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PROXIMAL TIBIAL FRACTURES:

Osteoporotic bone and pathological fractures

F. Benazzo

BIOLOGY

The cellular processes underlying fracture healing are complex

Key Phases

1) Inflammation: initial response to injury
2) Repair: formation of new bone tissue
3) Remodeling: bone restructuring and strengthening over time

The whole process requires an integrated action of different cell types and biochemical signals

Fracture healing can be **indirect** or **direct**, or a combination of both

Review > Osteoporos Int. 2024 Aug;35(8):1337-1358. doi: 10.1007/s00198-024-07059-8. Epub 2024 Apr 8.

Impact of osteoporosis and osteoporosis medications on fracture healing: a narrative review

M Chandran [1], K E Akesson [2], M K Javaid [3], N Harvey [4], R D Blank [5] [6], M L Brandi [7], T Chevalley [8], P Cinelli [9], C Cooper [10] [11], W Lems [12], G P Lyritis [13], P Makras [14], J Paccou [15], D D Pierroz [16], M Sosa [17], T Thomas [18], S Silverman [19];
Fracture Working Group of the Committee of Scientific Advisors of the International Osteoporosis Foundation, on behalf of the International Osteoporosis Foundation, Société Internationale de Chirurgie Orthopédique et de Traumatologie

NON-UNION: RISK FACTORS

- Patient-dependent factors: age, tobacco and alcohol abuse, NSAID use, malnutrition, diabetes, vascular disease, previous radiation therapy, hypothyroidism, and vitamin D deficiency

- Fracture- or trauma-related factors: comminution, poor cortical apposition, interposed soft tissue, soft tissue damage, bone loss, quality of surgical treatment, and infection

J Orthop Sci. 2014 Jan;19(1):120-4. doi: 10.1007/s00776-013-0472-4. Epub 2013 Oct 1.

Causative factors of fracture nonunion: the proportions of mechanical, biological, patient-dependent, and patient-independent factors

Takahiro Niikura [1], Sang Yang Lee, Yoshitada Sakai, Kotaro Nishida, Ryosuke Kuroda, Masahiro Kurosaka

OSTEOPOROSIS AND *FRACTURE HEALING*

Does osteoporosis contribute to non-union or delayed consolidation?

Altered biomechanical properties in osteoporotic bone:

- Reduced bone mass
- Decreased cortical thickness
- Increased cortical porosity
- Trabecular disorientation
- Changes in bone matrix composition

Cellular Compromise

Osteoporotic bone cells may have:

- Reduced cell proliferation
- Decreased release of TGF-β and nitric oxide under stress

The potential association between osteoporosis and delayed fracture consolidation/non-union is **unclear**

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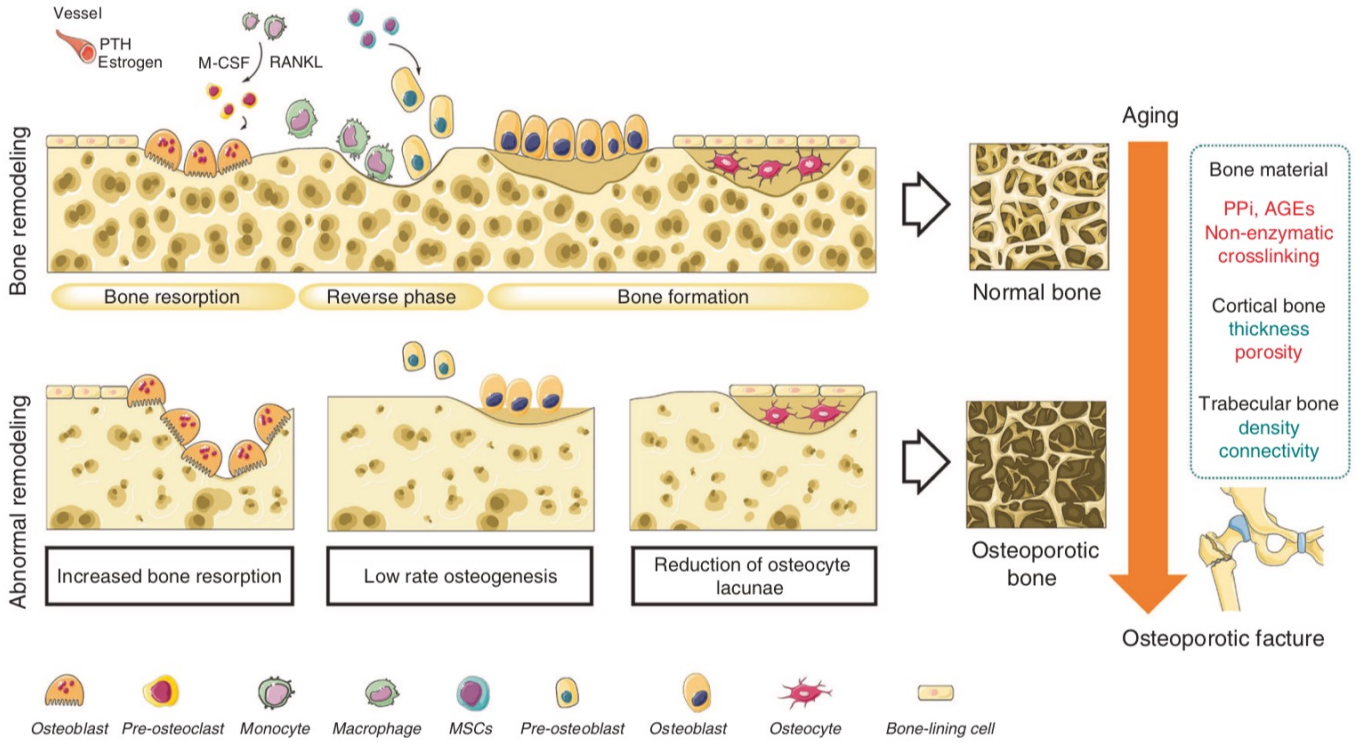
OSTEOPOROTIC BONE PATHOLOGY



PPi inorganic pyrophosphate, AGEs advanced glycation end-products

Review > Bone Res. 2019 Aug 15:7:25. doi: 10.1038/s41413-019-0066-7. eCollection 2019.

Bench-to-bedside strategies for osteoporotic fracture: From osteoimmunology to mechanosensation

Yong Xie # 1, Licheng Zhang # 1, Qi Xiong # 2, Yanpan Gao 3, Wei Ge 3, Peifu Tang 1

Osteoporotic fracture

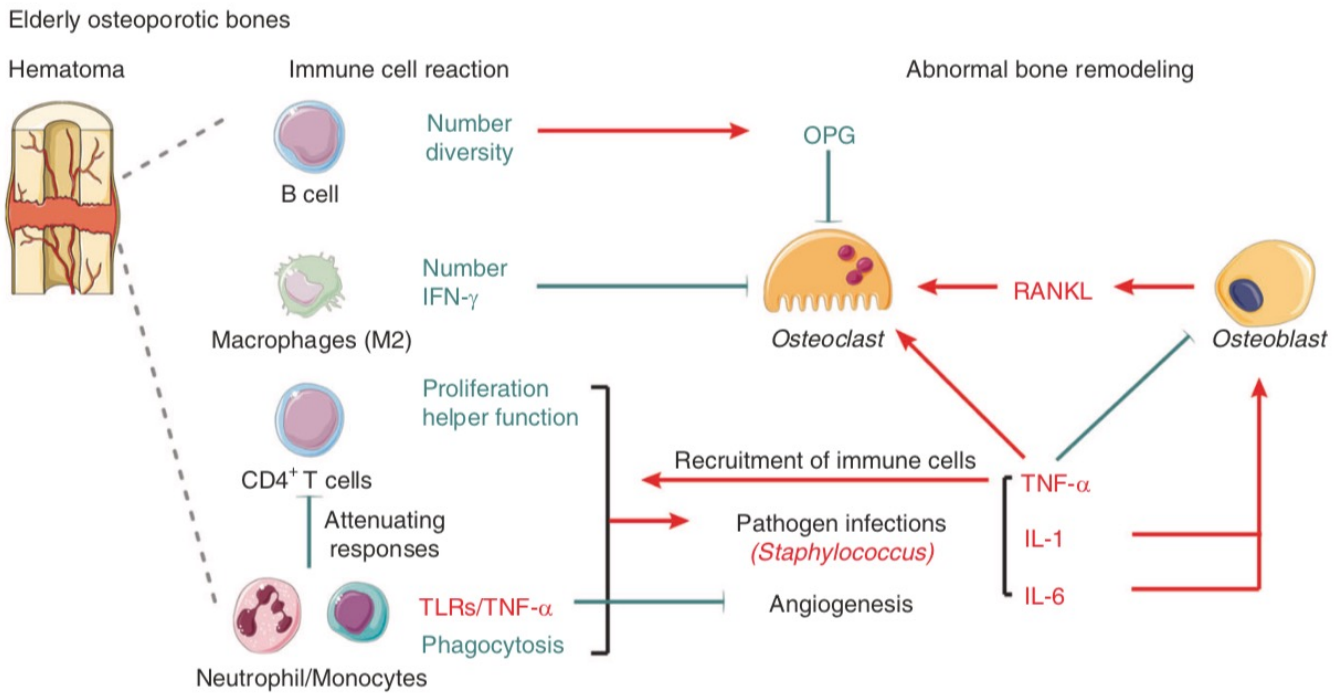
Macroscopic result of microstructural alterations that change the response of bone to applied load

Bone Aging

Excessive accumulation of PPi, AGEs, and to nonenzymatic cross-links of collagen, which alter normal bone structure

Increased bone resorption, reduced osteogenesis reduction of osteocyte gaps leads to **reduced trabecular thickness** and **more porous cortical bone**

OSTEOIMMUNOLOGY IN ELDERLY OSTEOPOROTIC BONES



OPG osteoprotegerin, RANKL receptor activator of nuclear factor kappa-B ligand

Review > Bone Res. 2019 Aug 15:7:25. doi: 10.1038/s41413-019-0066-7. eCollection 2019.

Bench-to-bedside strategies for osteoporotic fracture: From osteoimmunology to mechanosensation

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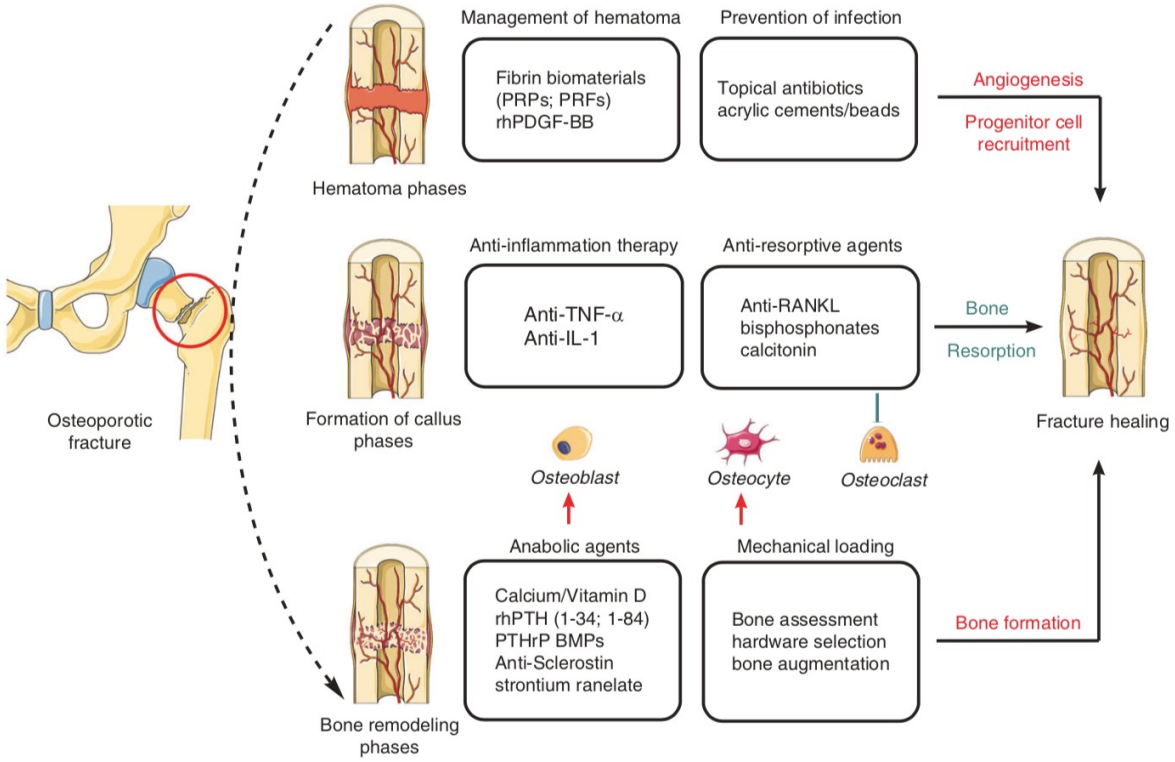
- Hematoma and inflammatory phases are the immediate reactions to a fracture
- The limited inflammatory response at the fracture site is essential to initiate repair processes and mobilize all the required factors involved in the early bridging of the fracture gap, especially in indirect bony unions without rigid fixation
- The high RANKL/OPG ratio caused by aging-related inflammation and the lack of mature B cells is associated with the hyperactivation of osteoclastogenesis and aggravation of bone resorption in elderly patients with bone loss, which increases the incidence of intra- or postoperative further fractures

TREATMENT STRATEGIES IN FRAGILITY FRACTURES



Creating the ideal environment for fracture healing in osteoporotic bones:

- management of **hematomas** and perioperative **infections**
- reduction of **inflammation**
- regulation of bone resorption
- **rigid fixation**
- improvement of **mechanical loading**

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Bench-to-bedside strategies for osteoporotic fracture: From osteoimmunology to mechanosensation

Yong Xie [# 1], Licheng Zhang [# 1], Qi Xiong [# 2], Yanpan Gao [3], Wei Ge [3], Peifu Tang [1]

TREATMENT CHALLENGES

Patient-related:

Elderly patients, increased risk of **falls**

Difficulty meeting load limitations, overloading of fixation devices

High prevalence of comorbidities, need for rapid, minimally invasive surgery for fast recovery

Bone related:

Osteoporotic bone: reduced density, increased fragility

Often more complex, multifragmentary fractures

Need for accurate surgical reduction and stable fixation

Review > Curr Osteoporos Rep. 2019 Dec;17(6):363-374. doi: 10.1007/s11914-019-00535-9.

Biomechanics of Osteoporotic Fracture Fixation

Marianne Hollensteiner [1 2], Sabrina Sandriesser [1 2], Emily Bliven [1 2], Christian von Rüden [1 2 3], Peter Augat [4 5]

CHALLENGES IN TREATING OSTEOPOROTIC FRACTURES

Mechanical stability needs

- Osteoporotic bone has poor mechanical strength (porous cancellous and thin cortical bone)
- Frequent complications: implant loosening, implant cut-out, and peri-implant fractures
- Implants must withstand loosening or be reinforced/augmented to prevent failure

Requirements for successful fixation

- Stable, durable fixation allowing immediate full load-bearing
- Especially important in fractures common among the elderly: pelvis, hip, ankle, and peri-implant fractures

Review > Curr Osteoporos Rep. 2019 Dec;17(6):363-374. doi: 10.1007/s11914-019-00535-9.

Biomechanics of Osteoporotic Fracture Fixation

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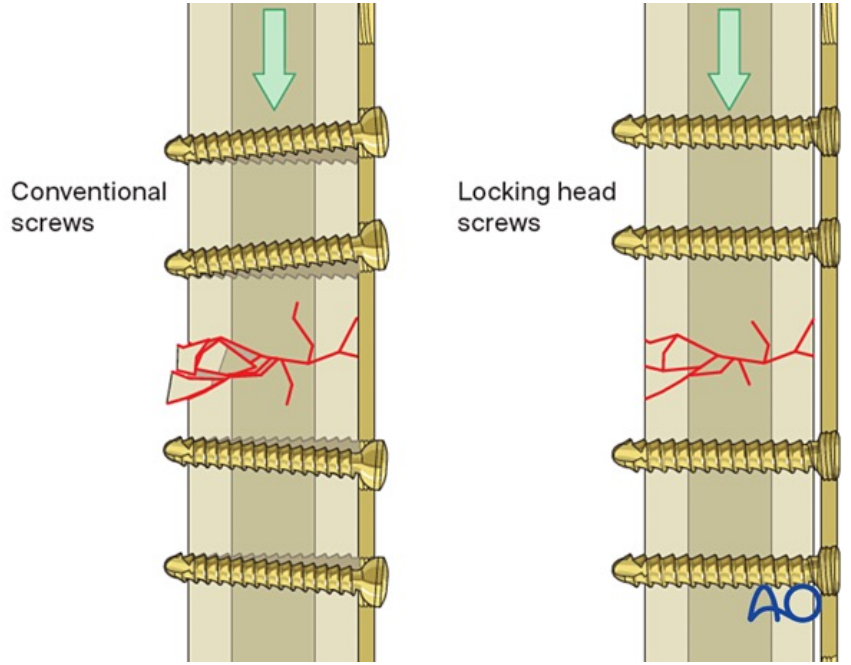
STRATEGIES FOR OSTEOPOROTIC FRACTURE

- Unstable and comminuted fracture patterns as well as early implant-bone fatigue in osteoporotic bones lead to implant loosening and fixation failure
- Locking-plate technology provides a more advantageous biomechanical environment that facilitates the formation of a fixed angle between the plate and screw
- Despite the greater overall stability, locking plates may create an excessively rigid construct, which is predisposed to peri-implant fracture



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Bench-to-bedside strategies for osteoporotic fracture: From osteoimmunology to mechanosensation

Yong Xie [# 1], Licheng Zhang [# 1], Qi Xiong [# 2], Yanpan Gao [3], Wei Ge [3], Peifu Tang [1]

STRATEGIES FOR OSTEOPOROTIC FRACTURE

- Intra-articular and complex fractures in patients with osteoporosis pose unique challenges for surgeons. These patients have inadequate subchondral bone quality to allow for anatomic reductions, and the stability of the implant is difficult to maintain after the reintroduction of weight-bearing and increased range of motion.

- Primary arthroplasty (total hip/knee/elbow arthro- plasty) has been adopted to obtain adequate weight-bearing and early mobilization, which has a superior prognosis compared to internal fixation in acute acetabular fractures, displaced intra- articular tibial plateau fractures and complex distal humeral fractures.

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TREATMENT STRATEGIES

Locking-plate technology provides a more advantageous biomechanical environment that facilitates the formation of a fixed angle between the plate and screw

N.B. Despite greater overall stability, locking plates can create an overly rigid structure that is predisposed to peri-implant fractures

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Bench-to-bedside strategies for osteoporotic fracture: From osteoimmunology to mechanosensation

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TREATMENT STRATEGIES

Proximal tibial fractures are intra-articular and complex fractures in patients with osteoporosis:

- inadequate subchondral bone quality not always allow for anatomic reductions
- Implant stability difficult to maintain after load reintroduction

Primary TKA has been proposed to achieve adequate loading and early loosening, with better prognosis than internal fixation

Review > Bone Res. 2019 Aug 15:7:25. doi: 10.1038/s41413-019-0066-7. eCollection 2019.

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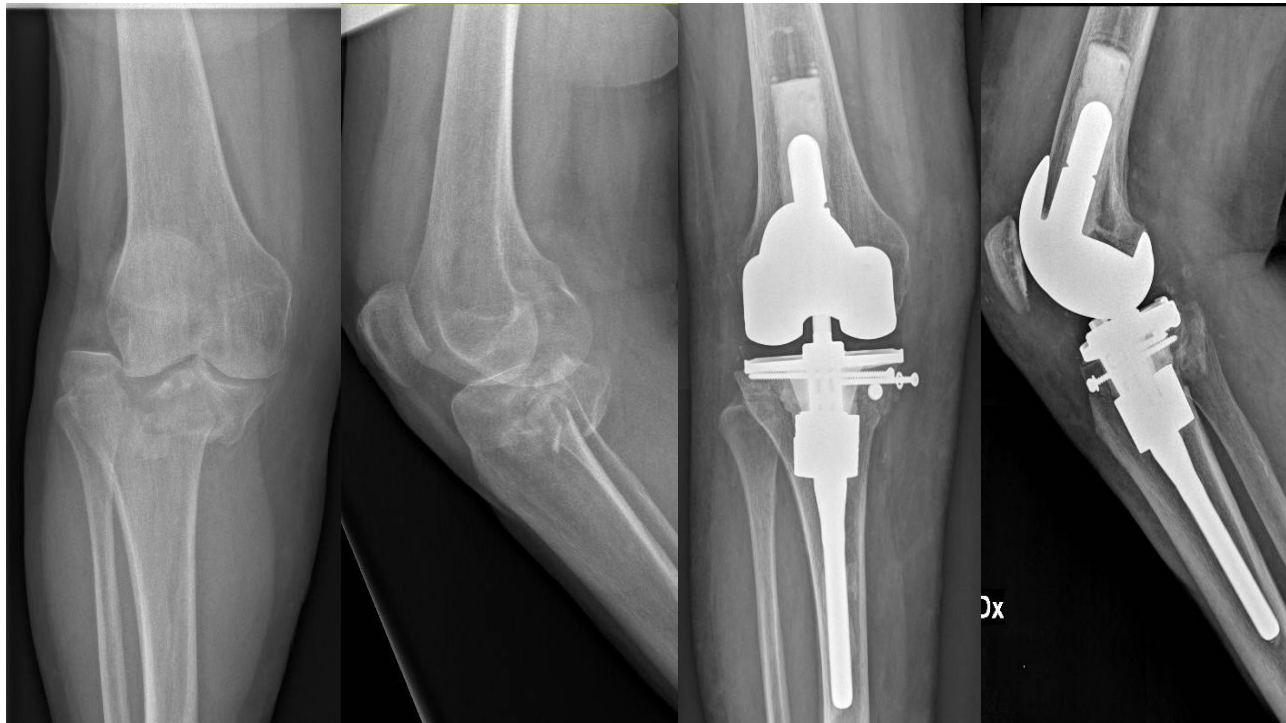
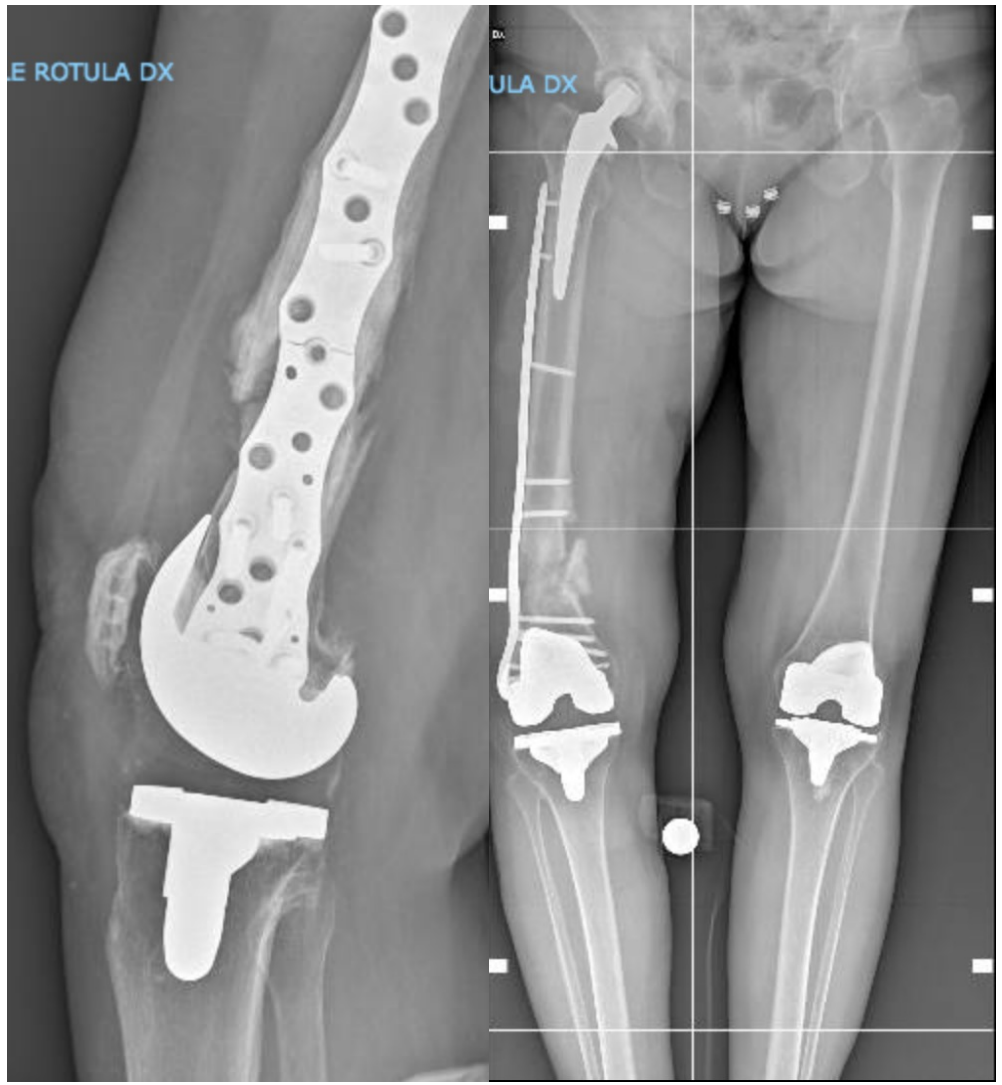
CLINICAL CASE

Woman, 58 y.o.
Known, untreated osteoporosis
Very low energy trauma

Schatzker IV plateau tibial fracture



Surgery: LCCK with tibial stem, tibial cone, 3 cancellous bone screws 3,5mm with washer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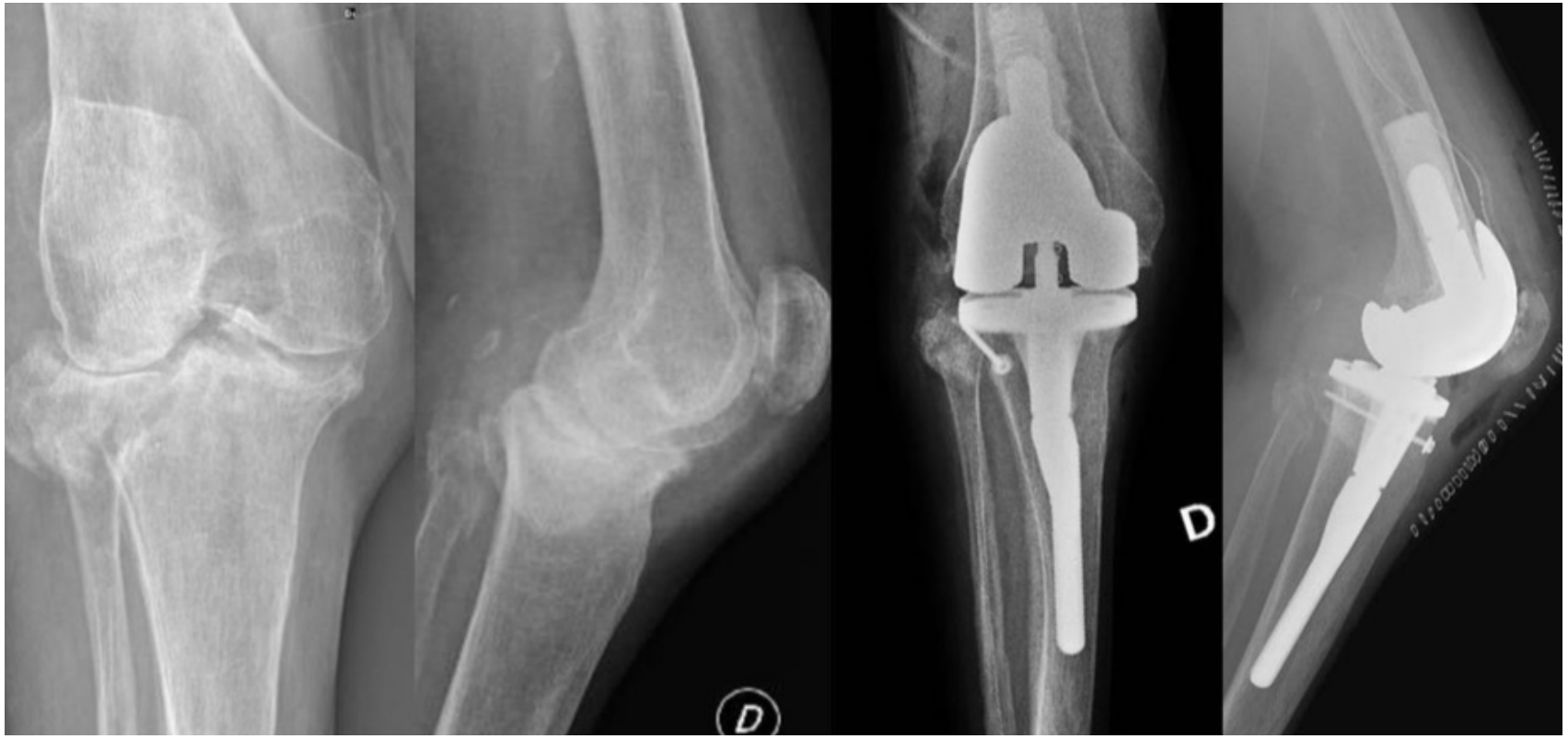
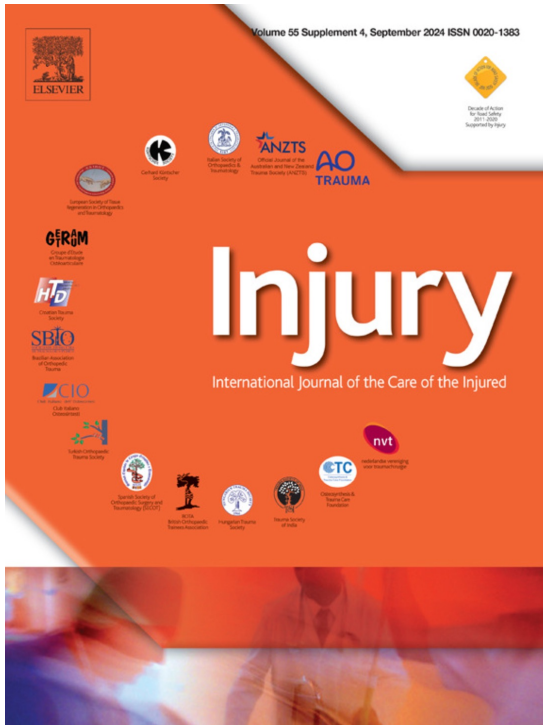


Despite the advent of locked anatomic plates, a majority of experts recommend arthroplasty in the context of poor bone quality and small fracture fragments

Observational Study > Injury. 2024 Sep:55 Suppl 4:111347. doi: 10.1016/j.injury.2024.111347.

Fractures around the knee in elderly patients: Balancing fixation and arthroplasty approaches, a multicenter experience

Fabrizio Quattrini [1], Luca Andriollo [2], Corrado Ciatti [3], Pietro Maniscalco [1], Francesco Benazzo [4], Stefano Marco Paolo Rossi [5]



BACKGROUND

To gain insight into this critical decision-making process, we undertook a comparative **analysis of the current literature associated with the clinical experiences from three distinct medical centers** both with a robust background in traumatology

The outcomes of this investigation aim **to propose a scoring system** that can be adopted for the choice between the two different approaches

METHODS

Inclusion criteria

- Aged > 65 years
- Fracture around the knee
- Surgical treatment with osteosynthesis or arthroplasty
- Follow-up > 12 months

Exclusion criteria

- Autoimmune diseases
- Local neoplastic conditions
- Open fractures
- Loss of follow-up data

Fractures around the knee, in accordance with the AO/OTA classification:

- distal femur types 33-A, 33-B, and 33-C
- proximal tibia types 41-A, 41-B, and 41-C

RESULTS

From August 2017 to October 2022:
96 patients aged over 65 with periarticular knee fractures underwent surgical treatment
91 patients were analyzed in this retrospective evaluation

Patient population	Number	%
Total no.	96	100,0
Died	4	4,2
Non traceable	1	1
Available	91	94,8

Indication	Number	%
Distal femur fracture	34	37,4
Proximal tibial fracture	57	62,6

Treatment	Number	%
Osteosynthesis	71	78
Replacement	20	22

Sex	Number	%
Male	21	23,1
Female	70	76,9

Age	Average (Y)	SD
	76,4	8,6

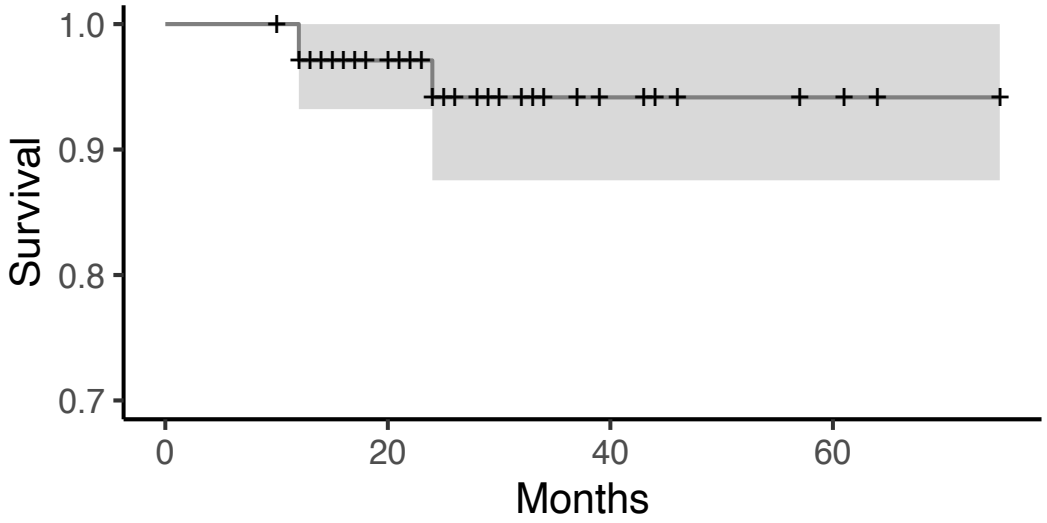
RESULTS

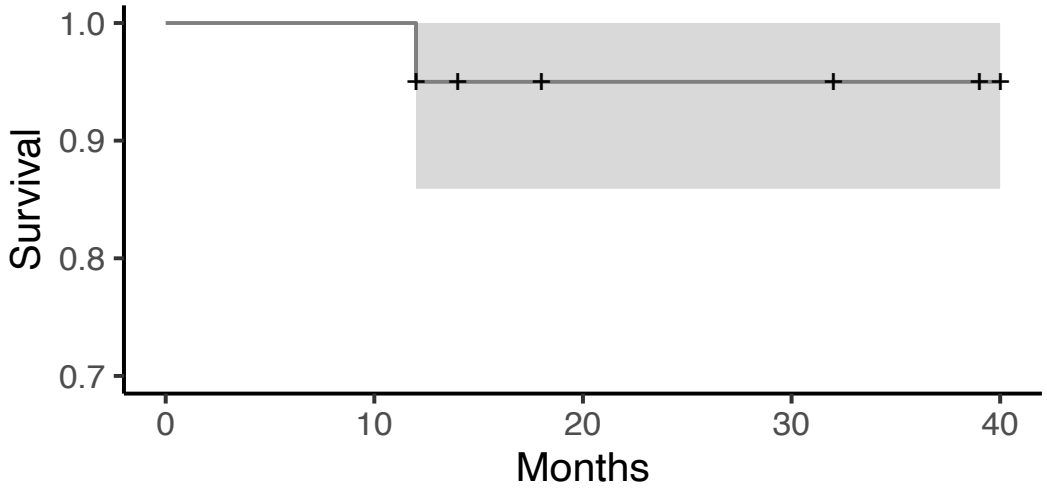
Synthesis treatment	Number	%
ARIF	3	3,3
Plate ORIF	19	20,9
Intramedullary nail	4	4,4
MIPO	45	49,5
Degree of constrained	Number	%
PS / CPS	4	4,4
Varus-valgus constrained	10	11
Megaprosthesis (Hinge)	6	6,6

RESULTS

Clinical outcome	Total (SD)	Osteosynthesis (N = 68; SD)	Replacement (N = 19; SD)	P value
WOMAC	36.9 (18.1)	39.9 (18.7)	26 (10.5)	P<0.05
OKS	31.2 (7.1)	30.3 (7.3)	34 (5.2)	P<0.05
FJS-12	55.6 (14.9)	53.1 (15.7)	65 (5.9)	P<0.05
Quality score OKS	Cases (N = 87; %)	Osteosynthesis (N = 68; %)	Replacement (N = 19; %)	
Excellent > 41	12 (13.8)	7 (10.3)	5 (26.3)	
Good 34 - 41	27 (31)	19 (28)	8 (42.1)	
Fair 27 - 33	38 (43.7)	33 (48.5)	5 (26.3)	
Poor < 27	10 (11.5)	9 (13.2)	1 (5.3)	

RESULTS





The Kaplan-Meier Survival Estimate shows a survival rate of 95% for both groups, at a final mean follow-up of 25.3 months (SD 15.4)

TKRISS

The functional results obtained and the related risk factors for treatment failure, specifically comparing osteosynthesis with replacement, were evaluated by a team of surgeons with varying degrees of experience.

A score was then proposed for the selection of the appropriate treatment in the presence of fractures around the knee, referred to as the

Total Knee Replacement Indication Scoring System for Knee Fractures Based on AO Classification (TKRISS)

TKRISS

Age:

- ≤ 70 years — 0 point
- 71-80 years — 1 point
- 80 years — 2 points

Pre-Traumatic Arthritic Status:

- No pre-traumatic arthritis — 0 points
- Mild to moderate arthritis — 1 point
- Severe arthritis — 2 points

Clinical Frailty Scale (CFS):

- CFS 1-2 (very fit to FIT) — 0 points
- CFS 3 (managing well) — 1 point
- CFS 4-6 (mild frailty to moderate frailty) — 2 points
- CFS 7 (severe frailty) — 1 point
- CFS 8-9 (vulnerable) or higher — 0 point

Diabetes:

- No diabetes — 2 points
- Controlled diabetes — 1 point
- Uncontrolled or severe diabetes — 0 point

Smoking:

- Non-smoker — 2 points
- Former smoker (>1 year without smoking) — 1 point
- Current smoker — 0 point

Malnutrition:

- No or mild malnutrition — 1 point
- Moderate Malnutrition — 2 points
- Severe malnutrition — 1 point

TKRISS

For AO 33 (Distal Femur)		For AO 41 (Proximal Tibia)	
Type A:	0 points	Type A:	0 points
Type B:		Type B:	
B1:	1 point	B1:	1 point
B2:	2 points	B2:	1 point
B3:	1 points	B3:	2 points
Type C:		Type C:	
C1:	1 points	C1:	1 point
C2:	2 points	C2:	2 points
C3:	3 points	C3:	3 points

Indication Levels:

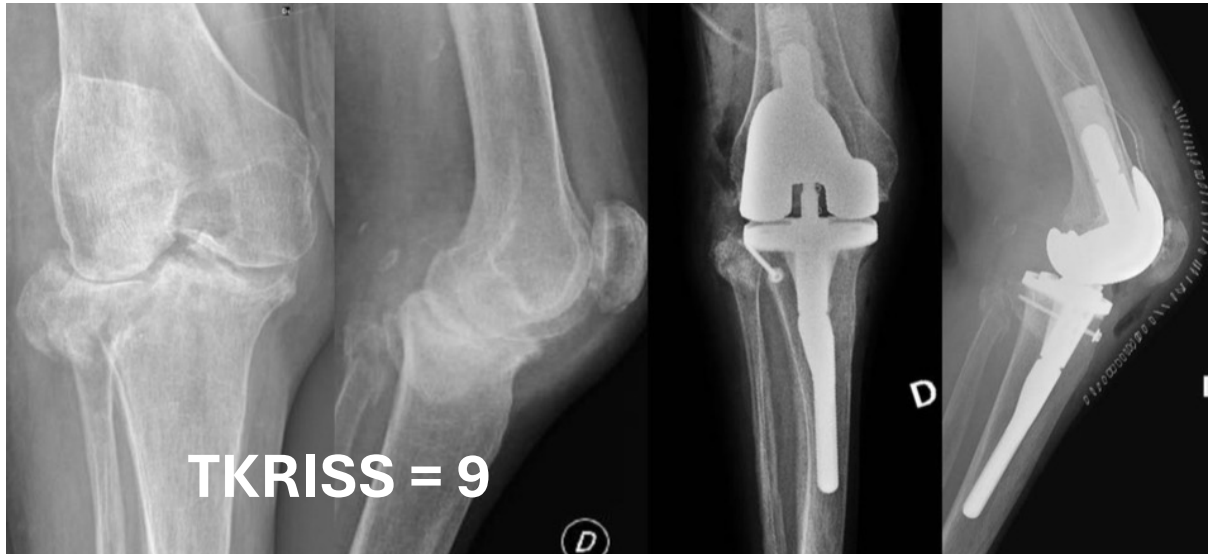
- Low Indication: Total score 0-5
- Moderate Indication: Total score 5-8
- Indication: Total score > 9

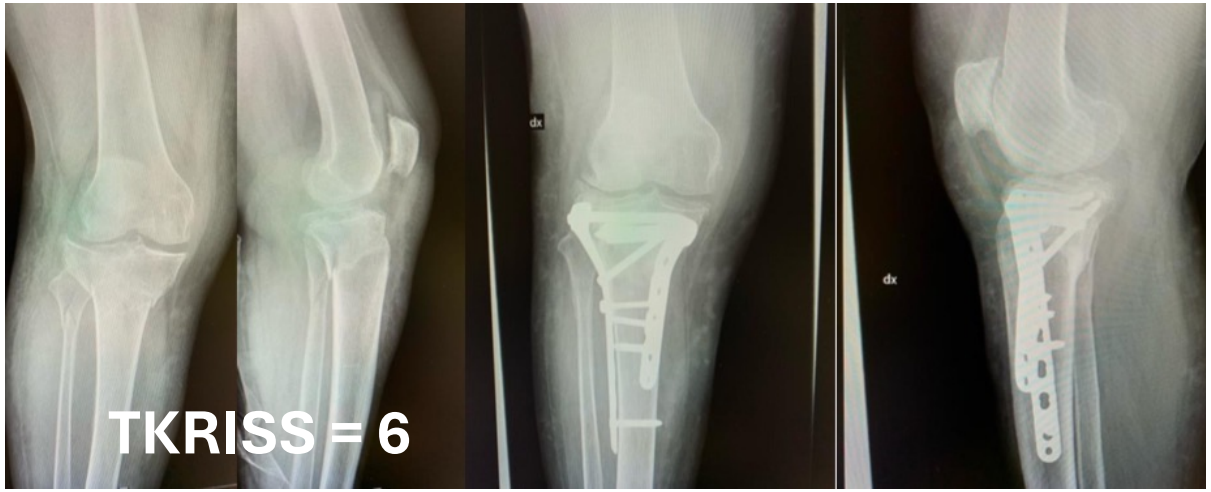
Scoring Interpretation:

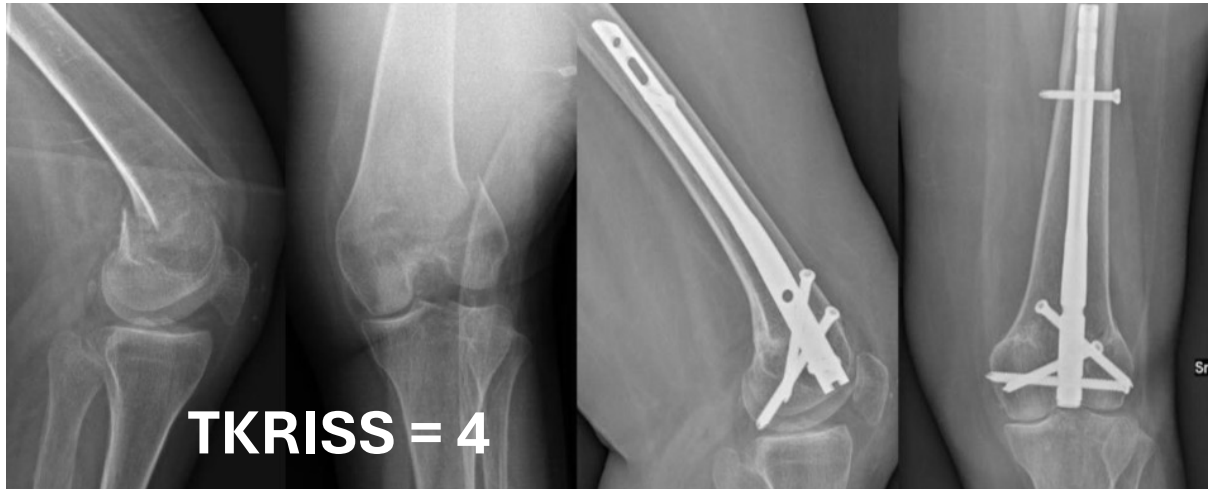
- The total score is calculated by summing the points assigned to each criterion
- The higher the total score, the greater the indication for total knee replacement

TKRISS

Total Knee Replacement Score	No. of cases (%)	Osteosynthesis (%)	Replacement (%)
Low indication 0 -5	51 (56)	51 (71.8)	0 (0)
Moderate indication 5 - 8	33 (36.3)	20 (28.2)	13 (65)
Indication > 9	7 (7.7)	0 (0.0)	7 (35)







CONCLUSIONS ABOUT TKRISS

Nowadays **osteosynthesis remains the main treatment option for fractures around the knee**. In a geriatric patients population and in carefully selected patients replacement can be an valid option.

The **Total Knee Replacement Indication Scoring System** provides a **useful tool** for healthcare to assess the **potential indication for TKR in the context of knee fractures**. It integrates a range of relevant factors, acknowledging the complex nature of patient care.

International, consensus-based, indications and treatment options for knee arthroplasty in acute fractures around the knee: a Delphi study

Stefano Marco Paolo Rossi[1], Luca Andriollo[1-2], Rudy Sangaletti [1], Alice Montagna[1-3], Francesco Benazzo[1-4]

Accepted on AOTS – on press

European Knee Society

The indications for TKA in acute knee fractures are undoubtful and clear

Delegate Vote: Agree: 34.1%, Disagree: 61%, Abstain: 4.9%

Pre-existing osteoarthritis is not mandatory for the indication of TKA in acute fractures, while age, co-morbidities and type of fracture are

Delegate Vote: Agree: 32.3%, Disagree: 51.6%, Abstain: 16.1%

European Knee Society

A series of established criteria with scores to give indication for TKA (approved algorithm) is needed

Delegate Vote: Agree: 88.24%, Disagree: 8.82%, Abstain: 2.94%

This (complex) surgery must be performed in referral centers with all technical options and specific peri-operative management and post-operative care

Delegate Vote: Agree: 32.35%, Disagree: 50%, Abstain: 17.65%

European Knee Society

TAKE HOME MESSAGES

- Biological environment is crucial to fracture healing
- Need for stable fixation, allowing early mobilization
- Success of treatment is related to the characteristics of the patient (risk of relapse, impaired proprioception and balance) and the bone
- Correct choice of device is crucial. TKA can be an effective alternative to open reduction and external fixation when the latter is unlikely to be reached.
- Primary TKA works better than revision TKA after failed fixation.