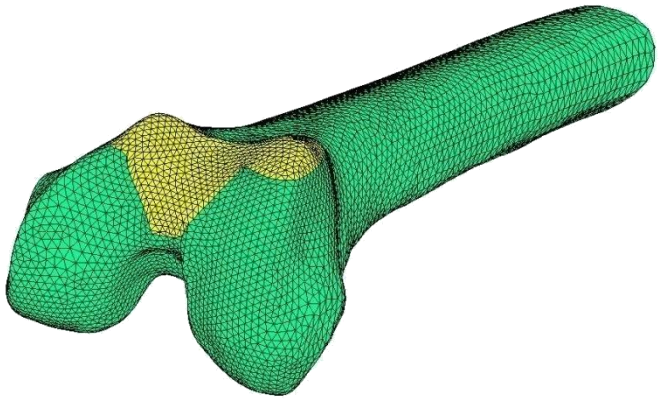
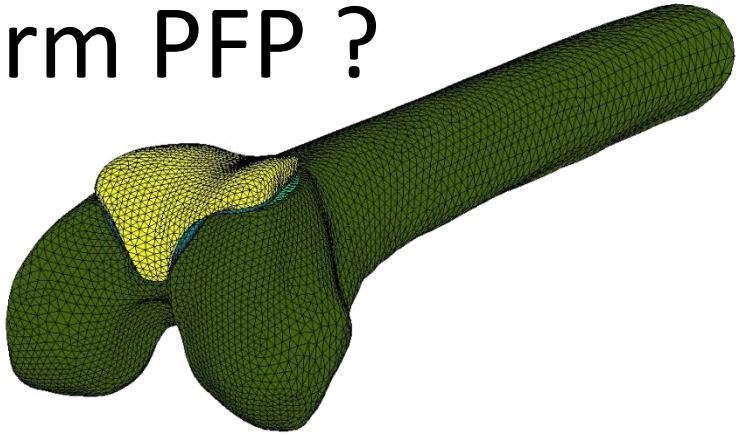


# Why do I perform PFP ?



**Fernando Fonseca, MD PhD**

**Head of Department Orthopaedics**

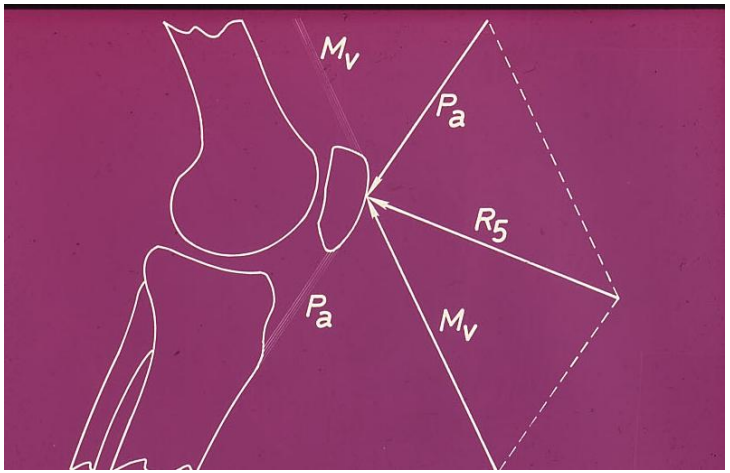
**Acknowledges to**

***António Completo***
***Paulo Flores***
***Susana Meireles***
***André Castro***

**Disclosures: None**

... Knee is one of the most complex systems in the universe!

… Patellofemoral joint supports compression and tension loads that often exceed its capacity, leading to a failure in its microstructure.




Scott Dye (1977)

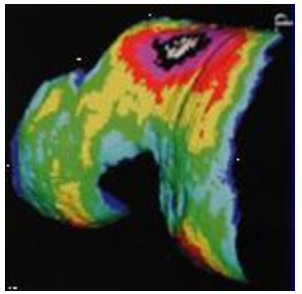
# Isolated patellofemoral osteoarthtitis

- *Isolated arthritis affects the patellofemoral is rare (5% patients with OA of knee)*
  - *Found predominantly in females (72%)*
    - *51% of the patients having bilateral symptoms.*
  - *"Young" patients*
    - *average age is 46 years.*
  - *Radiological evolution is slow,*
    - *average time interval of 18 years from stage I to stage IV.*

**D. Dejour, J. Allain, and SOFCOT; 2010**

# Isolated patellofemoral osteoarthrtitis(2)

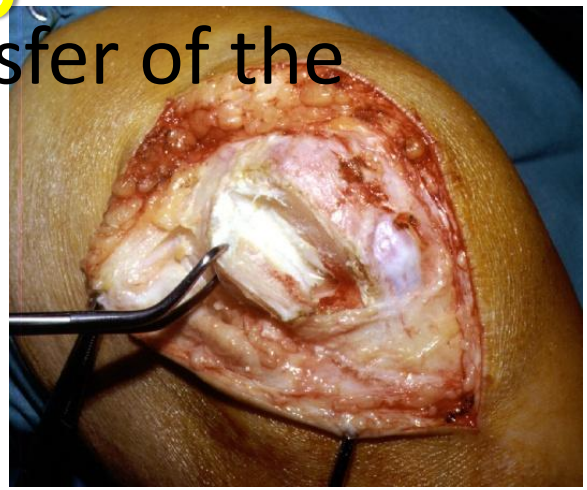
- *Four aetiologies have been identified:*
  - *Primary arthritis (49%)*
  - *Osteoarthritis secondary to instability (33%):*
  - *Post-traumatic osteoarthritis (9%)*
  - *Chondrocalcinosis: 9%*



**D. Dejour, J. Allain, and SOFCOT; 2010**

# Other surgical alternatives

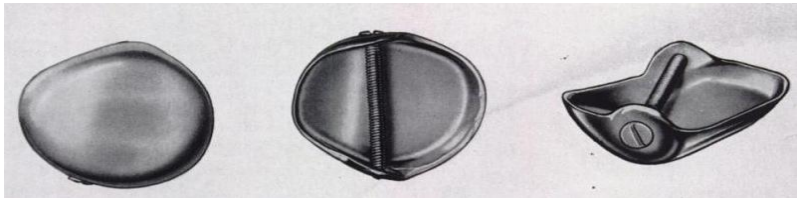
- Arthroscopic debridement
- Unloading anteromedial transfer of the tibial tubercle
- Patellectomy
- Cartilage grafting techniques
- Other
- …..

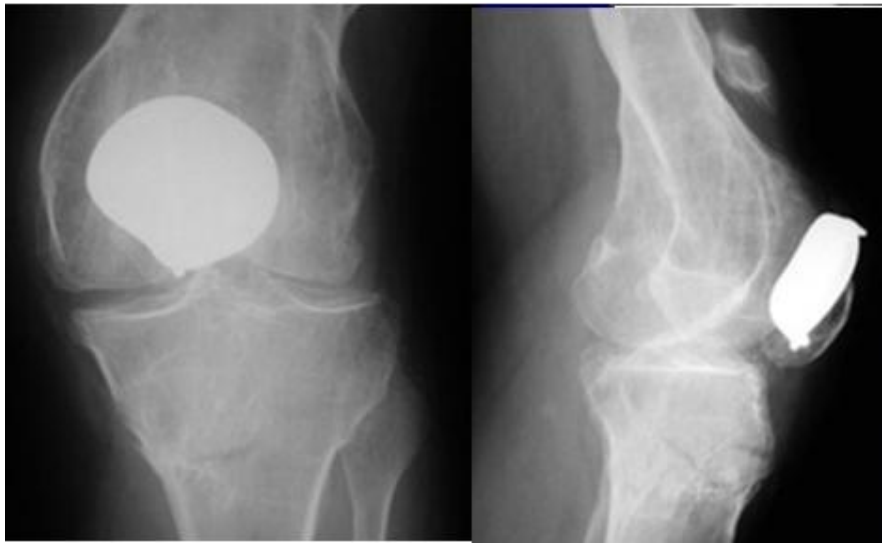


Results: 66% Good/Excellent

# Patellofemoral arthroplasty

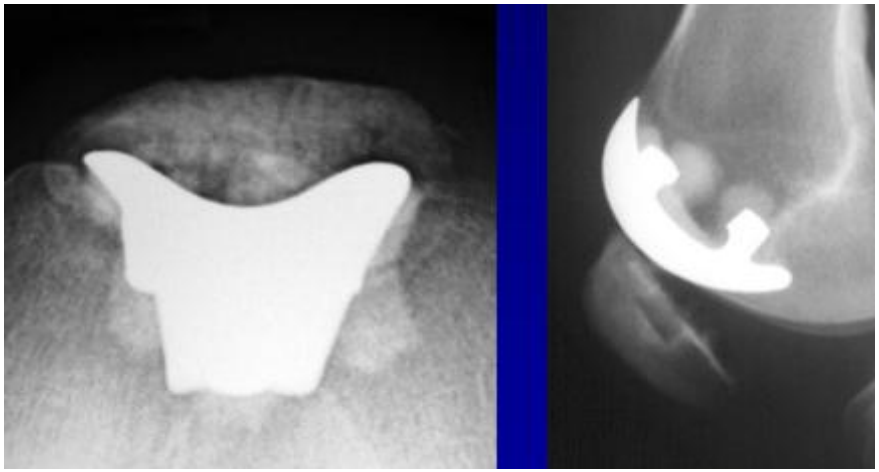
- Original
  - McKeever (1955)
  - De Palma





# Problems

- Patellar instability
  - Patellofemoral alignment incorrect
  - Soft tissue imbalance
- Design
  - Inadequate curvature
  - Depth trochlea
  - System fixation
- Cartilage
  - Contact in flexion



# Lessons learned with TKA

- Load at PF joint can reach 8 x body weight, often greater than the resistance of polyethylene
- Contact  area between patellar component and trochlea is less than in natural knee
- Kinematics PF joint, at TKA, does not reproduce a normal knee PF
- Patellar design doesn’t reproduce the original patella

# Experimental studies

ProPaFe project

FCT - PTDC/EME-PME/67687/2006P

# Strain shielding in distal femur after patellofemoral arthroplasty under different activity conditions

Meireles S Completo A, et al; J Biomech. 2010;10;43(3):477-84

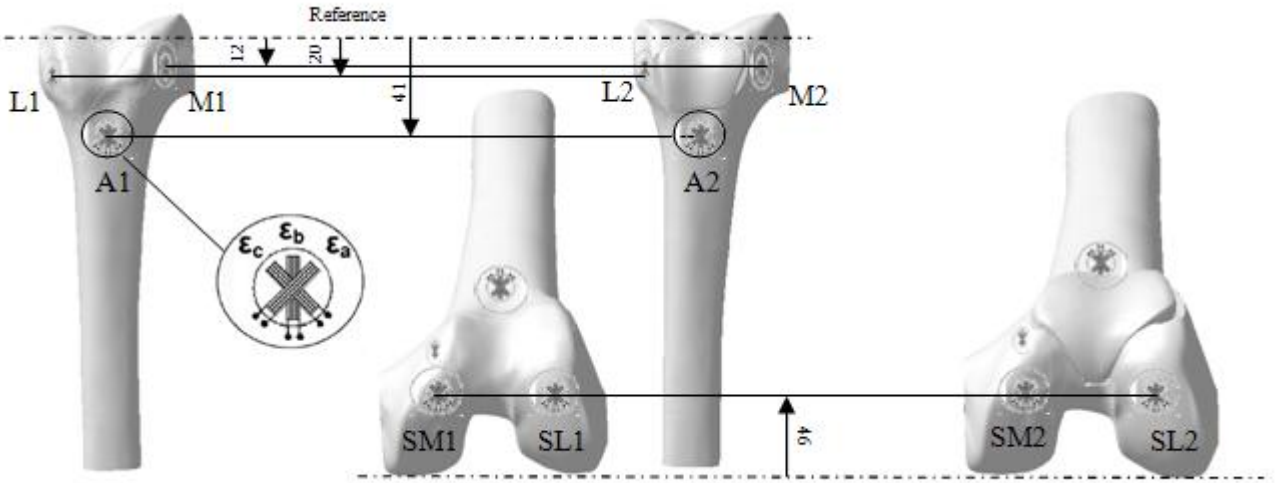
# STRESS SHIELDING

The stress shielding effect alters the normal stress stimuli for bone growth

In accordance with ***Wolff's law***: the reduction of bone stresses relative to the natural situation causes bone to adapt itself by reducing its mass in a process of resorption around the implant

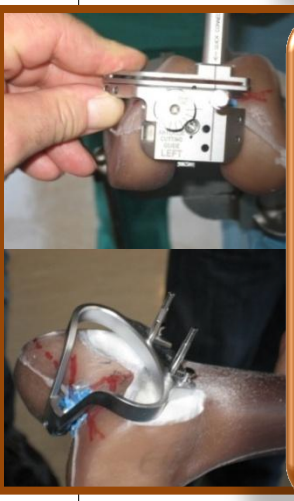
This will cause micromotion of the implant in response to external loads and could further damage the interfacing bone layer and anchorage performances subsequent to possible loosening of the implant

# STRAIN GAUGES POSITIONS



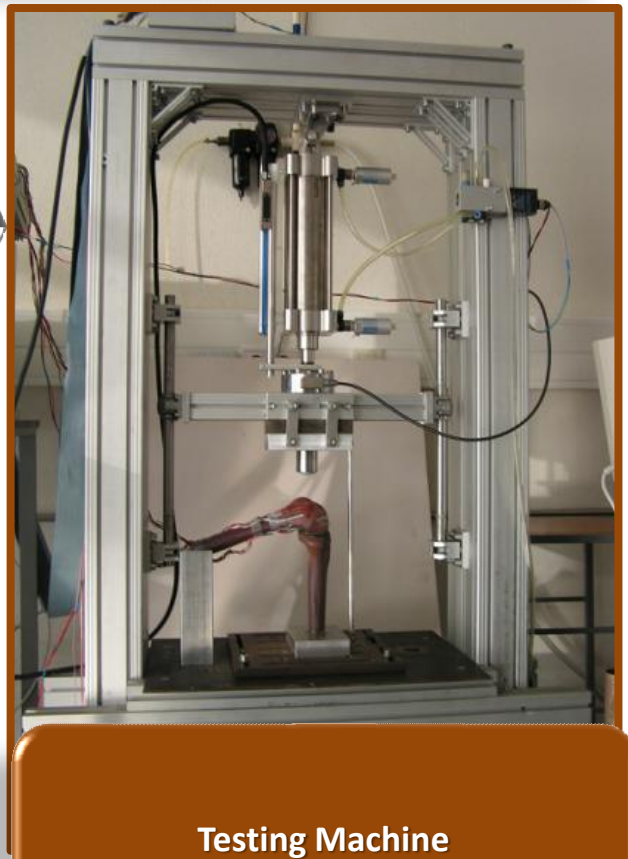

**Bone strains were measured with 2 gauges glued at the anterior side (A1 and A2), 4 gauges glued at the medial (M1 and M2) and lateral (L1 and L2) sides, and 4 gauges glued at the medial (SM1 and SM2) and lateral (SL1 and SL2) sides on the distal end of the femur.**

# EXPERIMENTAL TESTS



*In vitro* surgery on the femur to remove part of intercondilar region

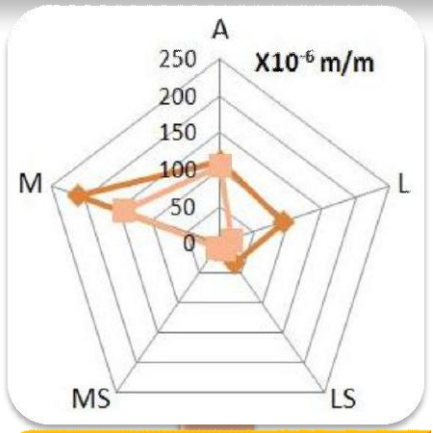
Placed triaxial strain gauges on the intact femur (left) and implanted femur (right)



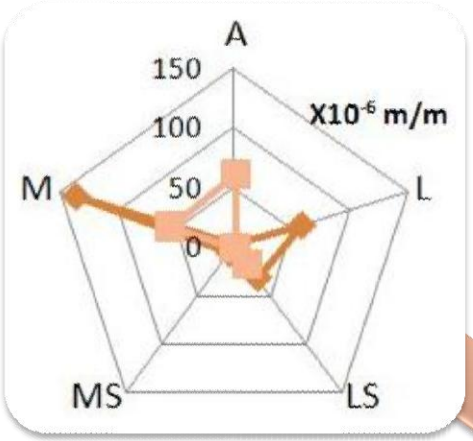
Testing Machine

Assays made on the testing machine for all studied knee flexion angles: 10º, 20º e 40º

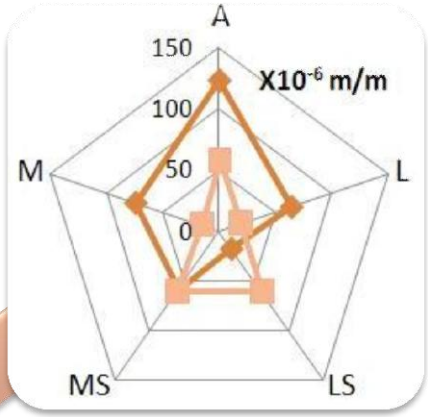
# RESULTS




Descending stairs with 20º of knee flexion




Level walking with 10º of knee flexion




Deep bending with 40º of knee flexion

Stress Shielding

E2
E1

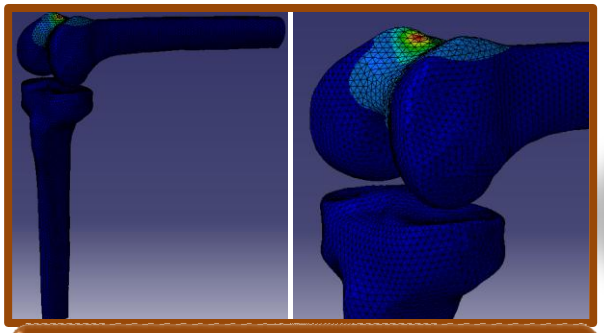
# COMPUTATIONAL SIMULATION

Smith & Nephew Patellofemoral Prosthesis

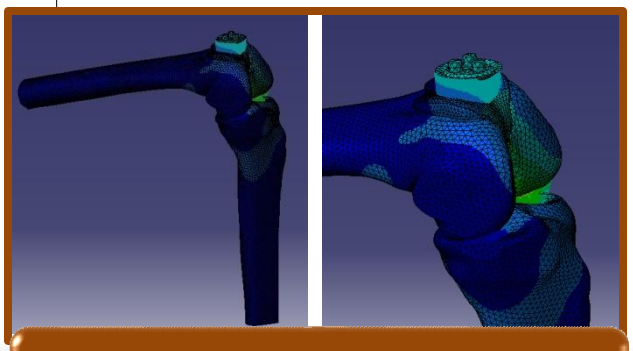

Arthroplasty Digitalization

STL obtained from digitalization

Arthroplasty modeling using CATIA V5 R18



Simulations with Intact Model



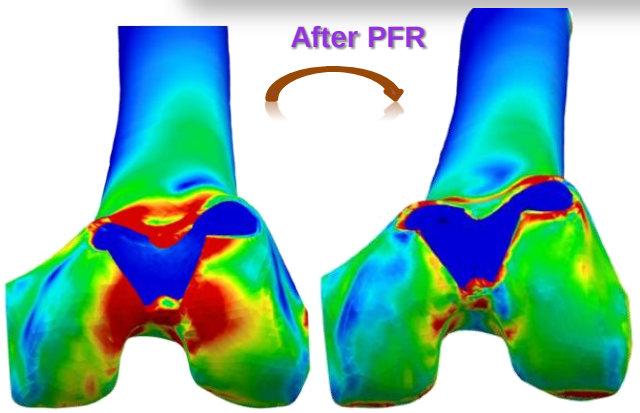
Simulations with Implanted Model

# COMPARING EXP/NUM

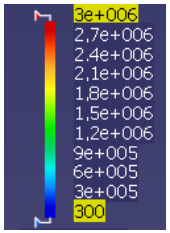
| | Intact with 10º | Implanted with 10º | Intact with 20º | Implanted with 20º | Intact with 40º | Implanted with 40º |
|---|---|---|---|---|---|---|
| Correlation coefficient | 0,686 | 0,795 | 0,715 | 0,728 | 0,893 | 0,747 |

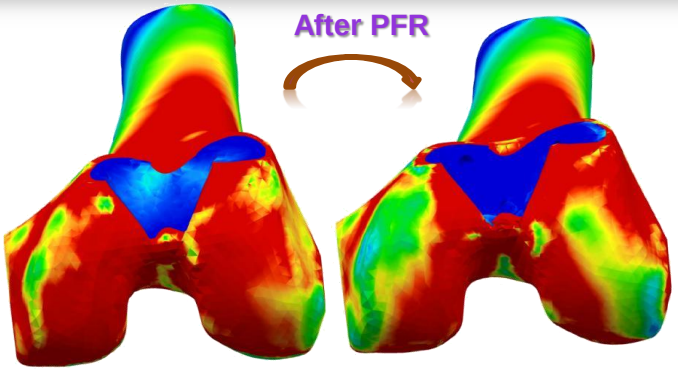
| | Intact with 10º | Implanted with 10º | Intact with 20º | Implanted with 20º | Intact with 40º | Implanted with 40º |
|---|---|---|---|---|---|---|
| RMSE ($x10^{-6}$ m/m) | 30 | 17 | 59 | 43 | 40 | 25 |
| RMSE % | 17.6 | 30.0 | 18.6 | 25.0 | 21.0 | 10.2 |

# VON MISES STRESS DISTRIBUTIONS

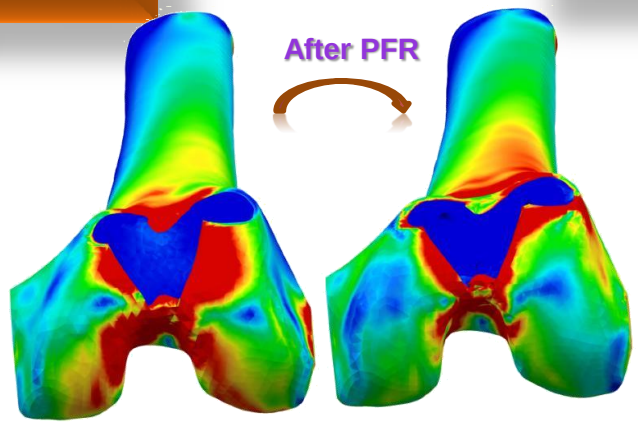



For level walking with 10º of knee flexion (350N)



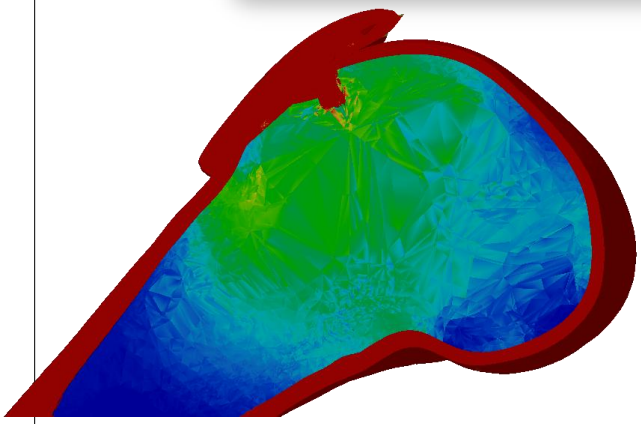




For descending stairs with 20º of knee flexion (928N)

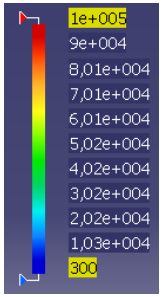


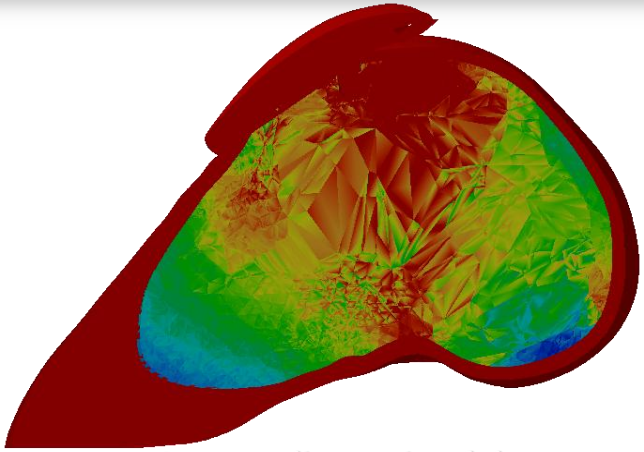

For deep bending with 40º of knee flexion (500N)

# VON MISES STRESS DISTRIBUTIONS

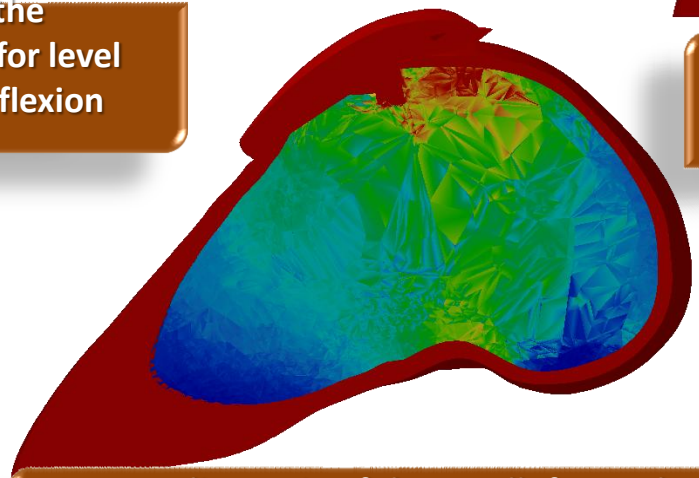


Surrounding a pin of the patellofemoral prosthesis for level walking with 10º of knee flexion (350N)



Surrounding a pin of the patellofemoral prosthesis for descending stairs with 20º of knee flexion (928N)



Surrounding a pin of the patellofemoral prosthesis for deep bending with 40º of knee flexion (500N)

# CONCLUSIONS

**Implanted specimen**

- ↑ strain values were found in the M and L sides in all studied activities in terms of $\varepsilon_2$.
- ↓ strain values were found in the A side in all studied activities in terms of $\varepsilon_2$.

**After PFR**

- Lower bony requirements will occur in the A side of the femur and greater in the M and L sides.
- These alterations in terms of bony requirements will lead to bone atrophy and hypertrophy in the A, and M and L sides, respectively.

**Consequences**

- The atrophy of the bone leads to its demineralization occurring consequently the loosening of the prosthesis later.
- The increase of the bony requirements, on the other side, leads to fatigue or even fracture of the bone later.

# Biomechanical behaviour of cancellous bone on patellofemoral arthroplasty with Journey prosthesis: a finite element study

Castro AP[1], Completo A, et al.

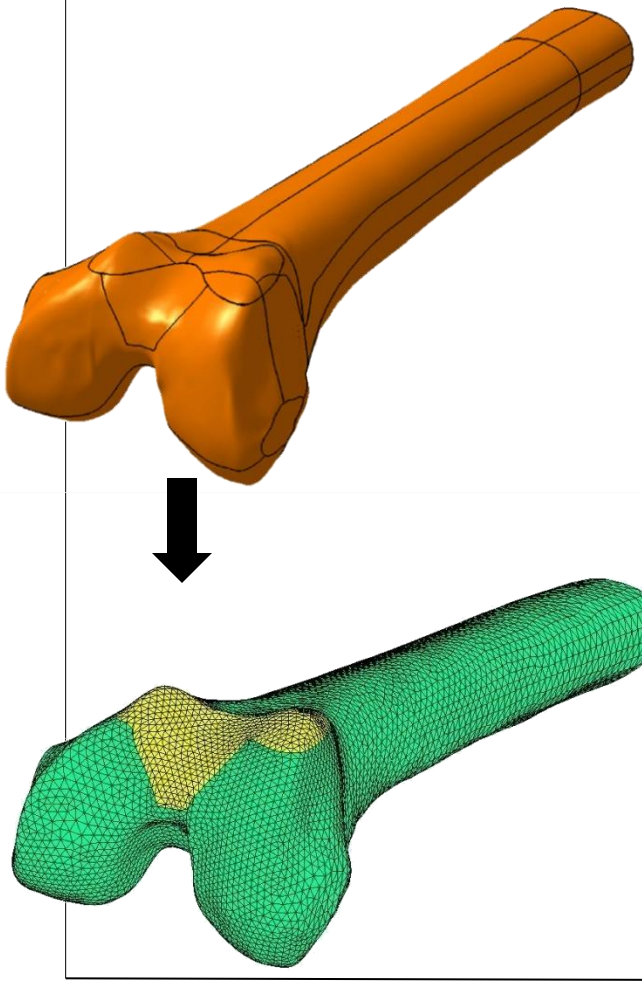
Comput Methods Biomech Biomed Engin; 2014 Jan 27.

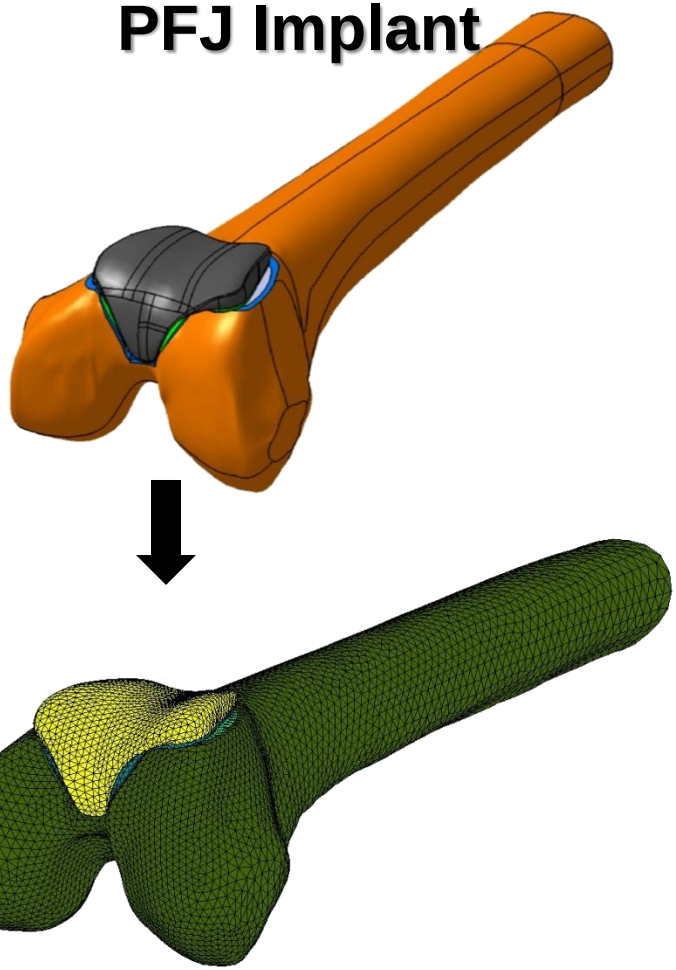
Mestrado Integrado em Engenharia Biomédica
Universidade do Minho

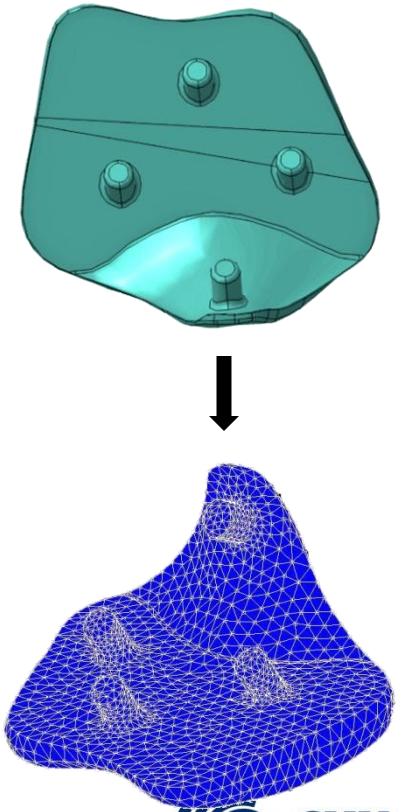
Natural Femur

Femur with Journey PFJ Implant

Journey PFJ Implant

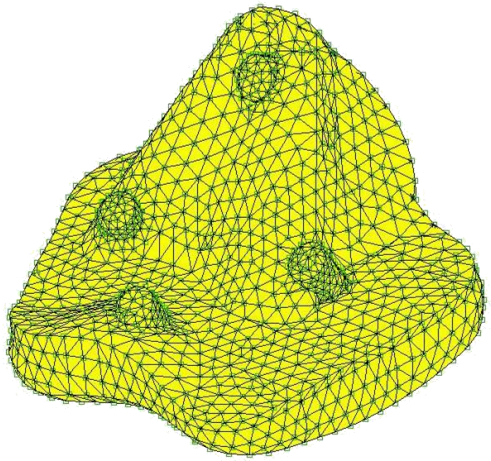




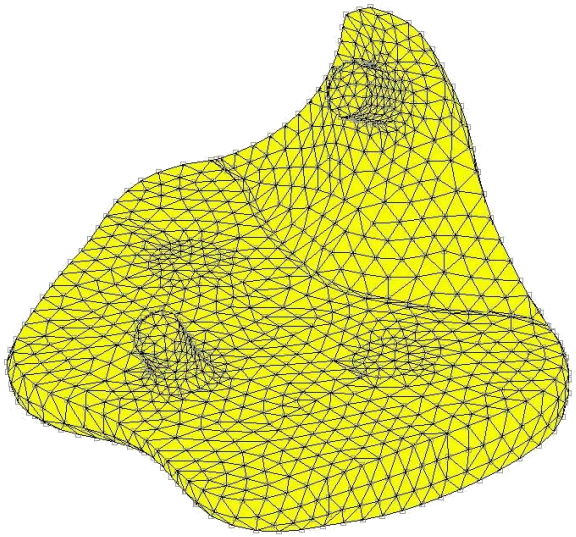


# The Adapted Models

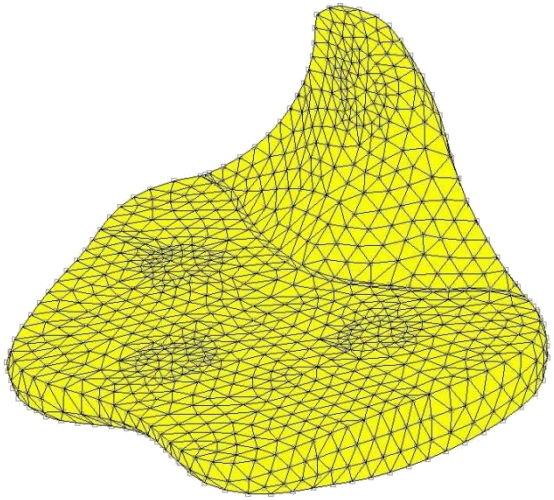
**High Thickness Journey**



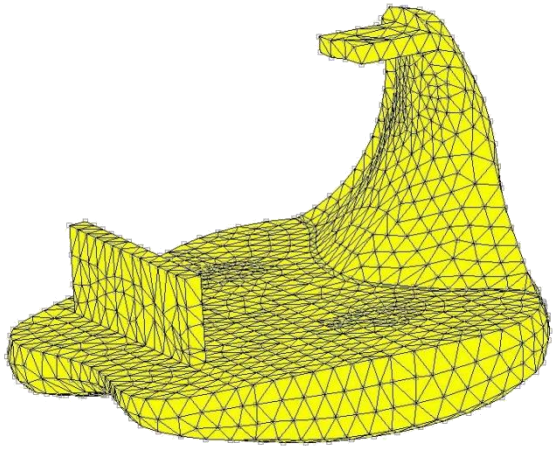
**Two Pins Journey**



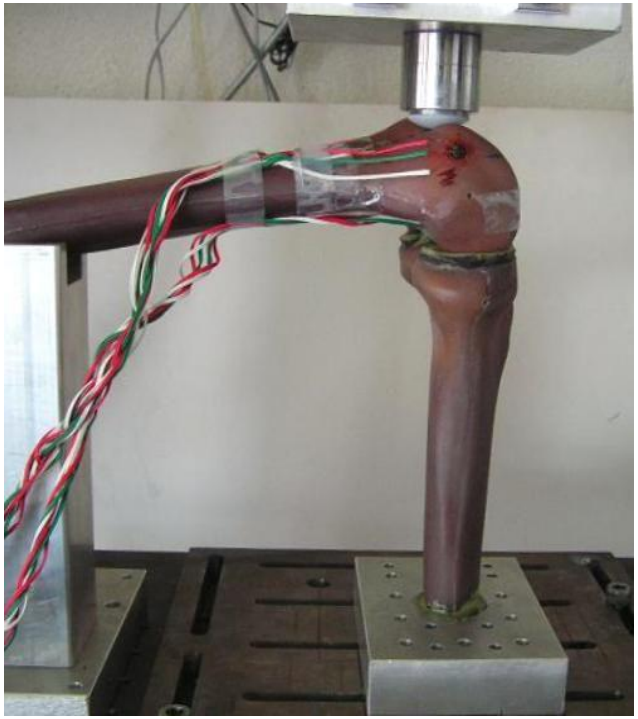
**No Pins Journey**



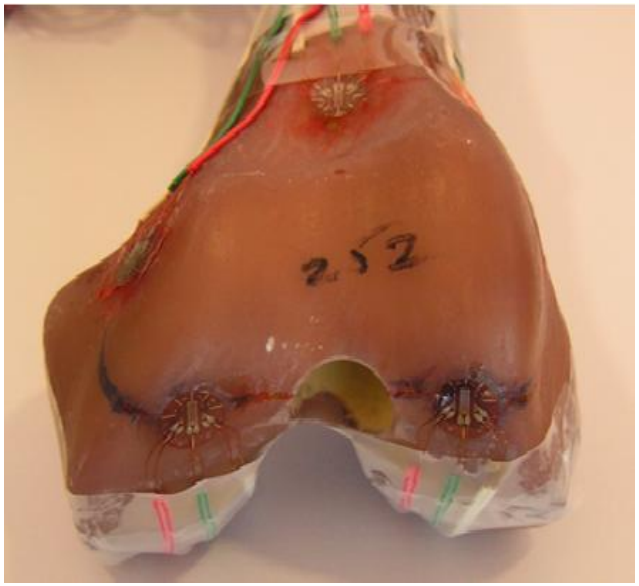
**Bar Pins Journey**



# Numerical-Experimental Validation



**The assembly, with the femur, the tibia and the patella, at 10 degrees of knee flexion**



**The natural knee model, with the strain gauges**

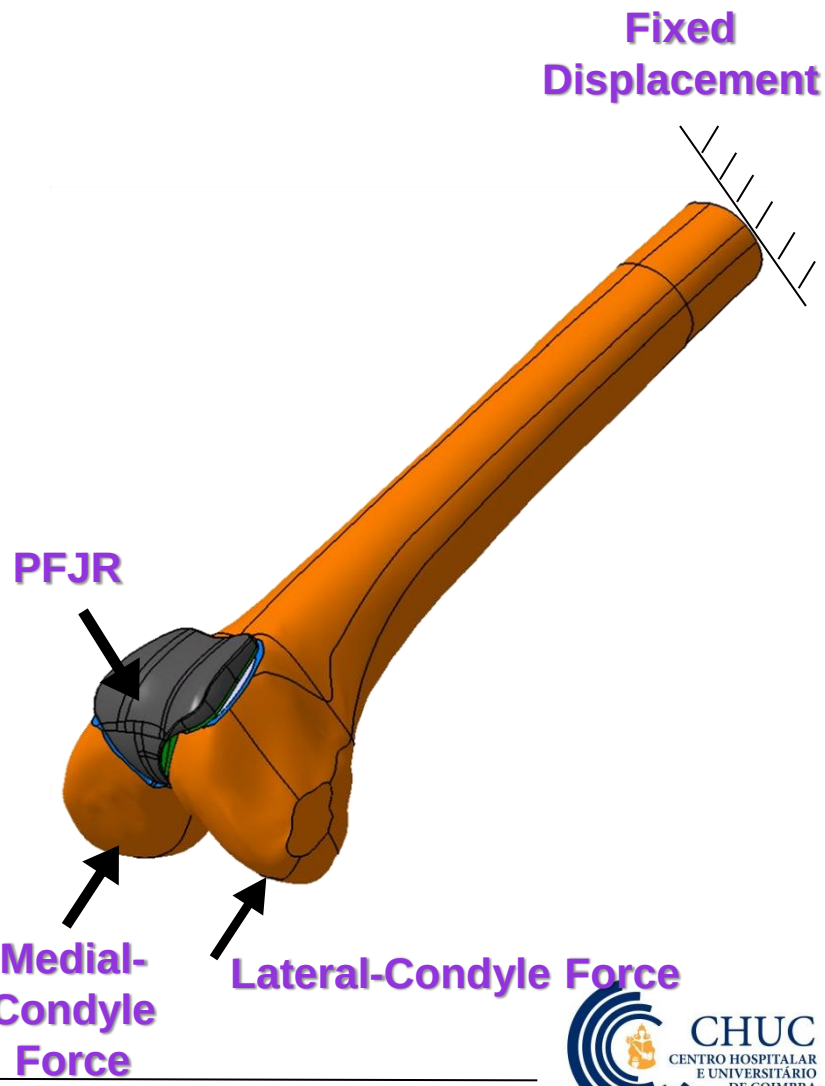
# Biomechanical Parameters

## Loads by Activity [Adapted from Matthews *et al.*, 1972]

| Activity | Knee flexion angle (°) | Patellar mechanism angle (°) | Tibial Reaction (N) | PFJR (N) |
|---|---|---|---|---|
| Climbing stairs | 45 | 54 | 2963 | 1756 |
| Descending stairs | 60 | 62 | 2668 | 1746 |
| Isometric Exercise | 90 | 78 | 2698 | 3424 |

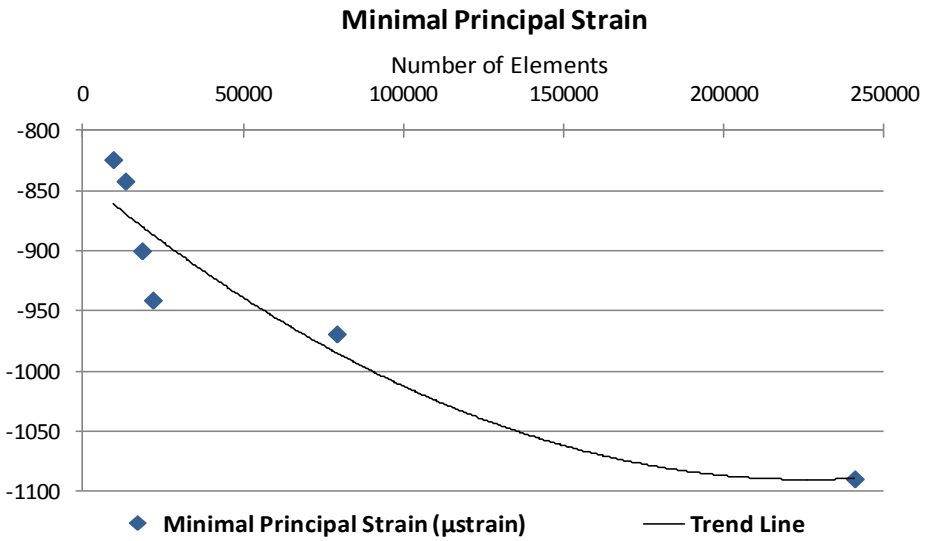
## Contact Table [Adapted from Completo, 2006]

| | Cancellous Bone | Compact Bone | Implant | Cement Layer |
|---|---|---|---|---|
| Cancellous Bone | | Glued | μ=0.3 | μ=1 |
| Compact Bone | Glued | | μ=0.3 | μ=1 |
| Implant | μ=0.3 | μ=0.3 | | μ=0.25 |
| Cement Layer | μ=1 | μ=1 | μ=0.25 | |

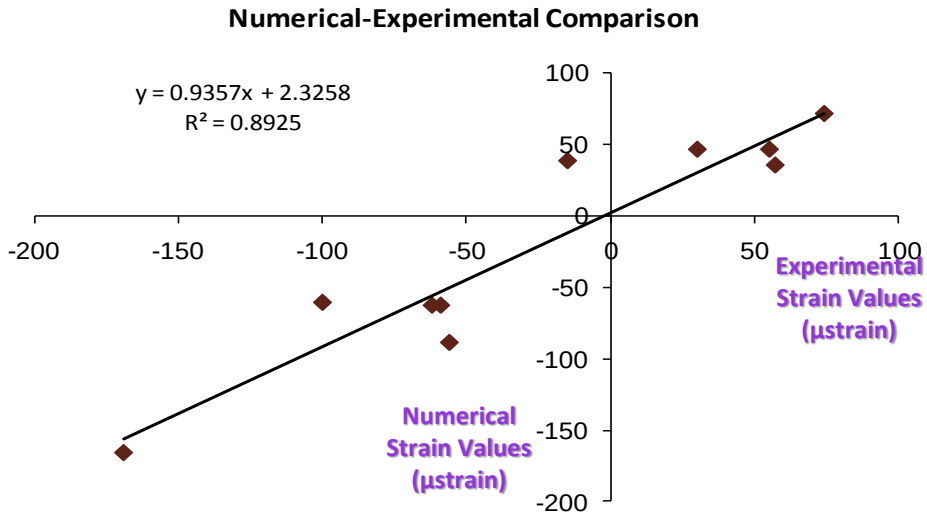


# Results and Discussion

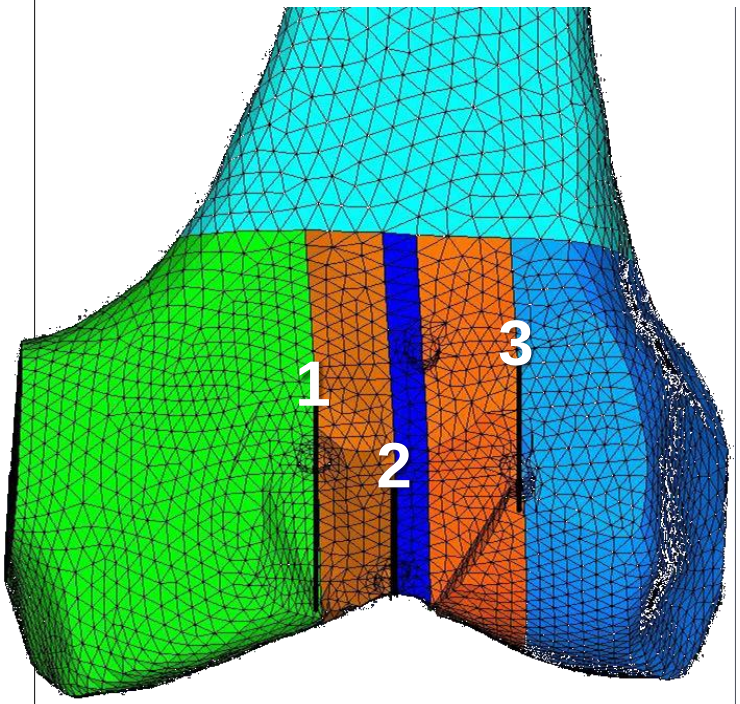
- **Convergence Study**
  - The indicated mesh size is 2 mm per element
    - 1 mm for the fixation pins
    - 3.5 mm for the femur body



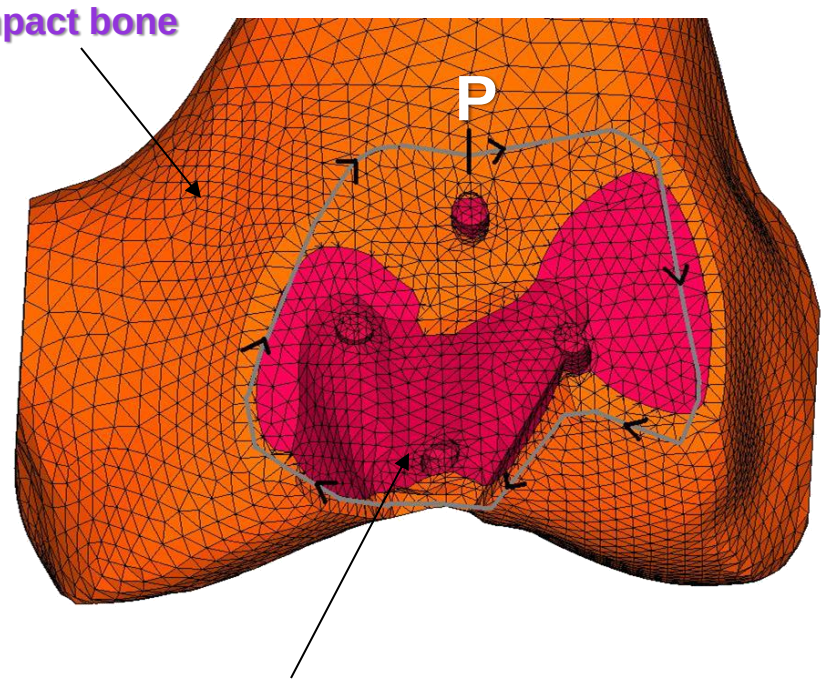

- **Numerical-Experimental Validation**
  - $y = 0.9357x + 2.3258$
  - $R^2 = 0.8925$



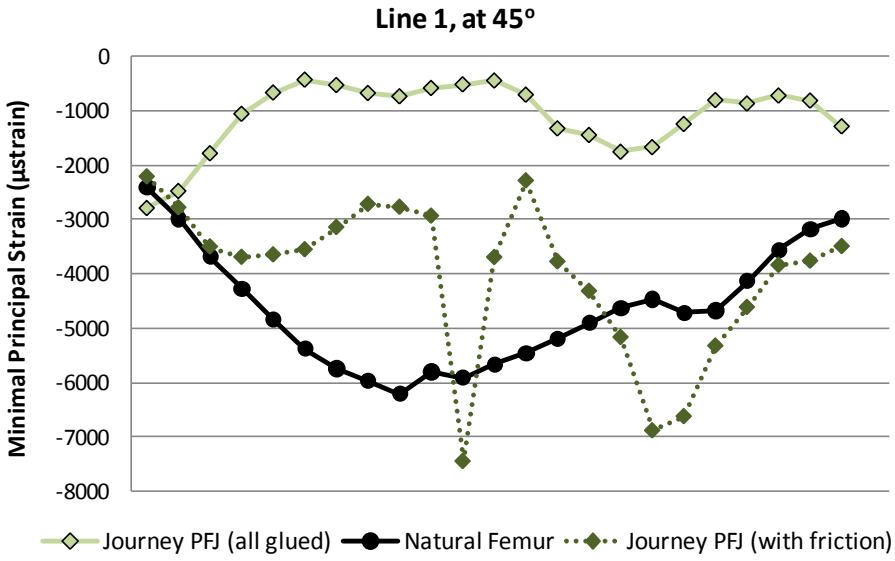
## The Line Measurements

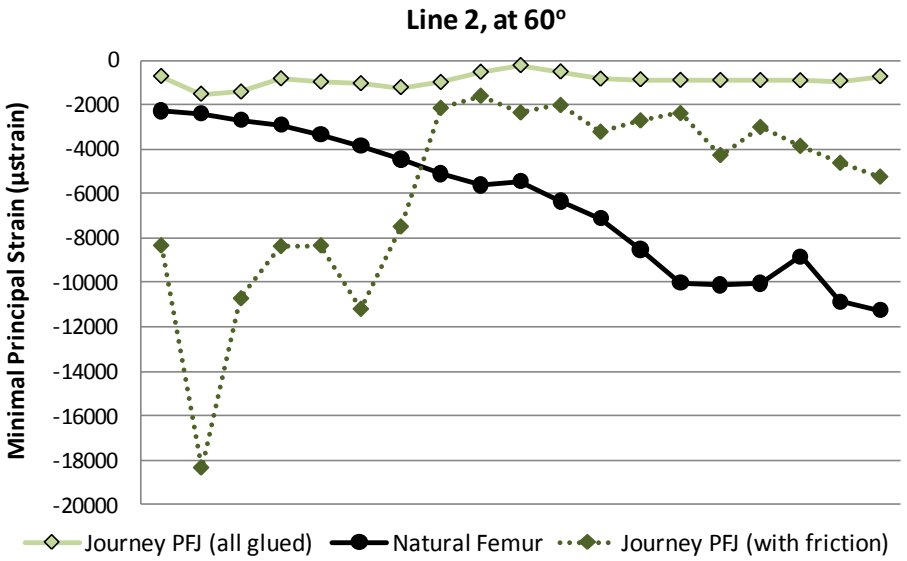


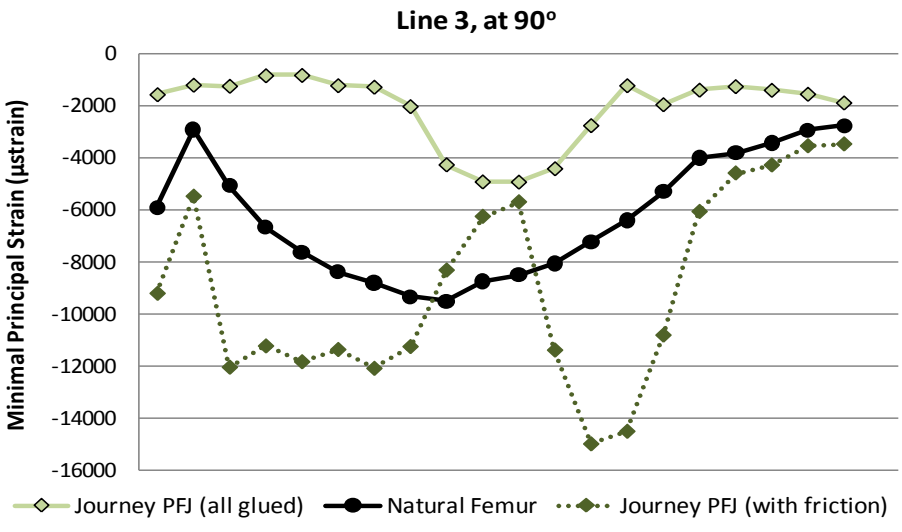

## The Contour Measurements



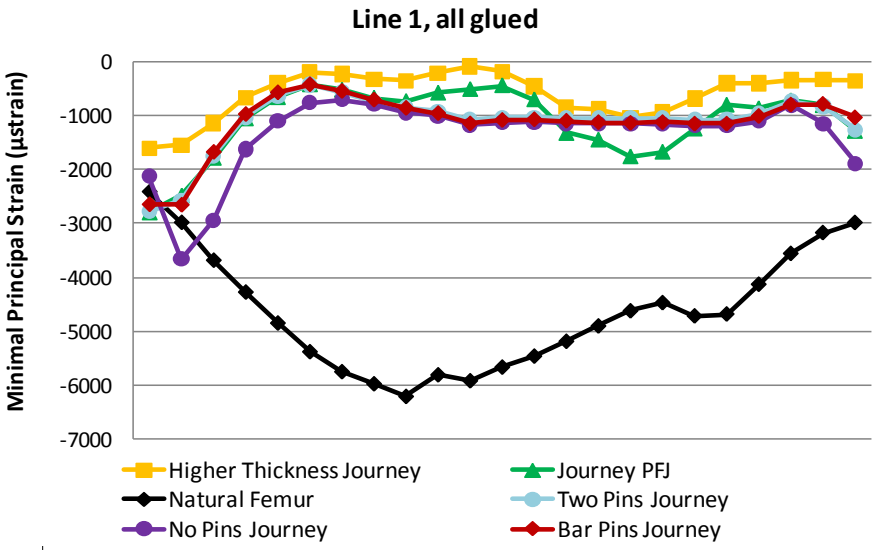
# Analysis of the Journey PFJ Implant

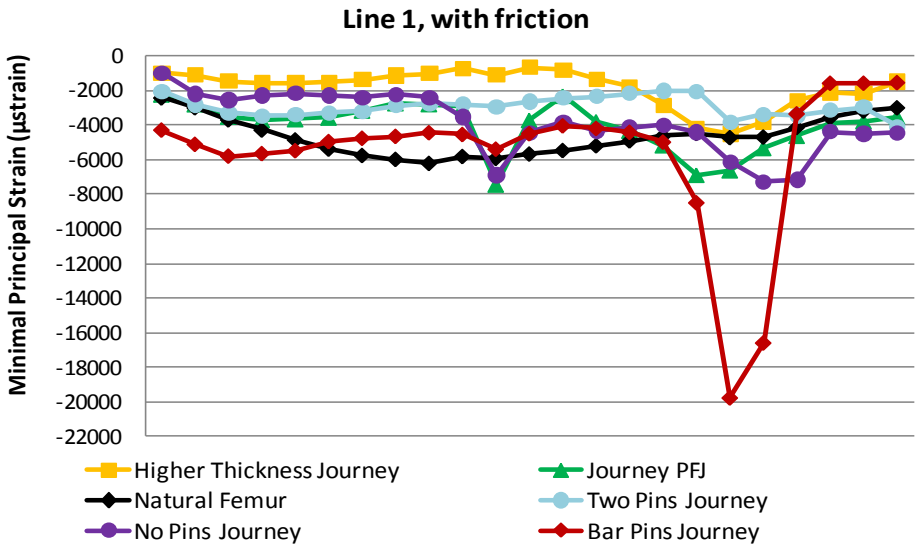


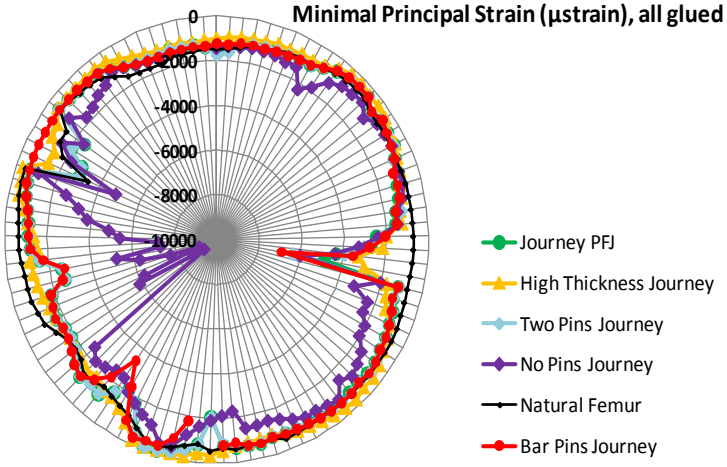



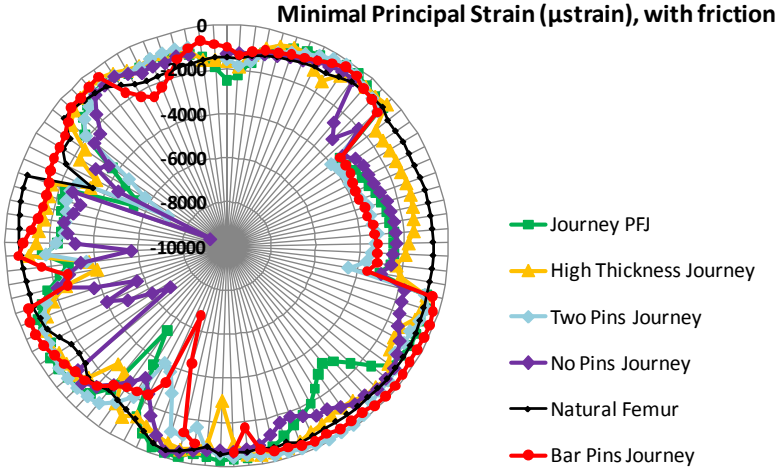



# Analysis of the Adapted Models

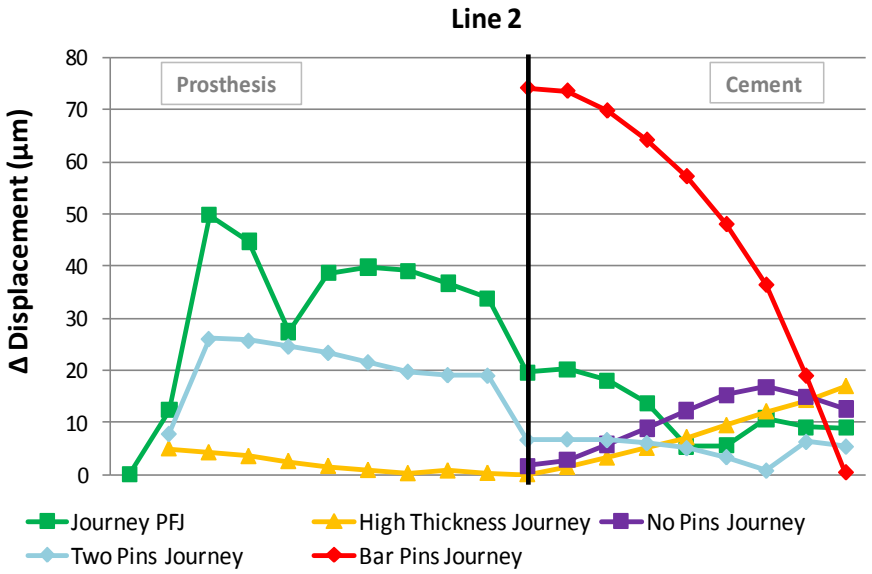


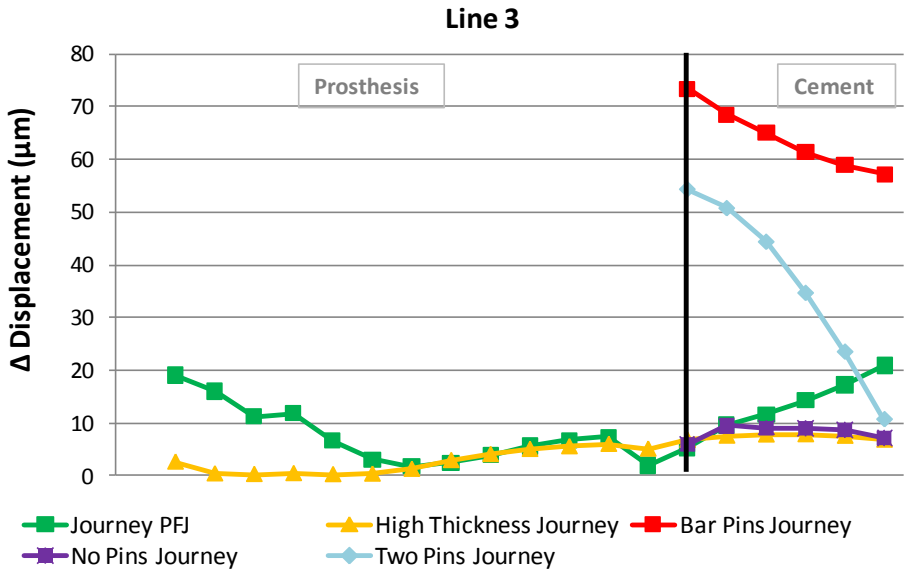



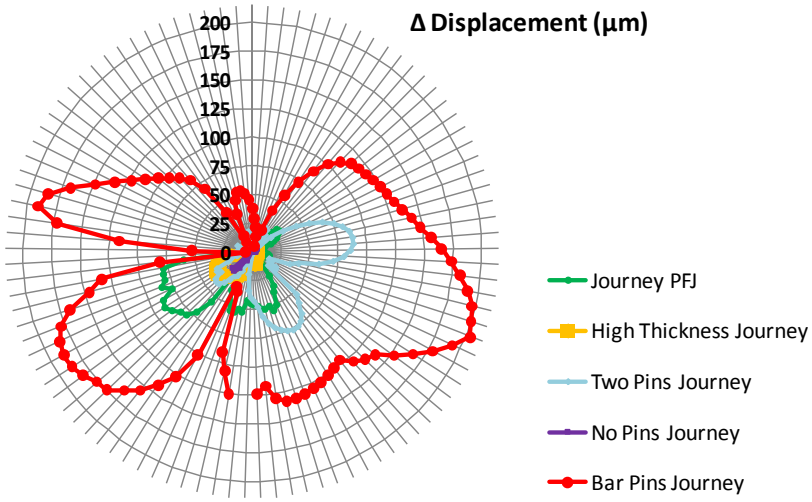



# Analysis of the Adapted Models

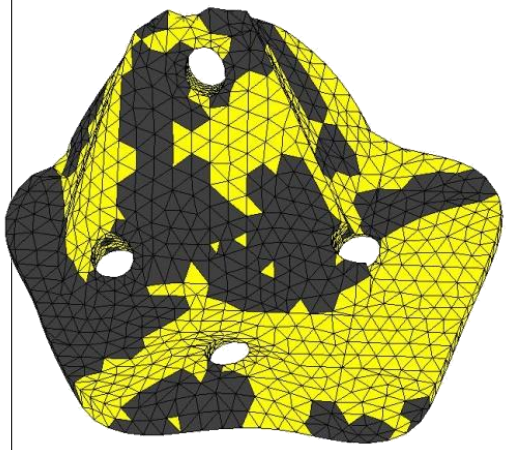


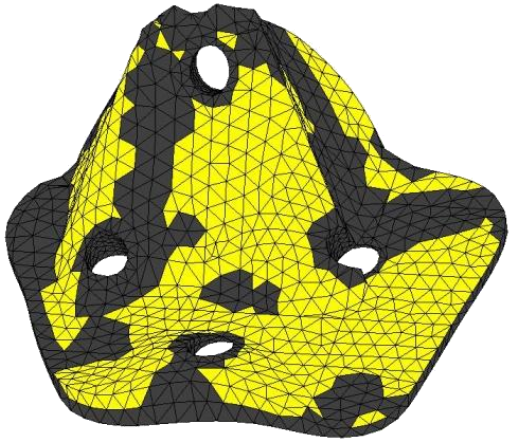



# Analysis of the Adapted Models

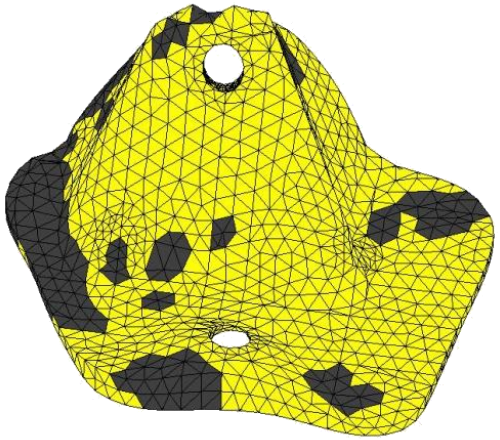
**Journey PFJ**



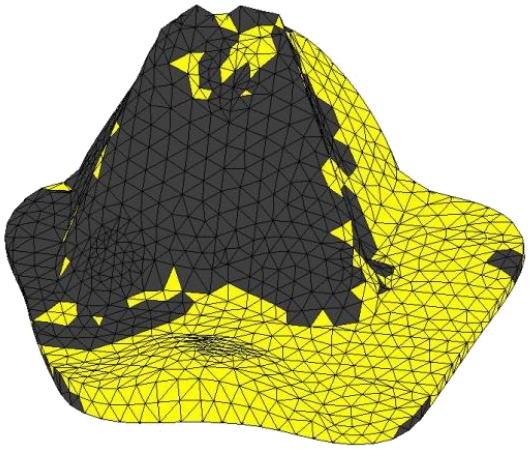
**High Thickness Journey**



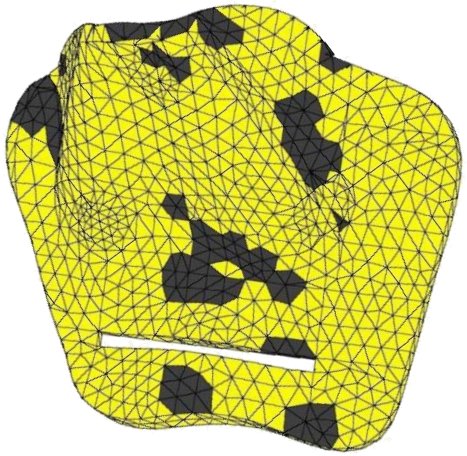
**Two Pins Journey**



**No Pins Journey**



**Bar Pins Journey**



# Conclusions

- **Stress shielding effect is a serious issue;**
- **Bone rupture by fatigue is another serious problem that may shorten the life of an implant;**
  - **However, a smoother surface on the trochlear interface has proven to reduce the probability of such effect to occur;**
- **The same smoothing process is also useful to reduce the probability of the prosthesis to become loose;**
- **Pins conformation is crucial on the prosthesis' performance;**
- **The cement layer can't be effectively removed without harm for the whole set of components.**

# When I perform a PFP ?

# My indications

- Patient > 65y. with isolated PF OA ?
  - I propose a TKA
- “Young” (< 55 y.) patient?
  - Missing credible long-term results
  - I may propose a PFP
- Patient between 55 and 65 y.
  - Possibility of converting in TKA

# Ideal

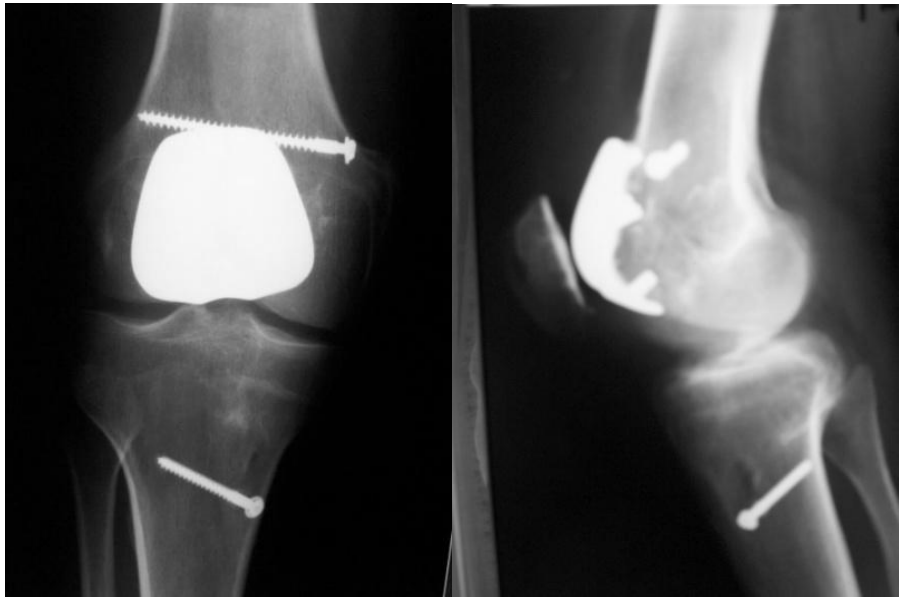
- Isolated patellofemoral arthritis
- Age between 55 and 65 years

- Avoid
  - Inflammatory arthritis
  - Chondrocalcinosis
  - PF malalignment
  - Very active patient

**Lonner – JAAOS 2004**

# Clinical results

- Patient satisfaction
- Fiability ?



# Literature review

| | Year | n | Age | f/u | G/Exc |
|---|---|---|---|---|---|
| Sisto | 2006 | 25 | 63 | 6 | 99% |
| Merchant | 2005 | 16 | 55 | 2 | 94 % |
| Ackroyd | 2005 | 306 | 52 | 5 | 91 % |
| Board | 2004 | 16 | 55 | 2 | 53 % |
| Lonner | 2003 | 30 | 38 | 4 | 84 % |
| Kooijman | 2003 | 45 | 72 | 4 | 69 % |
| Smith | 2002 | 95 | Nd | 4 | 83 % |
| DeWinter | 2001 | 26 | 59 | 11 | 76 % |

ORIGINAL PAPER

# Patellofemoral arthroplasty: a multi-centre study with minimum 2-year follow-up

Wayne B. Leadbetter · Frank R. Kolisek · Richard L. Levitt · Andrew F. Brooker · Patrick Zietz · David R. Marker · Peter M. Bonutti · Michael A. Mont

Received: 23 August 2008 / Revised: 23 September 2008 / Accepted: 24 September 2008 / Published online: 5 December 2008

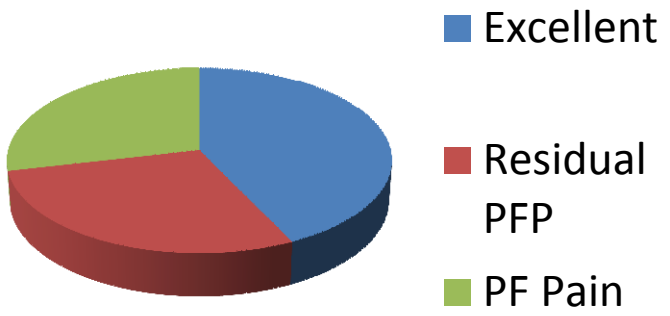

**Abstract** Recently, patellofemoral arthroplasty has attracted increased interest as a salvage treatment for isolated patellofemoral arthritis. However, there are very few reports of the experience with modern generation patellofemoral arthroplasties. This investigation describes a collective experience of four centres reporting on the outcome in patients of the use of one patellofemoral arthroplasty device. There were 70 patients (79 knees) who had failed an extensive non-operative treatment regimen and/or various conventional alternative surgical treatments. At a mean follow-up of three years (range: 2–6 years), there were 66 knees that had Knee Society Scores greater than 80 points (84%). Seventy-one knees (90%) functioned without pain in daily activity and stair climbing. Symptomatic isolated patellofemoral arthritis was successfully treated with a patellofemoral arthroplasty in the short term. We are encouraged by these excellent early results and await longer follow-up.

**Résumé** Les prothèses fémoro patellaires ont connu récemment un intérêt croissant dans le traitement des arthroses fémoro patellaires isolées. Cependant, peu de nouveaux travaux sont publiés concernant la nouvelle génération

International Orthopaedics, 2009; 33

# Personal experience

- 2007 - 2010
  - 10 patients
  - Median age 63 y.
  - f/u 4 y
  - Results
    - Excellent - # 6 cases
    - Residual patellofemoral pain- #2
    - Severe patellofemoral pain- #2



# Take home message

- Low incidence of isolated PF arthritis
  - Prevalence of PF pain, not OA
- PFP
  - *Stress shield* is unsolved problem
  - Isn't a good solution for patellofemoral pain
- Good patient selection
- Advise patient that PFP is a …. temporary solution

# Thank you

pereirafonseca@gmail.com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Obrigado
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