AI prediction modelling

Aim

The project aims to develop an AI prediction model to use as a clinical decision model for determining patient specific risk factors for knee arthroplasty survival and complications based on patient demographics, lifestyle factors, radiographic evaluation, bone biomarkers, bone mineral density and radiostereometry measures. The perspective is individualized patient selection and optimization before, during and after surgery to lessen complications, increase patient satisfaction and knee arthroplasty survival, and reduce an expensive revision burden for the health care system.

Background

Total Knee Arthroplasty (TKA) is a successful and effective treatment of knee osteoarthritis (OA), which is one of the most common degenerative joint diseases. Approximately 11.000 TKA are inserted per year in Denmark, 20% are unsatisfied with the result and 5-10% are revised within 10 years. It is expected that the number of TKA will increase due to an aging population with a desire to maintain an active lifestyle, increasing body weight and a demand for TKA in younger patients with secondary OA due to previous knee injuries. Revision surgery has greater risk of complications compared to primary TKA and are more expensive. The most common reason for revision is aseptic loosening, which occurs several years after the primary surgery, and currently there is limited knowledge concerning risk factors of late loosening and National Knee Arthroplasty databases do not contain the optimal information to study such risk factors. Knowledge of risk factors could improve implant survival by optimizing the individual patient treatment pre-, peri- and postoperatively.

Small movements of an implant (migration) within the first 2 years after surgery have been shown to predict the long-term survival of an implant. The early implant migration can be measured by Radiostereometry Analysis (RSA) and is a precise and validated method for the analysis (3D movement of the implant in relation to the bone). Hence, RSA is a proxy measure for long-term implant survival. Risk factors for implant migration can be investigated using RSA as a surrogacy marker for implant survival (true outcome).

Design and methods

Prospective longitudinal cohort study investigating predictors of tibial component migration in 1500 patients from the AutoRSA database with 2 years follow-up. All patients operated at AUH with TKA (cemented or cementless) between April 2014 and July 2018 are included in the study. Patients were examined preoperatively with questionnaires, blood samples, knee radiographs and DXA of the hips and lumbar spine. Blood samples included BTMs (CTx and P1NP) and markers of bone metabolism. During surgery tantalum beads were inserted in the periprosthetic tibial bone to monitor tibial component migration by RSA. Postoperatively, baseline RSA was performed, and at 1- and 2-years follow-up questionnaires and RSA were obtained. The data from this database will be used to build and train the risk prediction models.

The anonymized dataset (excel file) includes data from 450 patients. The data consists of preoperative data (potential risk factors) and postoperative migration data (true outcome measure).

Preoperative data (potential risk factors)

Variables	Variable name in dataset		Type of data in dataset
Anonymous number, 1-450	Number		
Sex	Sex		Male = 1, female = 0
Age (years)	Age		Continuous
T-score	Tscore	(Compares bone mass to a healthy young adult)	Continuous
Height (cm)	Height		Continuous
Weight (kg)	Weight		Continuous
BMI (g/cm^2)	BMI		Continuous
Implant fixation type (cemented/uncemented)	Cem_ucem		1 = cemented 0= uncemented
Implant type (total knee (TKA) /unilateral knee (UKA))	TKA		1 = TKA, 0 = UKA
Side (Left knee, right knee)			Right = 0 Left = 1
Blood samples • CTx • P1NP • BASP • PTH • Vit-D • Calcium-ion • Creatinine • eGFR		CTx: Bone resorption marker P1NP: Bone formation marker Bone metabolism markers (PTH, BASP, Vit-D, calcium-ion, creatinine, eGFR)	Continuous
Knee Function score (Oxford Knee Score)	oks_total	Score between 0-48, 48 being the best/no symptoms	Continuous (0-48)
Knee Function score (VAS active)	VAS_active	Pain in knee when active, Visual scale (0 = no pain, 100 = worst thinkable pain)	Continuous (0-100)
Exercise	Exercise	Daily exercise	1 = yes, 0 = no
Former smoker	Former_smoker		1 = yes, 0 = no
Current smoker	Smoker		1 = yes, 0 = no
Former alcohol abuse	Former_alcoholabuse		1 = yes, 0 = no

Postoperative data (true outcome measure)

Implant migration is measured in a 3D coordinate system with translation (mm) and rotation (degrees) along the x-, y- and z-axis. Clinical thresholds for acceptable migration of tibial implants in the first 2 years postoperative has been established on combined group measures of early migration and later failure.

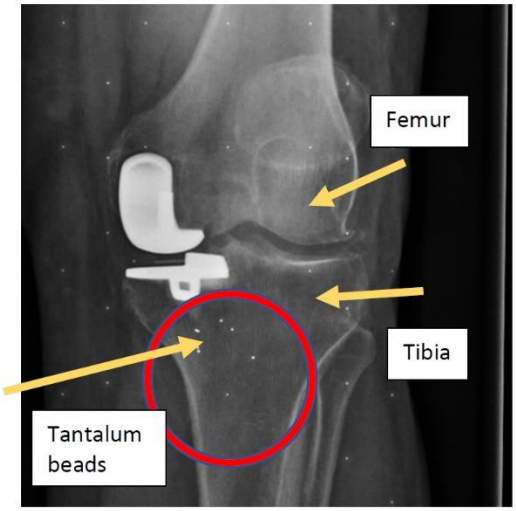
In the dataset continuous migration (migration > 0.2 mm between 1 and 2 years) is used as the true outcome as a proxy measure for later implant failure.

True outcome measures	Name in dataset		Description	Type of data in dataset
Continuous migration	MIG_group	Migration (mm) between 1- and 2-years follow-up	Cut of value of 0.2 mm: >0.2 mm = risk of later failure <0.2 mm = no risk of later failure	Reported as a dichotomous variable 1=yes 0= no

Supplementary data

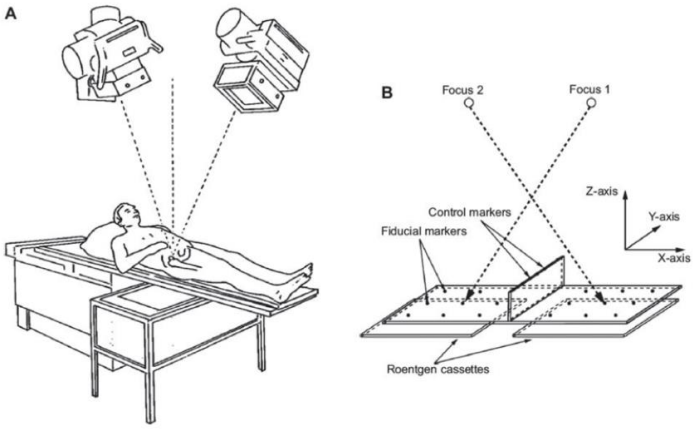
Radiostereometry Analysis (RSA) is a precise and accurate tool for the assessment of 3D migration (mm) of joint implants with respect to the bone. Early migration can predict long term stability of the implant.

1) During surgery tantalum beads are inserted in the periprosthetic tibial bone.

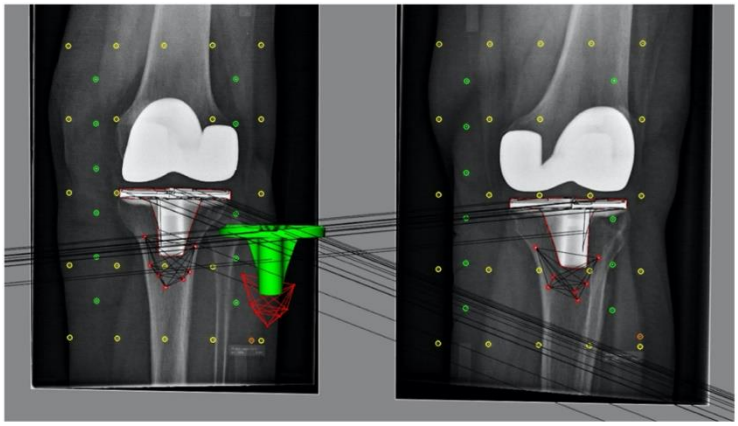


2) RSA are performed by two x-ray canons which obtain two images of the same knee from two different angles (making it a stereo-image). Behind the patient is a calibration box.

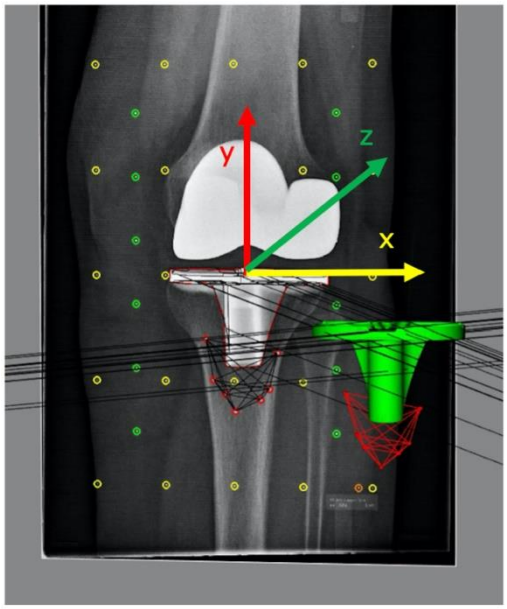
3) RSA was performed postoperatively and at 1- and 2-years follow-up.



4) The analyses are performed in a software program, where the image present the same knee by the two x-rays canons. The green model is a computer implant model fitted to the implant on the x-ray-image. The red figure below the green implant model represents the marker model of the beads in the bone. The green and red models are thus a 3D model of the exact location of the implant in the bone. By comparing images postoperatively with 1- and 2-years follow-up it can be calculated if the implant has moved (migrated) in relation to the markers in the bone, which should not move.



5) The movement of the implant (migration) are measured in translation in x, y and z direction in millimeter (mm), or rotation in the same axes. Furthermore, summary measures of migration were given as total translation (TT), total rotation (TR) (Ö(x2+y2+z2)) and MTPM which refers to the point that migrates the most.



6) Implants will migrate in the early period after surgery as they settle to the bone, which is normal, however migration after 3-6 months represents a risk of later loosening and thus failure of the implant. Clinical thresholds for acceptable migration of tibial components in the first 2 years postoperative has been established. Implant migration above 0.2 mm between 1- and 2-years follow-up are established to be a continuous migration and are at risk of later loosening.