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Opinion

Predictive Models for Surgical Approach Selection in Total Hip Arthroplasty

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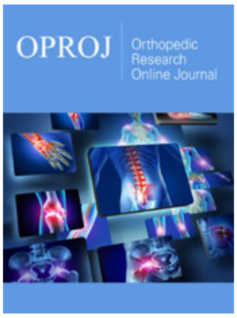

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Opinion

Total Hip Arthroplasty (THA) can be performed through several approaches, each with distinct soft-tissue impact, complication profile, and early functional trajectory. An important emerging question is whether simple clinical parameters, combined with Artificial Intelligence (AI), could help predict the most appropriate approach for specific patient subgroups, such as those with spinopelvic imbalance, sacroiliac joint dysfunction, lumbar spondylosis, or muscular shortening patterns [1-4].

Over the past years there has been rapid growth in the application of AI and Machine Learning (ML) to hip and knee arthroplasty. Recent reviews report dozens of models developed to predict outcomes, complications, readmission, or perioperative pathway allocation [1,2]. Most of these models use demographic data, comorbidities, imaging, and patient-reported outcome measures to forecast pain, function, transfusion, or length of stay, rather than to directly recommend a surgical approach [1-3,5]. Nevertheless, the same predictor variables that drive these models are highly relevant to approach selection and could be repurposed into a decision-support tool.

A key step toward such a tool is the quantification of patient-specific technical difficulty. A retrospective analysis of 960 Direct Anterior Approach (DAA) procedures showed that body mass index, a narrow anterior access corridor (DAA plane), older age, and a prominent abdominal fat flap significantly prolonged operative time and increased technical complexity [6]. In multivariable modelling, these variables explained a meaningful proportion of variation in operative time [6]. This suggests that relatively simple preoperative measurements weight, soft-tissue distribution, pelvic femoral morphology could be combined into a risk score indicating when DAA is likely to be straightforward versus when a posterior or lateral approach might be safer.

For patients with spinal or sacroiliac pathology, the hip spine concept currently provides the most structured quasi-algorithmic framework [4,5]. Spinopelvic classification systems that incorporate lumbar stiffness and sagittal balance identify patients at higher risk of instability and guide individualized cup anteversion and inclination targets [4,5,7]. These systems show that a substantial proportion of THA candidates have "unfavourable" spinopelvic mechanics that may require deviation from standard component positioning [4,5]. In flat-back or stiff-spine phenotypes, higher cup anteversion is often recommended to maintain functional stability; here a DAA with precise control of cup orientation may be advantageous [4,7]. Conversely, in ankylosing spondylitis with rigid hips, modified lateral approaches have demonstrated good functional and radiographic outcomes while allowing safer exposure and correction of deformity [8].

Although these hip spine frameworks are not yet implemented as AI tools, they already define measurable clinical and radiographic variables that an ML system could use standing and sitting sacral slope, pelvic tilt, lumbar lordosis, hip flexion contracture, and simple functional tests [4,5,7]. An AI model could, in principle, integrate these measures with patient factors such as age, BMI, and comorbidities to generate individualized risk–benefit profiles for each approach. For example, a patient with high BMI, narrow DAA plane, large abdominal pannus, and stiff lumbar spine might be flagged as “high technical risk” for DAA but suitable for a posterior approach with spinopelvic-adjusted cup orientation [4,6,7].

Large-scale AI initiatives are now being developed for arthroplasty care pathways. The ARCHERY project was designed to build prediction models using routine clinical data to support decisions along the hip and knee arthroplasty pathway, including patient selection and perioperative planning [9]. In parallel, “second-opinion” ML systems have shown high accuracy when assigning patients to fast-track versus standard pathways using only baseline patient-reported outcome measures and basic clinical data [10]. These studies demonstrate that ML can safely support complex, multifactorial decisions in arthroplasty without replacing the surgeon’s judgement. Extending such models to include radiographic spinopelvic metrics, simple range-of-motion tests, and basic strength assessment (for example, hip flexor or abductor shortening on clinical examination) is a logical next step toward approach-specific recommendations [3-7,9,10].

At present, therefore, there is no validated AI model in routine clinical use that recommends the “best” THA approach for an individual patient. However, the building blocks already exist robust hip spine classifications, quantifiable predictors of DAA difficulty, and pathway-prediction models that operate reliably on routine clinical data [1]. Combining these elements into a transparent, examination-based decision-support tool could help surgeons select approaches more systematically for patients with complex spinopelvic or axial pathology, while preserving the primacy of surgical expertise and patient preference.

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