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# Preoperative infection risk assessment in hip arthroplasty a matched-pair study of the reliability of 3 validated risk scales

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**Peri-prosthetic infection (PJI) represents one of the most devastating complications of total hip arthroplasty (THA). The aim of this study is to assess the reliability of different PJI risk assessment scales between two matched pairs of THA groups. This study included 37 patients with PJI following THA performed between 2012 and 2020 (Group A). Each patient in this group was matched, based on sex, age, and follow-up duration, with a control patient who underwent the same surgical procedure without any septic complications (Group B) during the same period. Each patient's assessment included the American Society of Anesthesiologists (ASA) score and a retrospective evaluation using three different preoperative, specific PJI risk assessment scales: the International Consensus Meeting (ICM) Preoperative Risk Calculator for PJI, the Mayo PJI Risk Score, and the KLIC-score. The two groups were statistically compared using descriptive analyses, both for binomial data and numerical variables. Statistically significant higher values were observed in the preoperative ASA score and surgical time in Group A. Statistically different higher scores were determined only with the ICM risk calculator score in Group A. No significant differences were found using the KLIC score and Mayo score between the two groups. We emphasize the reliability of the ASA score as a nonspecific preoperative assessment scale for PJI. The ICM risk calculator was confirmed as a reliable, specific preoperative assessment scale for PJI, suggesting its routine adoption in THA clinical practice.**

**Keywords:** Peri-prosthetic infection, total hip arthroplasty, infection, risk assessment, scales.

## INTRODUCTION

Total Hip Arthroplasty (THA) is one of the most successful orthopedic procedures, with a progressively increasing number of cases worldwide. However, this surgical procedure is not without risks, and peri-prosthetic joint infection (PJI) remains one of the most devastating complications, significantly impacting the healthcare system[1-3]. Studies in the literature have pointed out that, considering all joint arthroplasty procedures performed in the USA, additional costs are expected to exceed $1.6 billion annually for septic revisions, with projections of even higher costs in the coming years[4]. The literature reports a 24-fold increase in costs in cases of arthroplasty with PJI compared to primary uncomplicated arthroplasty[4,5]. Various studies have highlighted the poor clinical outcomes associated with a potential high mortality risk following multiple septic revisions, with a high rate of infection recurrence[6,7]. Prevention should be considered the first step in addressing this significant challenge, and surgeons should carefully select patients before any joint reconstruction procedures to identify potential risks of PJI occurrence[4-7].

In recent decades, the ASA (American Society of Anesthesiologists) Physical Status Classification System has commonly been used to assess a patient's pre-anesthesia medical comorbidities and, consequently, to assess the general complications risk in surgical procedures, without specifically addressing the risk of septic complications in orthopedic procedures[8,9]. Over the last 30 years, many studies have specifically highlighted significant correlations between a patient's pre-operative pathological conditions and the occurrence of post-surgical infections, suggesting the need for appropriate scoring systems to precisely assess this risk. More recently, several pre-operative risk assessment scales, specifically designed to address PJI occurrence, have been proposed, but there is no general consensus on the most reliable one[10-16]. At the time of this study, only three of these scales had been internationally validated: the more recent International

Consensus Meeting (ICM) Risk Calculator[17], the Mayo Risk Score[18,19], and the Kidney, Liver, index and C protein (KLIC) score[20-22]. The first two scales were developed and validated to assess the risk of PJI occurrence following primary and revision arthroplasty procedures, while the KLIC score was proposed to assess, even more specifically, the risk of failure due to infection recurrence following an early debridement and implant retention procedure (DAIR) in PJI, with further indications for native joint septic arthritis.

The aim of this study is to assess and compare the reliability of both the ASA score and these three specific PJI risk assessment validated scales by retrospectively evaluating two matched-paired groups selected from all primary hip arthroplasties performed in a single general multi-specialist hospital by a single orthopedic team between January 2012 and December 2019.

## MATERIALS AND METHODS

Between 2012 and 2020, 1,175 primary THA were performed in our orthopedic department. During this period, all consequent periprosthetic infections among these implants were identified. Patients were selected using the ICD codes corresponding to hip PJI, and we included only patients in which the PJI diagnosis was based on the latest International Philadelphia Consensus diagnostic criteria[17]. Any further patients treated for hip PJI who were not implanted in our hospital or had PJI following hip revision procedures or partial hip replacement were excluded from the study. We identified 37 patients treated for PJI following a primary hip procedure in our institution, and 1 additional patient was later excluded from the study due to incomplete documentation, leaving 36 patients eligible for the study (Group A).

Each patient in Group A was consequently matched with one patient who underwent the same surgical reconstructive procedure in our orthopedic department without any septic complications (Group B). The matching criteria were sex, age (+/- 3 years), follow-up from the index replacement (+ 1 year), and the joint involved at the index replacement. The complete documentation of patients in both groups was reviewed, collecting all the required data according to three selected scales: ICM Preoperative Risk Calculator for PJI, Mayo PJI Risk Score, and KLIC score.

The ICM Risk Calculator for PJI includes 17 items with different values, generating single risk points that, when summed together, give a cumulative numerical risk value (ranging from 0 to 160), with a higher score indicating a higher risk of PJI. The original study for the development and evaluation of this calculator even provides a conversion table expressing a corresponding estimated lifetime rate of developing PJI[18]. Using the dedicated conversion scale provided by the ICM Risk calculator score, we also calculated and compared the estimated "lifetime" risk rate of developing PJI for each patient between the two groups, considering four ranges: a risk below 1%, a risk between 1% and 2%, a risk between 3% and 4%, and a risk equal to or above 5%.

The Mayo PJI Risk Score considers 10 preoperative items with different scores to be summed together, achieving a cumulative numerical risk value ranging from -5 to 18[19]. This score does not provide a dedicated conversion table, and the overall score could be related to the possibility of developing PJI only using a regression model plotted by a baseline graph and repeated one month later.

The KLIC score considers 5 preoperative items, each with a specific value to achieve a cumulative numerical risk value (0-9.5)[20]. The corresponding validation studies showed a direct correlation between every added point to the final score and a 1.32 times higher risk of DAIR surgical procedure failure in PJI[21,22].

Results obtained from the clinical records of all patients in both groups were first analyzed using descriptive statistical analyses for both binary data (presence or absence of a single item) and numerical variables. For the statistical analysis, we utilized the R statistical software, version CRAN 4.0.3 (© The R Foundation for Statistical Computing, c/o Institute for Statistics and Mathematics, Wirtschaftsuniversität, Wien, Welthandelsplatz 1, 1020 Vienna, Austria, https://www.r-project.org/). Descriptive statistics for the analysis of baseline items were performed with a Student t-test for the comparison of continuous variables, Fisher's test for the comparison of binary data, and the chi-square test for percentage analysis. A significance level of 0.05 was considered for both types of data.

## RESULTS

The two matched THA groups were demographically homogeneous in terms of sex and involved joints (Table I), with no statistically significant differences in age and BMI (Table II). The incidence of PJI ranged from 7.1% in 2012 to 0.6% in 2018, showing a progressive reduction in incidence, with a mean of 3% per year (Fig. 1). A statistically significant difference (P=0.0008) was observed in the preoperative ASA score, indicating a significantly higher presence of more complicated

**Table I.** — Descriptive statistics in numerical variables of the demographic data

| | AGE | | WEIGHT (kg) | | HEIGHT (cm) | | BMI | | ASA SCORE | | SURGICAL TIME (MIN) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group A | Group B | Group A | Group B | Group A | Group B | Group A | Group B | Group A | Group B | Group A | Group B |
| MEAN | 69.72 | 71.61 | 75,30 | 72,89 | 165,10 | 163,36 | 27,6 | 27,16 | 3 | 2,31 | 160 | 96 |
| MEDIAN | 73,00 | 75,00 | 73,50 | 69,50 | 165,50 | 165,00 | 27,80 | 26,80 | 3 | 2 | 105 | 88 |
| SD | 12,64 | 13,35 | 13,70 | 17,21 | 8,70 | 9,51 | 4,60 | 5,57 | 1 | 0,62 | 110 | 44 |
| MIN | 40,00 | 44,00 | 49,00 | 47,00 | 150,00 | 145,00 | 17,20 | 18,60 | 2 | 1 | 55 | 45 |
| MAX | 91,00 | 96,00 | 100,0 | 123,00 | 185,00 | 183,00 | 37,10 | 40,10 | 4 | 4 | 480 | 230 |
| P value (Student T test) | 0.5394 | | 0.5131 | | 0.4873 | | 0.7159 | | 0.0008 | | 0.0018 | |

**Table II.** — Statistical analysis results between Group A and B

| Risk scores | Mean | Standard deviation | P-value |
|---|---|---|---|
| ICM | 91,623 | 45,819 | 0,0012 |
| MAYO-score | 1,166 | 4,081 | 0,2301 |
| KLIC-score | 2,430 | 2,240 | 0,4340 |

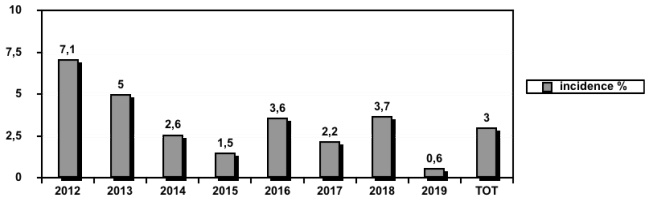


*Figure 1. — Rate of PJI incidence for year of the study.*

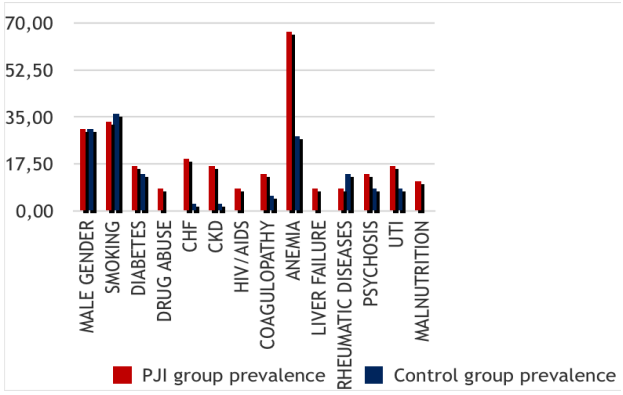


*Figure 2. — Distribution of risk factors' prevalence.*

patients in the group that developed PJI. Similarly, in group A, we demonstrated a statistically significant longer surgical time (P=0.0018), highlighting both a higher ASA score and longer surgical time as highly reliable tools for predicting the overall risk of patient poorer health conditions and the development of post-surgical complications in primary THA (Table 1).

The distribution of all the risk factors for each risk assessment scale is represented in Fig. 2. We observed

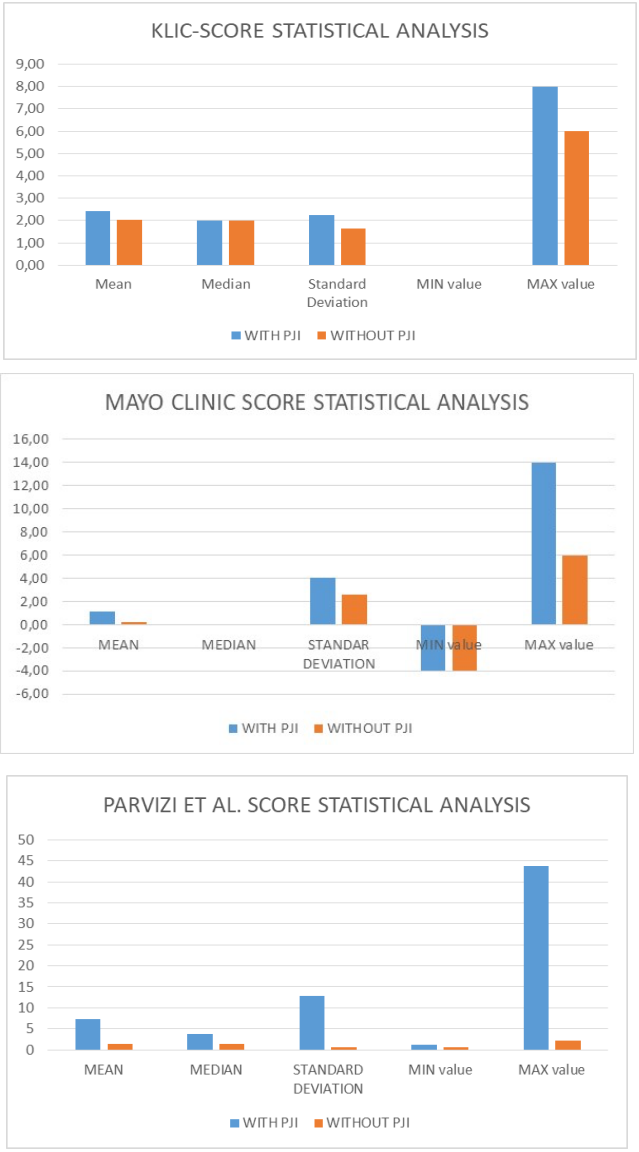


*Figure 3. — Statistical results in risk evaluation scales.*

that the most represented risk factors in Group A (patients who developed postoperative PJI) were anemia (24 patients, with a prevalence of 66.67%), followed by smoking (12, 33.33%), and congestive

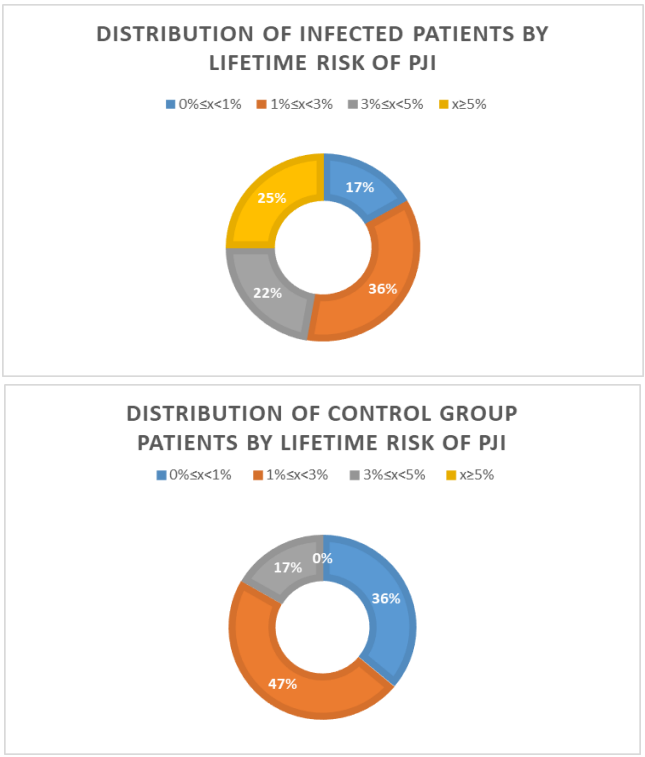


*Figure 4. — Lifetime PJI infection risk in group A and B.*

heart failure (7 patients, 19.44%). In the matched group that did not develop any PJI infection, the most frequently reported risk factors were smoking (13 patients, 36.11%), followed by anemia (10, 27.78%), diabetes mellitus, and rheumatologic diseases (5 each, 13.89%).

We analyzed the numerical risk scores provided by each of the three scales for both groups using Student's T-test, identifying statistically significantly higher scores in Group A compared to Group B only using the ICM risk-calculator score (P=0.0012). No significant differences between the two groups were found using the KLIC-score and Mayo score (respectively, P=0.4043 and P=0.2301) (Fig. 3 and Table 2).

Using the tool proposed by the ICM scale, the numerical values were converted into the percentage "life-time" risk of developing PJI (Fig. 4). In Group A, we observed that 17% of the patients had a "life-time" risk of PJI occurrence lower than 1%, 36% had a risk between 1% and 2%, 22% had a risk between 3% and 4%, and 25% had a risk equal to or higher than 5%. In Group B, we noted that 36% of the patients had a "life-time" risk of PJI occurrence lower than 1%, 47% had a risk between 1% and 2%, 17% had a risk between 3% and 4%, and no patient had a risk higher than 5% for PJI occurrence "life-time." Analyzing the converted values more precisely, in Group A, 47% of the patients showed a "life-time" risk of PJI occurrence higher than 3%, while in Group B, a "life-time" risk of PJI higher than 3% was present in only 22%, showing a statistically significant difference (P=0.04).

## DISCUSSION

Based on our study findings, we noticed a notable decrease in PJI occurrence among patients primarily treated with THA at our hospital, even though the literature predicted a year-by-year increase. This risk reduction seems to be linked to a gradual reduction in surgical times and an enhancement in the surgical techniques employed. Likewise, in accordance with the literature, both higher ASA scores and longer surgical times significantly increased the risk of septic complications in our patients undergoing hip arthroplasties[23-25].

Regarding the three validated scales used in this study, only the ICM score, which considers the highest number of preoperative items, showed a statistically significant difference between the two groups, with a significantly higher pre-operative risk of PJI in the group developing a postoperative septic complication. Furthermore, it provides a conversion table that expresses a corresponding estimated lifetime rate of developing PJI. However, this score, despite being confirmed as a valid tool in assessing the risk of PJI occurrence, does not provide either a clear cut-off or a well-defined "threshold value" to define a "high-risk patient," leaving the interpretation of risk rate results to the clinician. In our PJI group, we registered 47% of patients with a lifetime risk higher than 3% (25% higher than 5%), while only 22% in group B (no patient higher than 5%), showing a significant statistical difference. According to our opinion, this evidence could suggest a practical application of a lifetime risk of 3% as an arbitrary threshold for defining a "high-risk patient" for developing PJI and consequently considering a dedicated preoperative protocol, ranging from more aggressive antibiotic prophylaxis to discouraging surgical procedures. Furthermore, clear threshold identification for high-risk patients, in our opinion, should be advocated to treat these high-risk patients in a multi-specialistic environment with a higher capacity to prevent PJI.

In this study, the Mayo Clinic risk score, although validated in the literature[17], was not able to lead to statistically significant results between the two groups. A further critical issue linked to this risk scale is the impossibility of precisely calculating the percentage of risk related to a given score: although the original article

indicates two growth curves of the risk of infection as the score increases, it does not indicate whether the risk is either annual or lifetime[17].

Even the KLIC-score was not able to provide statistically significant results between the two groups. Specifically addressed and validated to assess the risk of failure following DAIR procedures in joint arthroplasties, we could not confirm its extensibility to a cohort of primary hip arthroplasty as a general PJI risk calculator[21,22].

However, these two scores, despite no evidence of statistically significant differences between the two groups, showed interestingly similar high numeric overall final values in groups A and B, suggesting a similar high preoperative risk in both. A possible explanation for this symmetrical high infection risk could be the general clinical complexity of patients routinely managed in our department in a hospital equipped with several departments (e.g., departments of infectious disease, rheumatology, and oncology) referring complex patients in need of primary hip arthroplasty.

To date, we have not found any similar studies in the literature comparing the efficacy of the three different validated scores assessing the preoperative risk of septic complications in joint arthroplasties. Obviously, this study presents some biases. It was a retrospective study with a relatively small sample size. However, we adopted strict inclusion criteria, considering only primary hip arthroplasties totally managed in a single center by a single surgical team, matching every single patient to a similar one always treated in our department. The groups were homogeneous, and the adopted PJI risk assessment score highlighted the high complexity of our patients in terms of preoperative co-morbidities.

## CONCLUSION

According to our results, the validity of the preoperative ICM risk calculator is confirmed statistically, suggesting its safe use within clinical practice. However, it does not provide clear threshold values, and in our experience, we identified a lifetime risk for PJI occurrence of 3% as a potential threshold to identify high-risk patients. Both this score and this threshold should be considered in different environments to create practical guidelines.

Given all of this, it would be beneficial to create clinical algorithms and guidelines for managing specific infection risk in hip and knee arthroplasties. It would be profitable to implement or improve existing scales, or rather create new ones that could combine the advantages.

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