


Collaborative Engineering

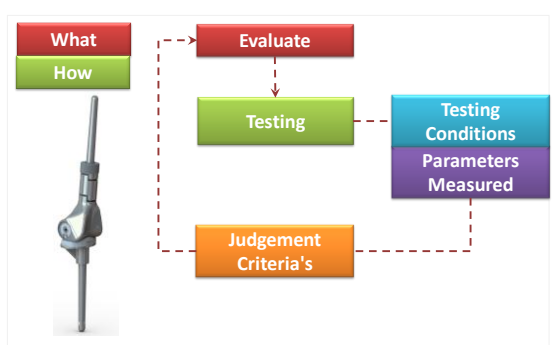
Safety, Reliability – TKP System

- Mechanism – FEA
- Physical testing
- Fatigue
- Wear

OrthoCAD Lab, I.I.T. Bombay



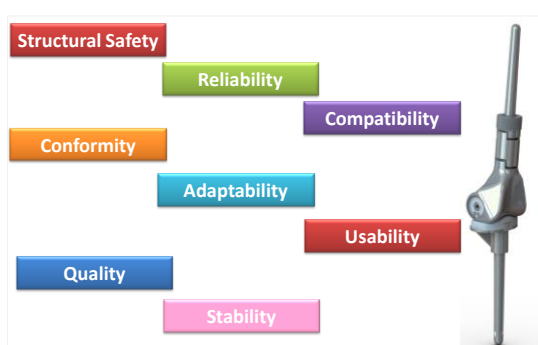
Evaluation, Testing – TKP



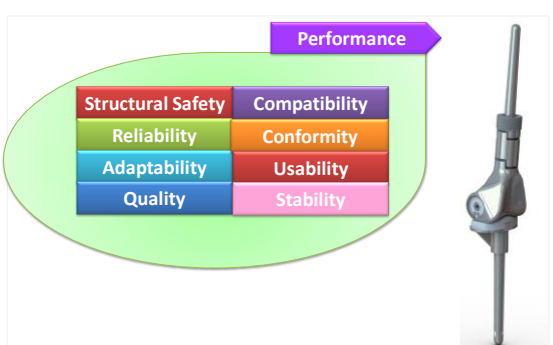
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    graph TD
      A[What  
How] --> B[Evaluate]
      B --> C[Testing]
      C --> D[Judgement  
Criteria's]
      C --- E[Testing Conditions  
Parameters Measured]
      E -.-> D
  
```

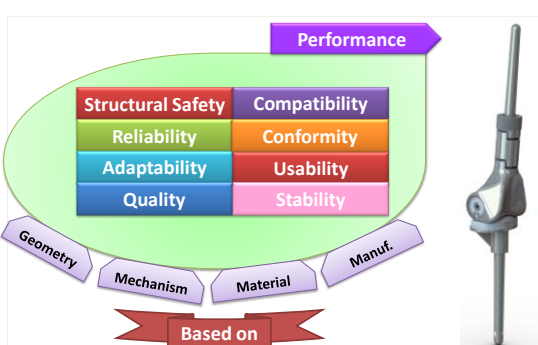
Overall Evaluation – TKP



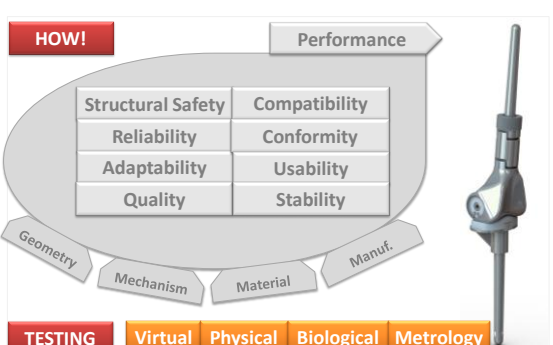
Overall Evaluation – TKP



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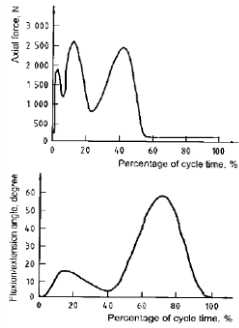


Overall Evaluation – TKP

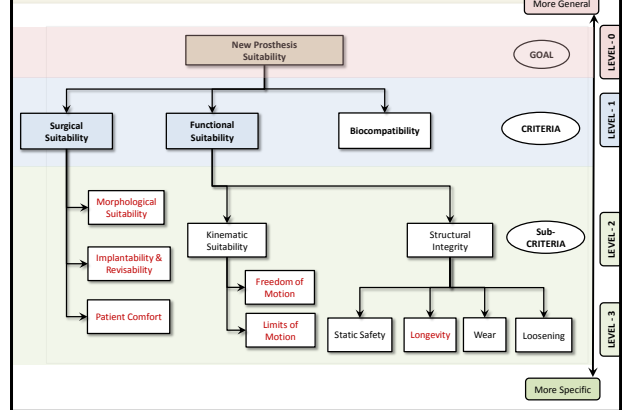


Safety, Reliability...Conditions

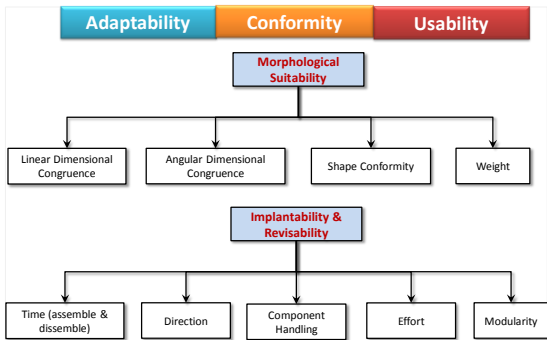
- Activities
 - Standing
 - Walking
 - Sitting
- Human body environment
- Factor of safety
 - Jump
 - Impact
- Replacement/ Revision



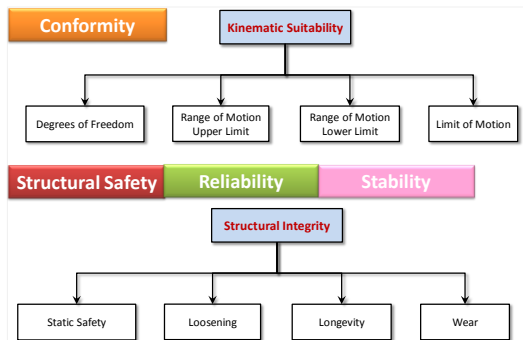
Overall Evaluation Plan



Evaluation Criteria's

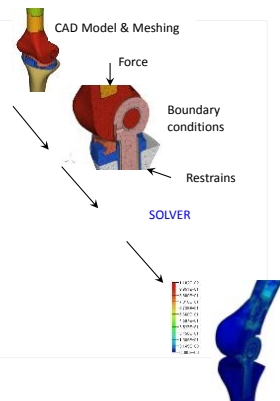


Evaluation Criteria's

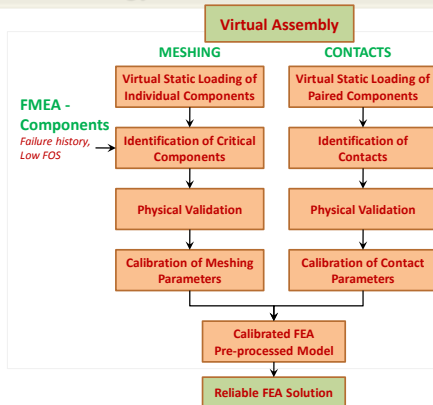


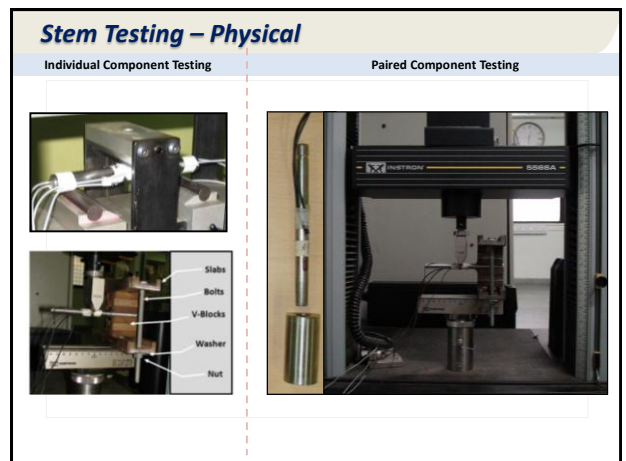
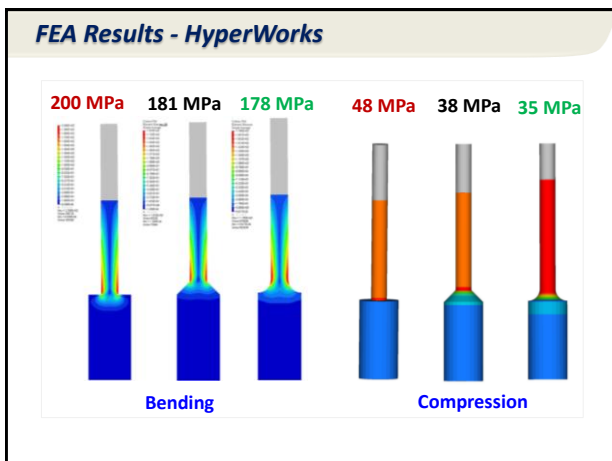
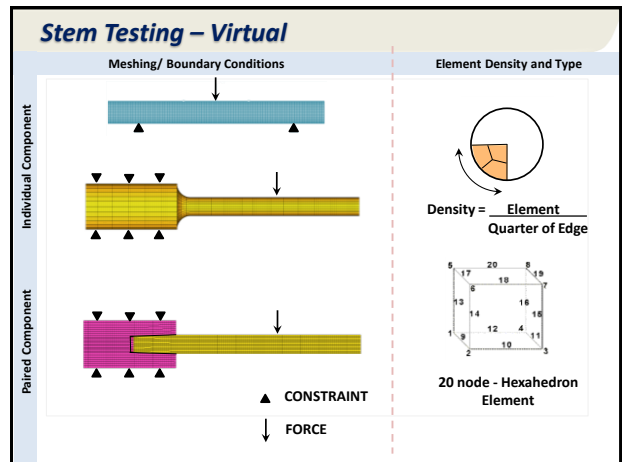
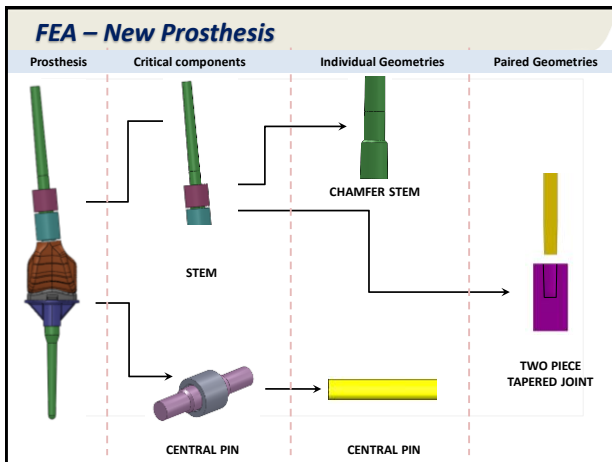
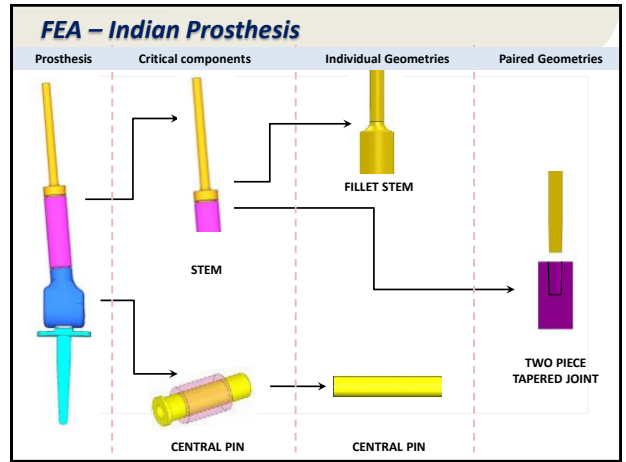
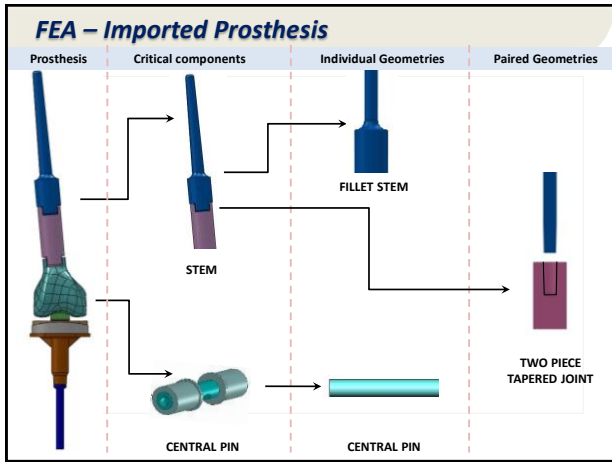
Testing – FEA

- Pre-Processing**
 - Solid Modelling
 - Meshing
 - Connectivity / Interfaces
 - Material Modelling
 - Boundary Conditions
- Processing**
 - Stiffness generation & modification
 - Solutions to equations (nodal variables)
- Post Processing**
 - Result visualisation
 - Plots and graphs
 - Animation



Methodology

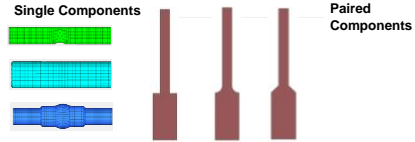




FEA Validation – UTM

Loading (2600 N)	Physical strain ($\mu\epsilon$)		
	Strain gauge 1	Strain gauge 2	Strain gauge 3
	SPECIMEN 1		
FEA	746	1200	746
EXPERIMENTAL	-672.04	1368.72	-779.15
ERROR %	-11.01	12.33	4.25
	SPECIMEN 2		
FEA	746	1200	746
EXPERIMENTAL	-785.78	1265.40	-801.90
ERROR %	5.06	5.17	6.97
	SPECIMEN 3		
FEA	746	1200	746
EXPERIMENTAL	-762.09	1269.19	-769.67
ERROR %	2.11	5.45	3.08

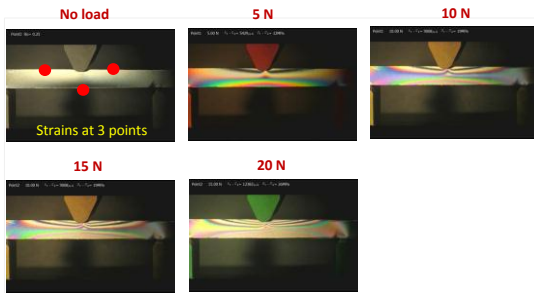
Standardization of FEA Parameters



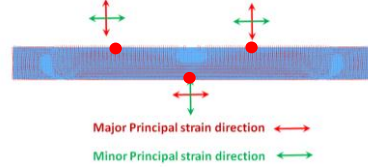
Standardization of parameters

Hexahedron element		Element size range 0.5 – 1.5 mm Warpage < 4 Skew < 60 Jacobian < 1
Boundary conditions	Bending Load	2600 N, 360 N, Highest values during walking
Material Law	Elastic Law	Density 8290 Young's modulus 225 Gpa Poisson's ratio 0.31
Analysis Type	Linear Static analysis	
Contact	Slide Type (Relative motion between nodes)	Friction 0.9

3 Point Bending – Photostress

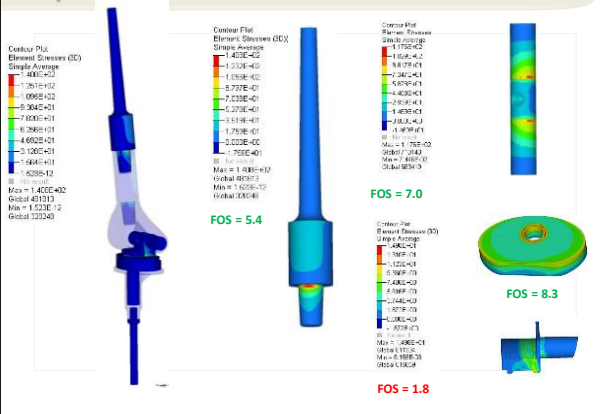


FEA Validation – Photostress

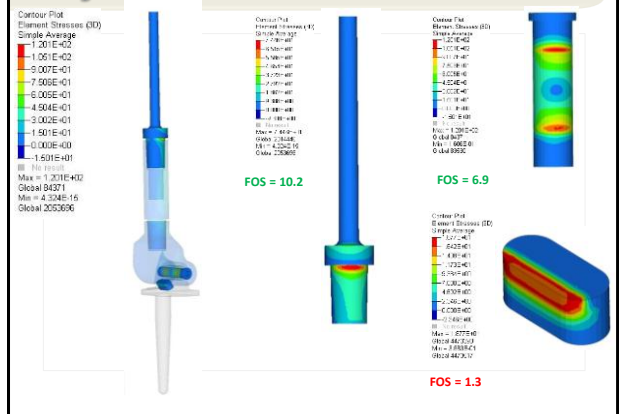


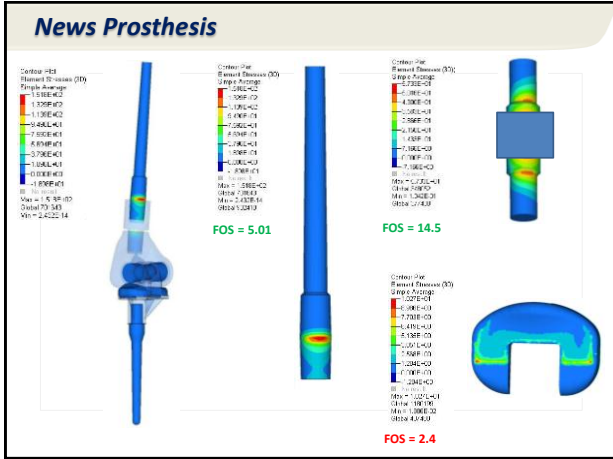
Relative Difference	FEA %	Photoelasticity %	Error in Relative Difference %
	$= (Pt1 - Pt3) / (Pt3) \cdot 100$	$= (Pt1 - Pt3) / (Pt3) \cdot 100$	
(No Load)	0	0	0
(5 N)	-0.40	-0.36	11.37
(10 N)	-0.45	-0.39	13.86
(15 N)	-0.40	-0.39	1.96

Imported Prosthesis



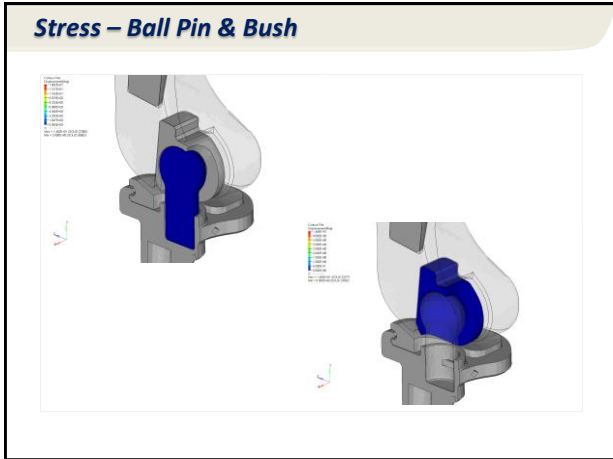
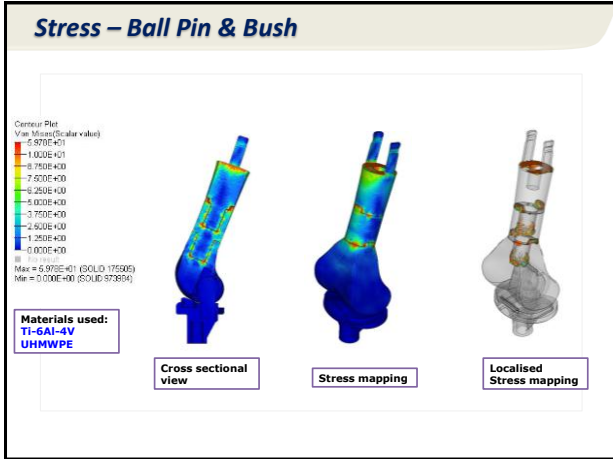
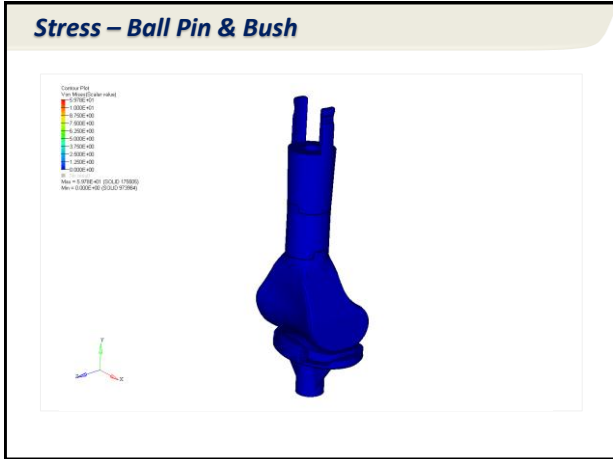
Indigenous Prosthesis





Comparison of Static Testing Results

	Prosthesis		
	Imported	Indigenous	New
FOS of HIGHEST STRESS Component	5.4 (Femoral Stem)	6.9 (Axle)	5.0 (Femoral Stem)
Lowest FOS	1.8 (Bumper)	1.3 (Bumper)	2.4 (Poly)



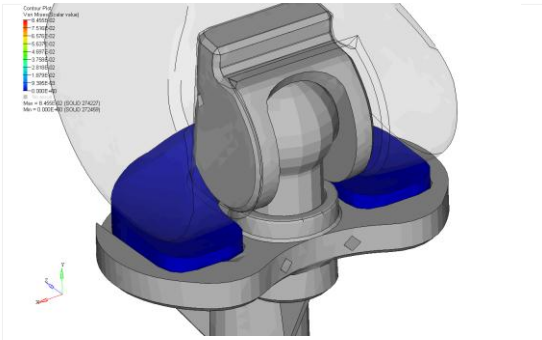
Stress – Ball Pin & Bush

Max = 1.400E+02 (SOLID 2297)
Min = 0.000E+00 (SOLID 2285)

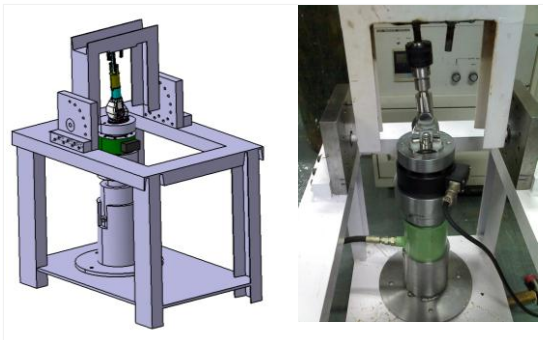
Material Information **Stress Comparison Ball & Pin**

Material	Parts	Component	Material	Yield Strength (MPa)	Factor of Safety	Permissible Stress (MPa)	Experienced Stress (MPa)
UHMWPE	All bushing parts (Bearing Bush, Tibial Poly)	Ball Pin	Ti-6Al-4V	900	3	300	139.8
		Bearing Bush	UHMWPE	60	3	20	110.3

Tibial Poly Contact Stress – Video



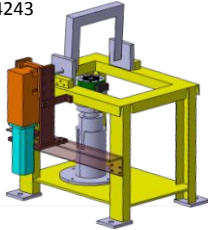
Reliability Testing – Dynamic Loading



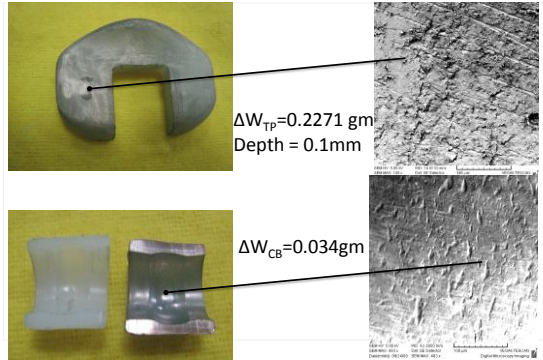
Knee Simulator Testing Machine

▪ KST-2 (NFTDC)

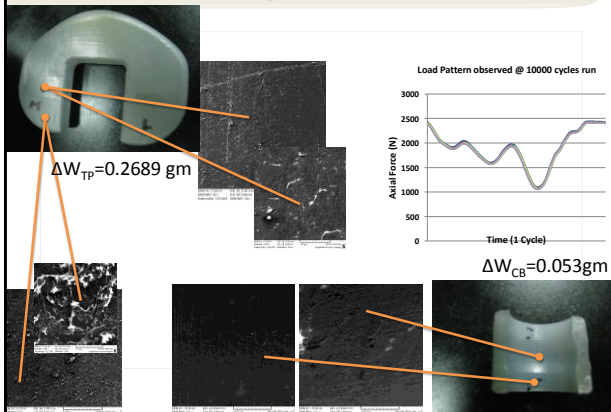
- Hydraulic pack, gear box
- Fixed tibia, hinge design
- Centering easier than KST-1
- Flexion angle & axial load
- ISO 14243



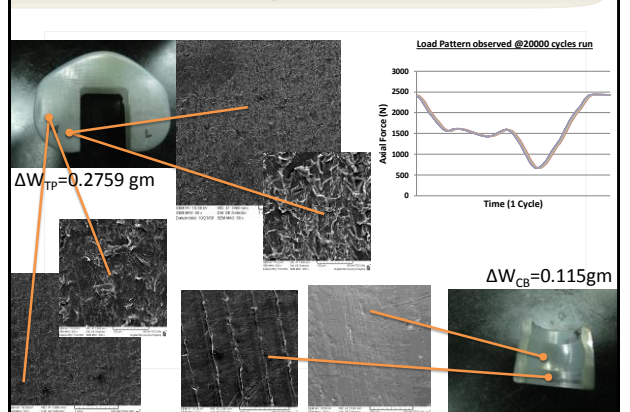
Wear Results – Initial

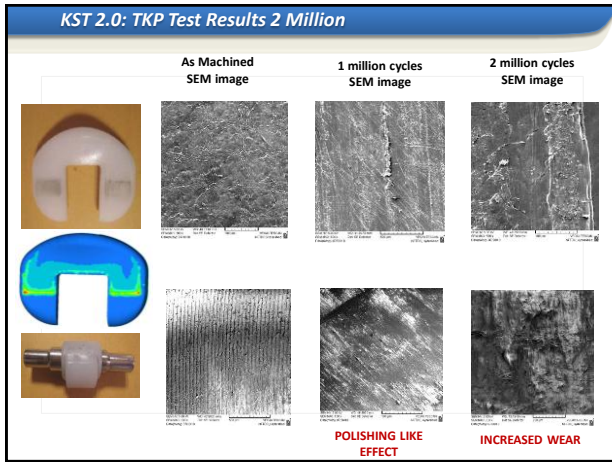


Wear Results – 10K cycles



Wear Results – 20K cycles





SUMMARY

- FEA – Tool for Structural Strength Analysis
- Standardization of FEA – Rapid & Reliable Results
- Comparison – Evaluation of Various Concepts
- Safety – Failure analysis
- Reliability – Life, Longevity