Anterior Tibial Subluxation Using Knee Extended Load-Bearing Radiograph Could Predict the Rotational Instability of the Knee

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Faculty Disclosure Information

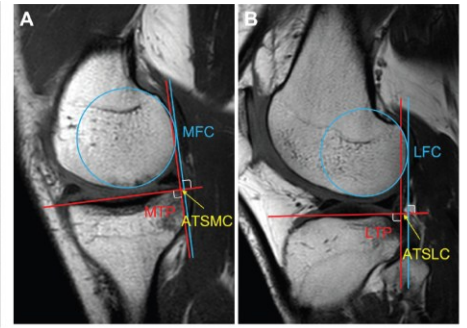
- I (and my co-authors) have nothing to disclose

Introduction: Evaluation of Anterior Cruciate Ligament (ACL) injury

Anterior Tibial Subluxation (ATS) : Evaluating tibial position relative to the femur

	Frequent examination	Cost	Load-bearing
MRI	difficult	difficult	difficult
Radiograph	capable	capable	capable

Müller B et al. KSSTA. 2016



Ye Z et al. Am J Sports Med. 2023

- ✓ Knee extended load-bearing Radiograph may be clinically useful
- ✓ It may be a solution for examiner bias in the Lachman test (Lach) and Pivot shift test (PS)

Kim S et al. J Orthop. 2021
Hamada T et al. JOA. 2024

ATS on MRI

- ✓ Two measurement method using articular surface or bone axis
- ✓ More useful when using the bone axis method, which reduces the influence of PTS

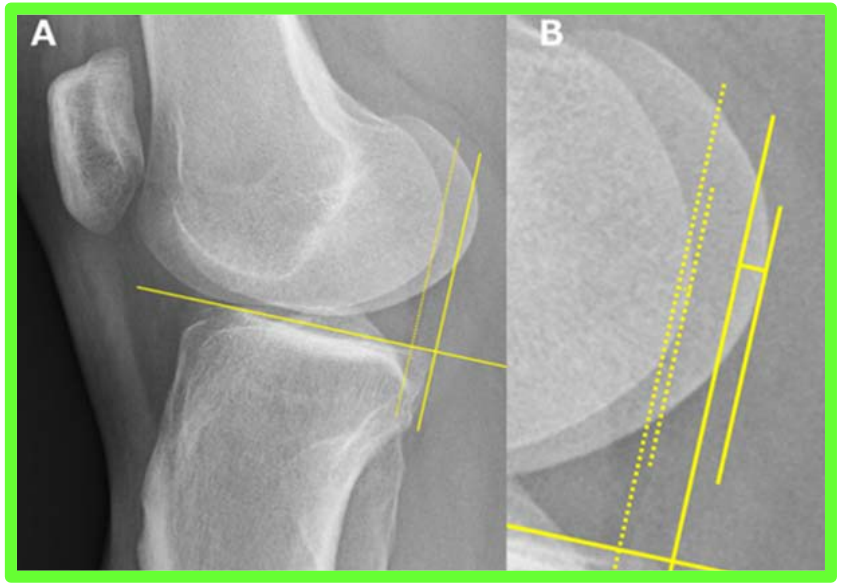
Zhang et al KSSTA. 2022

Which method is superior for evaluating **ATS on Knee extended load-bearing Radiographs?**

Purpose:

Investigate the relationship and utility between knee instabilities and two ATS measurements using knee extended load-bearing Radiographs

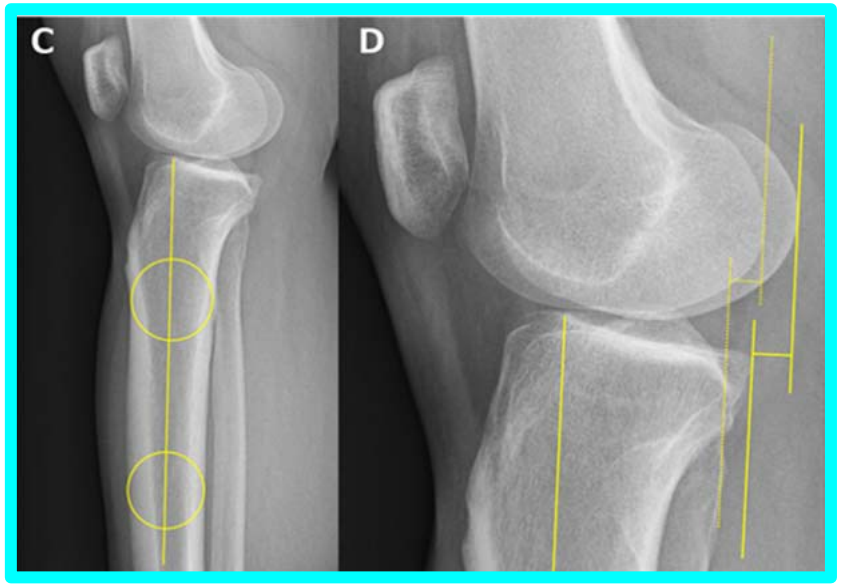
Methods: Two ATS measurement methods



Articular Surface ATS (AS-ATS)

A) Draw a line perpendicular to the medial tibial articular surface and tangent to the posterior margin of the medial and lateral sides of the tibia respectively.

B) Similarly, a line was drawn tangent to the medial and lateral posterior femoral condyles, and the distance was measured as AS-ATS.



Bone Axis ATS (BA-ATS)

C) A line through the midpoint of the anteroposterior cortex at 5cm and 15cm from tibial articular surface was defined as the tibial bone axis.

D) The tibial bone axis was translated so that it was tangent to the medial and lateral posterior tibial and femoral condyles respectively and the distance was measured as BA-ATS

Patient background

-Chiba LEAF study-

Prospective multicenter ACLR cohort study

300 patients
(2023-2024)

excluded

- Complex ligament injuries
- Missing data cases

included

Patients with radiographs at following timing

- ✓ Pre ACLR (Pre)
- ✓ 3-month postoperatively(3M)

89 cases

Statistical analysis

AS-ATS and BA-ATS
(Lateral, Medial, Midpoint, and Difference ATS)

✓ **Intra and Inter-rater reliability**

Intra Class Coefficients (ICC)(1.1) and ICC(2.1)**

**Measured twice by two orthopaedic surgeons (over 5 years exprerience)

✓ **Pre-ATS v.s. 3M-ATS** with Paired T test

✓ **Association with Instabilities (Lach* and PS*)**

- Adjusted with Age, BMI, Time from injury to surgery and PTS using Multi regression analyses
- Using Pre-ATS

*Evaluated by IKDC grade under Anesthesia
Grade B or below: Low grade / Grade C or above: High grade

Significance level of analysis: P-value<0.05

Results:

Patient characteristics

	Average	Standard deviation(SD)
Age	27.3	12.9
BMI	23.3	4.1
PTS	10.9	3.2

Sex	Male 42	Female 47

	Median	Quartile
Time from injury to surgery (month)	3.0	[1.5, 7.0]

	Low grade	High grade
Lach	52	37
PS	59	30

ICC and ATS comparison

	ICC (1, 1)	95%CI	ICC (2, 1)	95%CI	Pre-ATS, mm	3M-ATS, mm	p-value
AS-ATS							
lateral	0.96	0.91-0.98	0.94	0.88-0.98	1.3±4.0	-1.9±3.8	<0.0001
medial	0.91	0.81-0.96	0.87	0.72-0.94	1.4±3.6	-0.6±3.1	<0.0001
midpoint	0.94	0.88-0.98	0.91	0.80-0.96	1.4±3.3	-1.3±2.8	<0.0001
difference	0.95	0.89-0.98	0.90	0.78-0.95	-0.1±4.1	-1.4±4.2	0.01
BA-ATS							
lateral	0.96	0.91-0.98	0.93	0.86-0.97	8.4±4.4	5.3±4.0	<0.0001
medial	0.94	0.86-0.97	0.95	0.90-0.98	8.8±4.1	6.6±4.0	<0.0001
midpoint	0.96	0.91-0.98	0.97	0.94-0.99	8.6±3.6	6.0±3.4	<0.0001
difference	0.91	0.81-0.96	0.86	0.70-0.93	-0.4±4.4	-1.3±3.9	0.04

For all measurements methods:

- ✓ Both intra- and inter-rater reliability were good (ICC>0.85).
- ✓ ATS was significantly improved at 3M compared to preoperatively

Multi regression analysis

		Lach		PS		Age		BMI		Time from injury to surgery		PTS	
		Standarized β	P value										
AS-ATS	Lateral	0.07	0.56	**-0.24**	**0.04**	-0.24	0.03	0.09	0.41	0.08	0.48	-0.22	0.05
	Medial	0.04	0.73	-0.13	0.25	-0.23	0.04	-0.15	0.18	0.22	0.06	0.92	0.41
	Midpoint	0.06	0.58	-0.22	0.05	-0.29	0.01	-0.03	0.76	0.18	0.12	-0.08	0.49
	Difference	0.03	0.82	-0.10	0.37	-0.03	0.82	0.23	0.05	-0.13	0.28	-0.29	0.01
BA-ATS	Lateral	0.09	0.40	**-0.27**	**0.02**	-0.28	0.01	0.188	0.08	0.09	0.40	0.25	0.02
	Medial	0.02	0.82	-0.08	0.41	-0.12	0.23	-0.09	0.37	0.19	0.06	0.55	<0.01
	Midpoint	0.07	0.49	**-0.21**	**0.04**	-0.24	0.02	0.06	0.54	0.17	0.10	0.48	<0.01
	Difference	0.07	0.57	-0.18	0.13	-0.15	0.19	0.26	0.03	-0.09	0.45	-0.27	0.02

- ✓ A multiple regression analysis was performed adjusted with Age, BMI, Time from injury to surgery, and PTS.
- ✓ AS-ATS was not associated with either Lachman or Pivot Shift test, whereas Lateral and Difference BA-ATS were associated with Pivot shift test.

Discussion:
The relationship and utility between knee instabilities and ATS

The Inter-rater reliability of AS-ATS on radiograph was high, with an ICC of 0.894 (95% CI, 0.819–0.938).

Müller B et al. KSSTA. 2016

AS-ATS on MRI improved postoperatively at 3 years after ACLR.

Lin L et al. Am J Sports Med. 2022

Lateral AS-ATS on MRI was correlated with the Pivot Shift test.

Liu et al Arthroscopy. 2022

In our study:

- The ICC was 0.85 or higher for all measurement methods, with Intra and Inter-rater reliability being as high as previously reported
- All ATS at 3 months postoperatively was significantly improved compared to pre-ACLR values in all measurement methods
- Lateral AS- and BS-ATS, midpoint BS-ATS was associated with rotational instability

Utility and potential of ATS

From the result of our study:

ATS on knee extended load-bearing Radiographs may be useful for detecting ACL injuries and for pre or postoperative evaluation

Limitation

- ✓ Small sample size
- ✓ Lack comparison with dynamic test
- ✓ ATS on Knee extended load-bearing Radiographs may vary depending on knee angle and muscle activation during standing

In the future:

Further research is needed to establish the unique utility of measuring ATS with a knee extended load-bearing Radiographs

Conclusion

ATS evaluated by Knee extended load-bearing Radiographs :

- ✓ The reliability of the two measurement methods, AS-ATS and BA-ATS, was high
- ✓ ATS significantly improved after ACLR
- ✓ ATS measured using the Bone axis was associated with rotational instability

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