difference (°)	P value
0° Flexion 0° Abduction	22.9 ± 6.2	24.2 ± 5.9	1.3 ± 0.6	0.11
30° Flexion 0° Abduction	28.6 ± 5.0	31.7 ± 4.6	3.1 ± 0.9	**0.02**
60° Flexion 0° Abduction	29.8 ± 4.5	32.2 ± 3.7	2.3 ± 1.1	0.09
90° Flexion 0° Abduction	30.5 ± 5.8	33.5 ± 4.6	3.0 ± 1.3	0.08
0° Flexion 20° Abduction	38.7 ± 4.5	38.7 ± 4.8	0 ± 0.6	0.99

Change in Femoral Head Position Compared to Neutral

Position	Rotation	LT State	Medial (mm)	Superior (mm)	Anterior (mm)
0° Flexion 0° Abduction	Maximum IR	Exposed	0.0	0.5	0.1
		Transected	0.2	0.2	0.0
		Difference	0.2	-0.3	-0.1
		p value	0.76	0.58	0.91
	Maximum ER	Exposed	**-0.7**	0.7	-0.6
		Transected	**0.3**	0.3	-0.6
		Difference	**1.0**	-0.4	0.0
		p value	**0.04**	0.36	0.95
30° Flexion 0° Abduction	Maximum IR	Exposed	-0.5	0.4	-0.1
		Transected	0.1	0.1	0.2
		Difference	0.6	-0.3	0.3
		p value	0.27	0.24	0.64
	Maximum ER	Exposed	0.4	0.0	0.2
		Transected	-0.33	0.1	-0.2
		Difference	-0.75	1.0	0.4
		p value	0.37	0.82	0.72
60° Flexion 0° Abduction	Maximum IR	Exposed	-0.3	0.2	0.3
		Transected	0.0	-0.2	0.2
		Difference	0.3	-0.4	-0.1
		p value	0.67	0.50	0.82
	Maximum ER	Exposed	-0.9	**0.8**	1.05
		Transected	0.3	**0.0**	0.4
		Difference	1.2	**-0.8**	-0.6
		p value	0.24	**0.03**	0.30
90° Flexion 0° Abduction	Maximum IR	Exposed	-0.8	1.1	-0.2
		Transected	-0.4	1.3	-0.3
		Difference	0.4	0.2	-0.1
		p value	0.49	0.73	0.79
	Maximum ER	Exposed	**-1.6**	1.2	**0.7**
		Transected	**0.2**	-0.4	**-0.3**
		Difference	**1.8**	-1.6	**-1.0**
		p value	**0.04**	0.13	**0.02**
0° Flexion 20° Abduction	Maximum IR	Exposed	**-1.2**	**1.2**	0.2
		Transected	**0.3**	**0.0**	0.6
		Difference	**1.5**	**-1.2**	0.4
		p value	**0.03**	**0.02**	0.63
	Maximum ER	Exposed	-1.1	0.0	0.8
		Transected	-0.3	0.0	0.0
		Difference	0.8	0.0	0.8
		p value	0.41	0.85	0.20

Negative values indicate lateral, inferior, and posterior translation.

DISCUSSION

- Limitations:
  - Advanced cadaveric age
  - Flexion greater than 90° not assessed
  - Cannot account for dynamic stabilizers
  - Gross (not radiographic) assessment of hips

CONCLUSION

- Total rotational motion of the hip increased after transection of the LT.
  - Most pronounced at **90° of flexion (5.5°, p = 0.02**).
- LT transection did not significantly impact maximum extension/abduction motion.

CONCLUSION

- Transection of the LT resulted in a shift of the femoral head position during hip rotation.
  - Intact LT maintained the femoral head in a centered position
  - Transection of the LT resulted in an inferior and medial position shift of the femoral head
    - Statistically significant **medialization** occurred at 0° flexion/ER, 90° flexion/ER, 20° abduction/IR.

- The LT is known to wrap around the femoral head during rotational motion, and may serve as a buffer against medial translation of the femoral head.
  - Medialization could result in increased hip joint contact pressures, and potentially contribute to the higher rate of chondral wear seen at the time of arthroscopy in LT deficient hips[6]

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