CT Based Migration Analysis is as precise as Radiostereometric Analysis in Total Knee Arthroplasty – a Phantom Study on a Porcine Cadaver and Clinical Results

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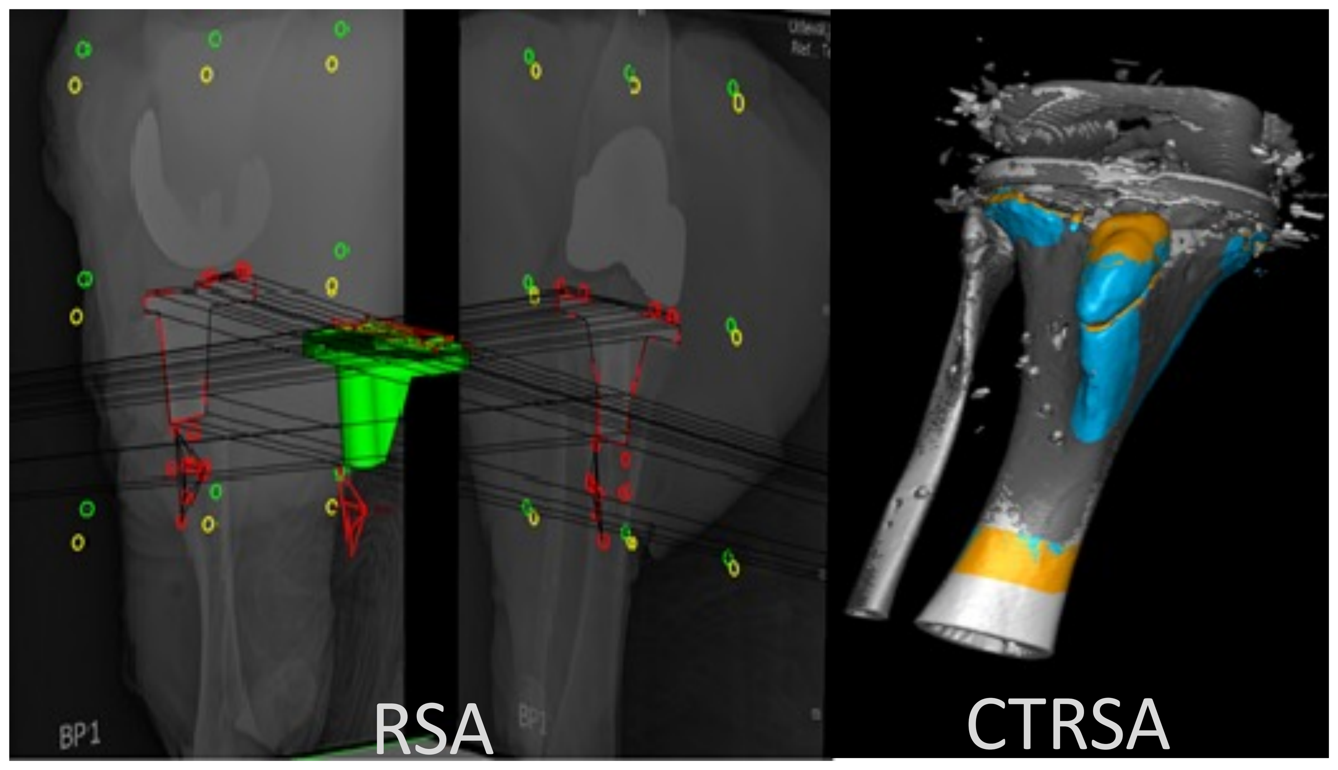
No conflicts of interest

Introduction

Radiostereometric analysis (RSA) is the gold standard for **in vivo migration analysis** but is rarely used in the clinical setting as it is expensive, invasive and resource intensive. Methods based on computed tomography (CT) have shown comparable results in shoulder and hip arthroplasty (1-3). Therefore, **the aim of the study was to validate the precision** of computed tomography-based migration analysis **(CTRSA)** compared to radiostereometric analysis **(RSA)** for migration analysis in total knee arthroplasty **(TKA),** both in a **phantom** and in a **clinical** setting.



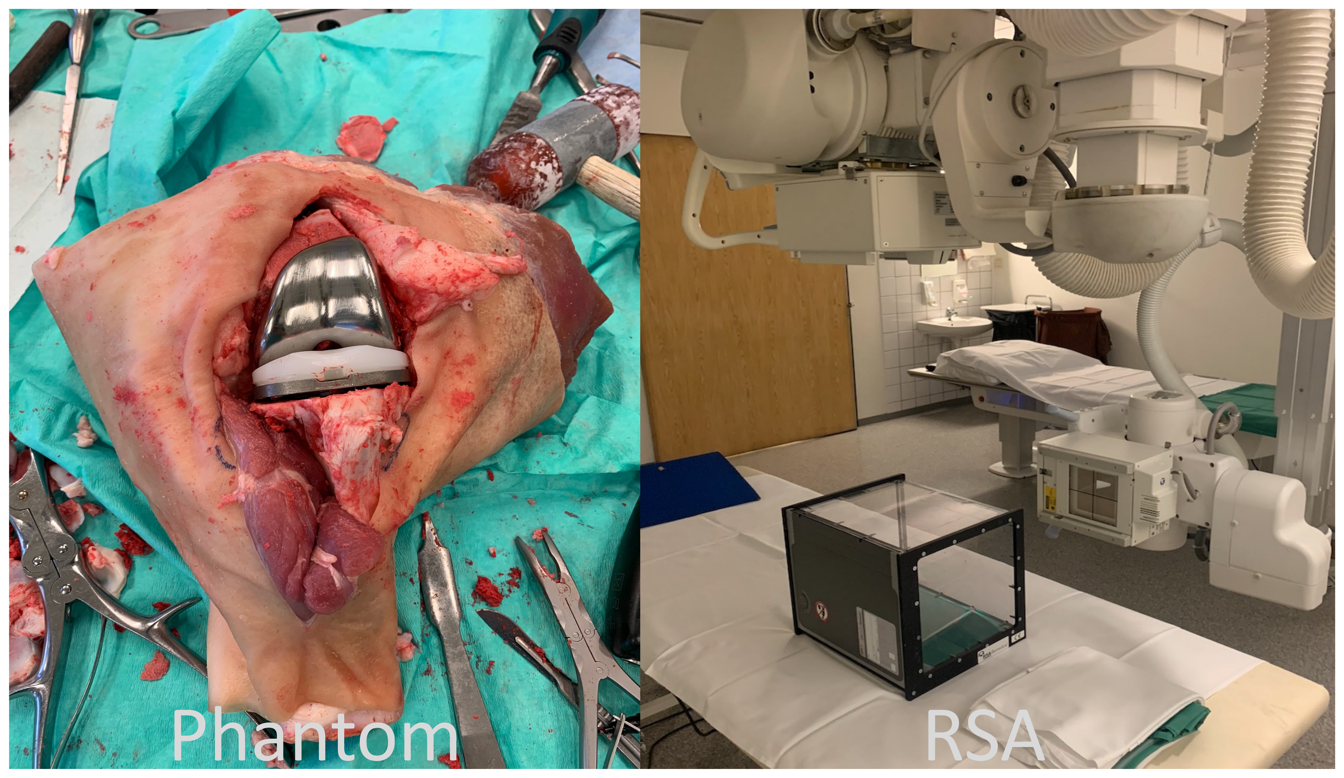
Methods and Materials

For RSA analyses, precision analyses were performed through 21 double examinations for Model-based RSA and Marker-based RSA (MBRSA) in both phantom and clinical patients.

For CTRSA analyses, precision analyses in the phantom study were performed through 21 double examinations with two different CT vendors (GE and Siemens), and 30 double examinations with a CT scanner from Siemens in clinical patients.

All images were analyzed using the commercially available RSAcore® software and CT-based Micromotion analysis software (CTMA®, Sectra AB).

Precision of zero motion is reported as mean ± 95% CI (±1.96*SD). A parametric two-sample variance-comparison test was used to compare differences in standard deviations between groups. A p-value below 0.05 was considered significant. Intra- and interrater agreement were calculated using intra-class correlation.

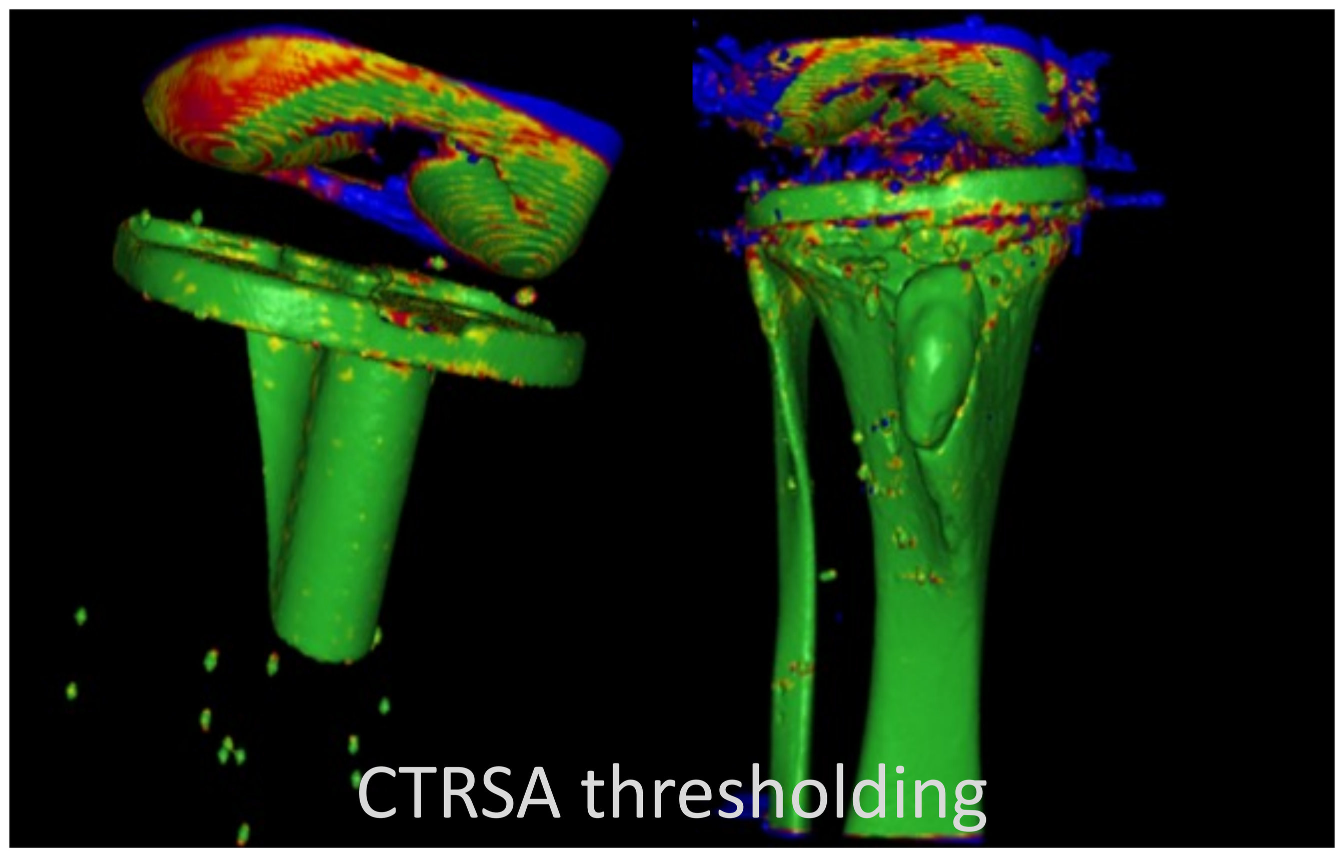


Results

For the phantom study, precision data (95% CI) for maximum total point motion (MTPM) using Marker-based RSA was 0.19-0.70 and 0.20-0.96 using Model-based RSA. Precision data for the point with the highest total translation (TT) for CTMA® using the GE scanner was 0.03-0.12 and 0.04-0.19 for Siemens. There was no difference between Marker-based RSA and MBRSA (p=0.07); but CTMA® from both vendors was more precise than both RSA methods (p<0.001); and CTMA® from the GE scanner was more precise than Siemens (p=0.03). The same pattern was seen for other migrations. Mean effective radiation doses for double exams were 0.01 mSv (RSA) and 0.016 mSv (CT). Intra- and interrater reliability for CT exams were 0.79 and 0.77, respectively.

In the clinical setting, precision data (95% CI) for MTPM using Marker-based RSA was 0.16-0.60 and 0.08-0.63 using MBRSA. Precision data for TT was 0.02-0.42 for CTMA®. There was no difference between the precision for RSA methods, or between RSA and CTMA®.

For translations, CTMA® was more precise than both RSA methods. Mean **effective radiation doses** for double examinations were 0.03 mSv (RSA) and 0.14 mSv (CT). **Intrarater reliability** for CT exams was 0.93.



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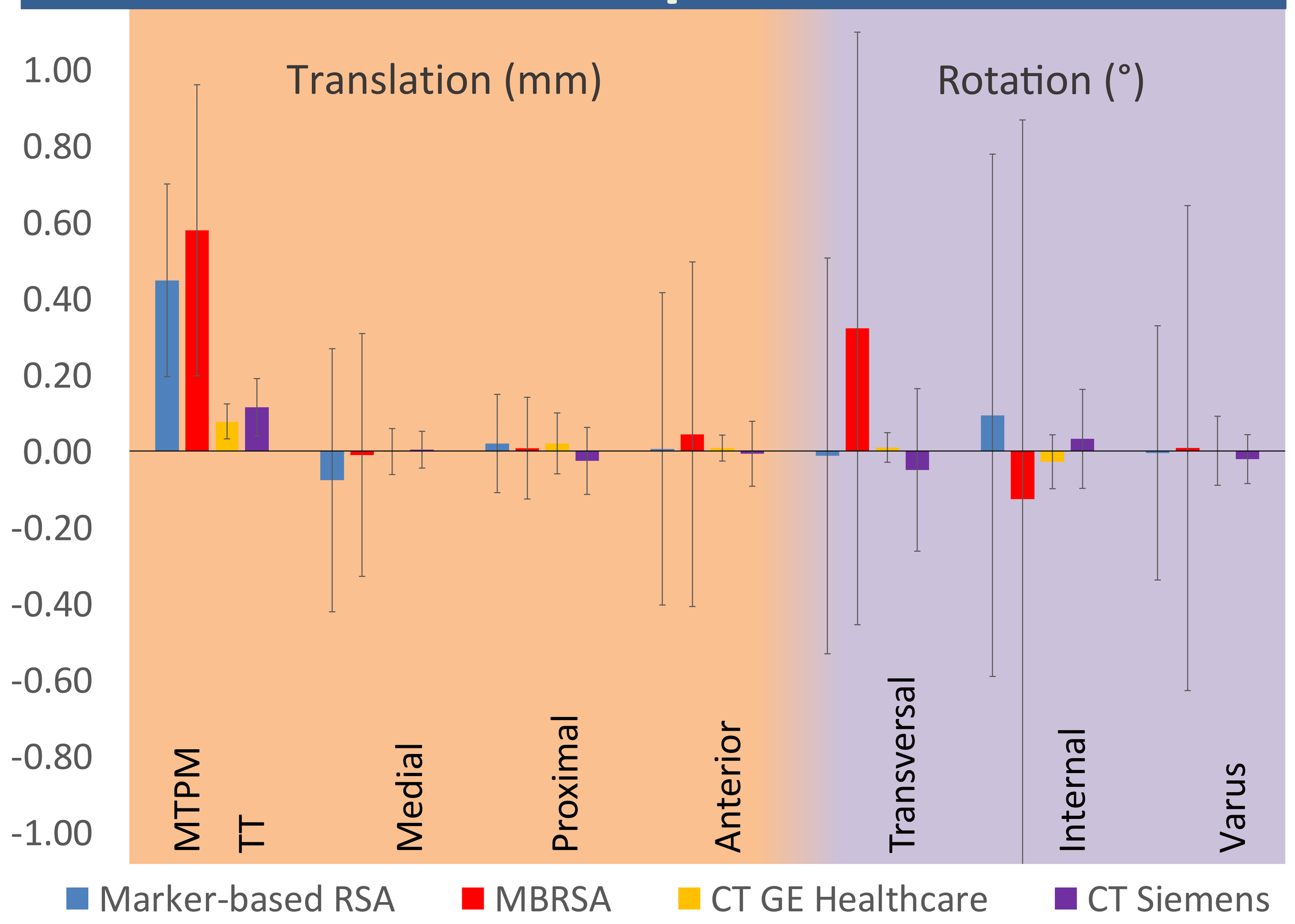
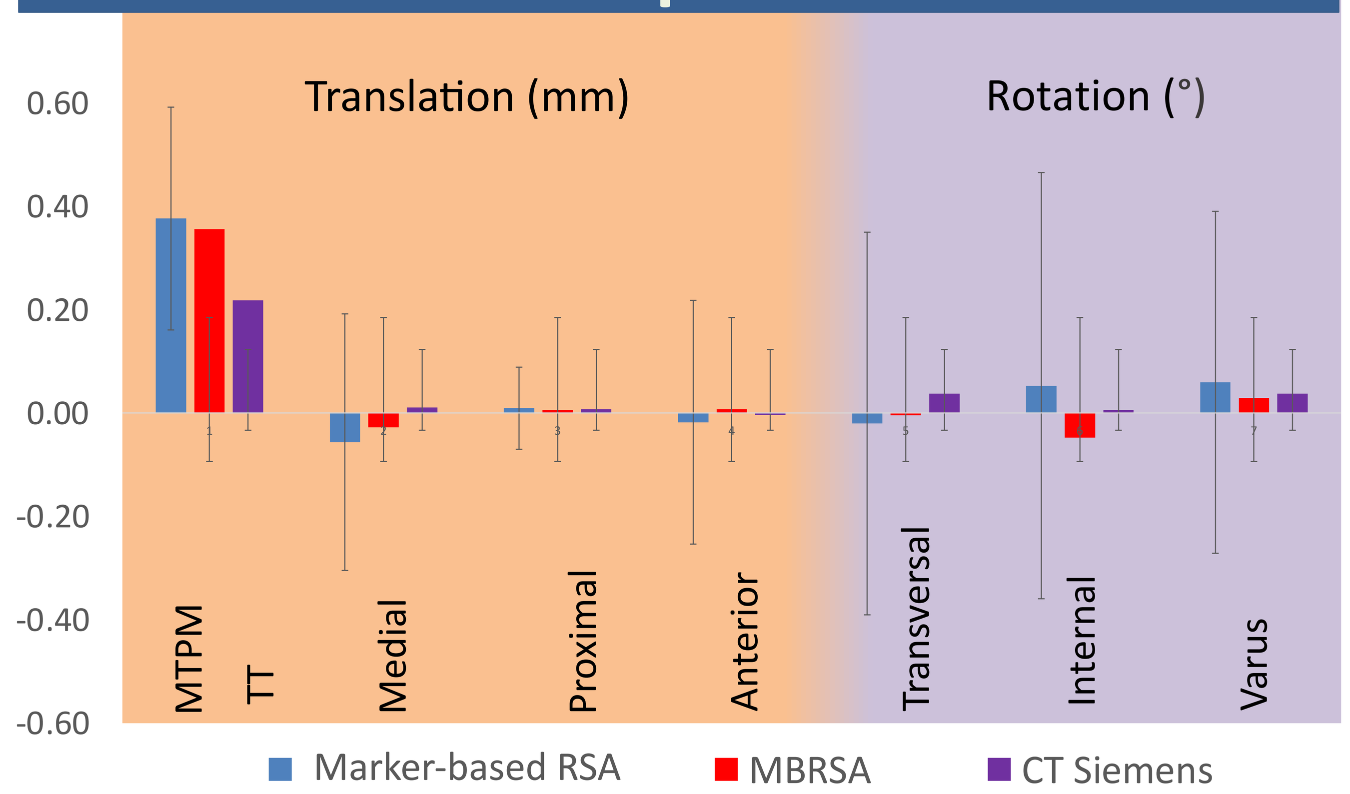
Phantom precision



Clinical precision



Discussion

For the phantom, CTMA® was more precise than RSA in TKA analysis for zero motion (precision) and had overall good intra- and interrater reliability. Accuracy measurements of real migrations are still recommended to ensure full validation.

In the clinical setting, CTMA® was equally precise or better than RSA in TKA analysis for zero motion (precision) and had an overall excellent reliability.

Effective doses for CT were 16x higher than for RSA in the phantom, but in the clinical setting only 4.6x higher, as RSA often required repeated examinations due to poor quality radiographs.

The high precision and ease of use of CTRSA can potentially lead to clinical use of this technology for diagnostics of loose implants.

Conclusions

The study shows **that CTRSA can be used in migration analysis of TKA** with high precision and with good-excellent reliability. This might **revolutionize** implant validation as CT is readily available, specialized equipment is not necessary and CTRSA is non-invasive.

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