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CASEMIX study: Assessment of patient factors influencing the subprocedure duration of trauma/orthopaedic surgeries

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ABSTRACT

Introduction: The social and financial burdens of the operative environment remains to be a major problem in modern society. We analyse the impact of the introduction and application of a perioperative cloud system that cross-analyzes the pre-/intraoperative risks to minimize surgical time and maximize operation theater efficiency through improved planning.

Methods: TCC-CASEMIX© was introduced to our Department of Trauma Surgery of the University of Szeged to objectively measure intraoperative time durations according to each essential subprocedure. The study is largely divided into pre-operative assessments and intraoperative measurements. Patient data (age, sex, and ethnicity etc.) was registered preoperatively, and the expected time per each essential intraoperative step (skin incision, reduction, fixation etc.) was entered. The steps were then timed intraoperatively by surveyors, and postoperative cross analysis was performed. Our study was divided into two phases; phase 1, the surveying of general trauma / orthopedic cases, and phase two; the examination of high volume surgeries.

Results: Acute cases of Open Reductions and Internal Fixation (ORIF) procedures depended heavily on the presentation of the fracture, and no clear correlations in the risk factors were found. Arthroscopies were a short, high-volume procedure, but there was a large difference between the surgeon's estimates and the operation duration. In high volume surgeries, although individual factors only slightly influenced surgical duration, patient cohort stratification led to a better understanding of factors that impact surgeries, namely the combination of BMI and surgeon years of experience. While the average (Intraoperative Duration) seemed to increase with BMI, younger surgeons were more influenced by the patients BMI.

Conclusion: A data filtering algorithm-assisted cloud system can be a reliable way to facilitate the planning of operating theater schedules. Patient stratification according to BMI and surgeon years of experience seems to affect intraoperative duration significantly, and the understanding of the risks and intraoperative steps has the potential to forecast surgeries with high precision.

Introduction

"How long will my surgery take?" The best answer a surgeon can currently give is from a historical mean average for that particular procedure, considering how long surgery took for all patients, regardless of disparate diagnostic codes, demographics, surgeon experiences,

Abbreviations: ACL, Anterior Cruciate Ligament; AP, Anterior Posterior; ASA, American Society of Anesthesiologists; BMI, Body Mass Index; CI, Confidence Interval; DM, Diabetes Mellitus; HT, Hypertension; IOD, Intraoperative Duration; IQR, Interquartile Range; JLCA, Joint Line Convergence Angle; JSW, Joint Space Width; KL Classification, Kellgren-Lawrence Classification; LMWH, Low Molecular Weight Heparin; NOAC, New Oral Anticoagulants; OA, Osteoarthritis; PA, Posterior Anterior; SD, Standard Deviation; TAI, Thrombocyte Aggregation Inhibitor; TKA, Total Knee Arthroplasty; THA, Total Hip Arthroplasty.

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comorbidities and other risk factors. With so much diversity in procedure complexity, operation duration becomes inherently variable, and inhibits robust and predictable planning. For example, publications describe an inverse relationship between the experience of the operating surgeon and operation duration [1].

The lack of productivity that follows is a significant barrier to the effectiveness of public healthcare systems in Europe. As surgical service delivery organizations fail to deliver surgery in an efficient and predictable way, therefore increasing surgery volume, millions of people languish on waiting lists. This is found not just in Hungary [2] but the United Kingdom [3], Austria [4] and more. This attracts social burdens that remains a major problem for modern society: without their required surgery, pain continues, functional ability worsens and symptoms progress, even requiring attendance in emergency wards. Patient experience is poor, with repeated cancellations and long waits. The morale of clinicians falls, both being overworked due to late finishing surgeries and the direct impact seen on their patients. Experienced surgeons are left feeling underutilized where lists are underbooked. With the impact of COVID-19, it is estimated to take a typical country nearly one year (45 weeks) to clear their elective surgery backlog even with a 20 % increase in surgical activity over their baseline [5].

Not only this, but operating theaters are cost intensive assets (both in terms of capital cost and operational costs), demanding efficient use. The mean cost of operating room (OR) time is $36 to $37 per minute, according to financial data from California's short-term general and specialty hospitals in the fiscal year of 2014 [6]. The means to improve revenue is improved productivity, which is currently out of reach due to unpredictability.

Our study was divided into two phases; phase 1, the surveying of general trauma / orthopaedic cases, and phase two; further examining high volume surgeries. By examining these two phases we aim to identify the factors determining the intraoperative duration, while stratifying the major patients' characteristics that may affect the intraoperative duration.

If these hurdles do not pose enough challenges, the increases in energy costs and continuing concern for carbon emission have been a relatively new field of interest [7]. Where energy costs have exponentially increased as well, health care providers are keen on decreasing the amount of non-productive energy usage, without compromising quality care [8].

We aimed to evaluate the relationships between patient characteristics and comorbidities, as well as surgeon experience and its relationship to intraoperative subprocedure duration. With a better understanding of these influential factors, our goal is to be able to identify the factors that largely influence surgical duration in certain surgical subprocedures.

Methods

This study has been accepted by the human biological ethical committee of the University of Szeged (1/2022-SZTE RKEB). Data for this monocentric study were prospectively acquired via real-time surveys from September 2020 to October 2022, in which TCC-CASEMIX® was utilized. TCC-CASEMIX® was deployed remotely in September 2020 to a touch screen interface and tablets in five theaters at the Szent-Györgyi Albert Clinic of Traumatology and Orthopaedics from the University of Szeged as a data cleansing and acquisition tool.

Every procedure, sub-procedure and risk factor was recorded according to its SNOMED CT definition and duration measured using TCC-CASEMIX®. This ensured consistency in clinical coding and high data usability. Pearson's correlation tests were performed to evaluate the parametric values, whereas the means and standard deviations were examined in non-parametric values. Data analysis was performed in *MATLAB R2021a*, delivered as part of the TCC-CASEMIX® system. Having captured the relevant data, TCC-CASEMIX® Data Analysis creates profiles of patients according to risk, with statistical methods assessing the impact of different patient demographics on surgery duration. The impact of each profile is described by the change in forecast duration (d) and impact on the variability (σ, or standard deviation) to appreciate the full impact of demographics.

Pre-operative data from 167 patients was acquired between September 2020 and October 2022. Patients were excluded according to our exclusion criteria, a lack of complete preoperative data sets, and failure of measurement. In phase 1, all general trauma and elective trauma/orthopaedic patients were assessed from both sexes and all age groups. We examined general trauma and orthopaedic patients to find correlations between data from pre-operative assessment with intraoperative duration. Preoperative assessments included; age, height, weight, body mass index, and comorbidities. In phase 2 of the study we examined patients who received primary Total Knee Arthroplasties (TKA), focusing on high volume surgeries in depth (Fig. 1). Phase one included patients only with primary knee osteoarthritis. Patients with immunosuppressive backgrounds, post-traumatic osteoarthritis, and those who underwent revision surgery were excluded.

Phase 1: wide spectrum survey of multiple surgeries and data filtration

The data acquisition tool acquired data for the study in two steps: Pre-operative Assessment (POAP) and *peri*/intraoperative measurement in a surgery data acquisition process. In POAP, a 3rd party volunteer captures information about the patient (including age, sex, body mass index, and ethnicity), and enters each child sub-procedure (such as skin incision, reduction, and fixation). Independent clinical surveyors participated in the measurements of the surgeries.

User acceptance testing took place in October 2020 for a trial cohort of surgeries. Patient data such as age, weight, height, Body Mass Index (BMI) and most importantly past histories of disease were double checked through interviews with the patient and from nursing documents, and finally with the help of E-MedSolutions, the native administrative system equipped in the University of Szeged. The presence of DM and use of anticoagulants were additionally recorded through patient interviews and prior discharge papers, with the consent of the patients. This cross referencing allowed us to minimize bias on patient comorbidities during POAP. Throughout the study, patient specific data was not exported to third parties. Surgeon experience was also recorded according to the years after the surgeon completed their specialty training, grouped accordingly.

Phase 2: patient stratification and high volume surgeries

After achieving a general understanding of multiple surgeries, our team decided on surveying a high volume surgery with a relatively homogenous background, utilizing similar techniques with fewer deviations across different surgeons. While the point of interest lies in surgeries such as arthroscopies, Total Hip Arthroplasties (THA), and TKAs, TKAs were chosen because they had minimal differences in approaches and intra operative techniques but still possessed complex steps that led to a large difference in operative time.

We largely grouped the detailed subprocedures into 3 major steps; 1. Skin incision to joint exposure, 2. Prosthetic implantation, 3. Wound Closure in TKA. Detailed subprocedures steps were registered preoperatively. While examining detailed subprocedure steps and its durations, we created macroscopic groups of the detailed subprocedures, facilitating the relationships between cohesive steps of TKA (Fig. 2). Joint Line Congruence Angle (JLCA) and medial and lateral Joint Space Width (JSW) were examined, and patients were categorized according to the Kellgren-Lawrence classification (from Grade 0 to Grade 4).

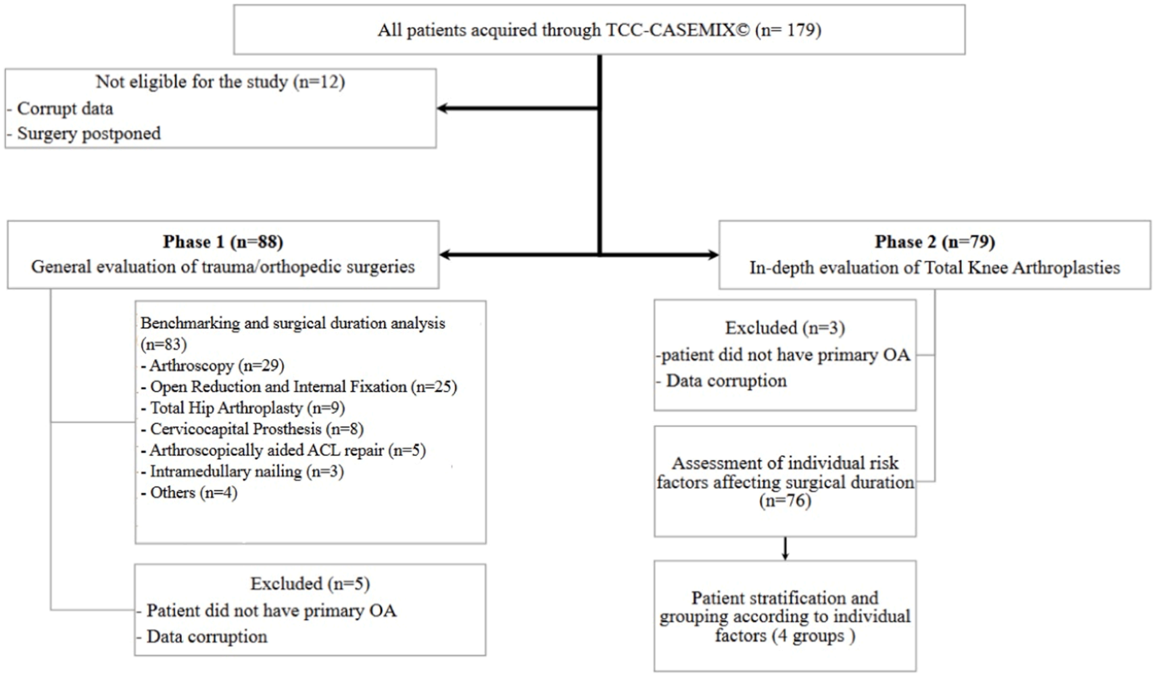

Fig. 1. A flowchart representing the study process acquired via real-time surveys from September 2020 to October 2022, in which TCC-CASEMIX® was utilized.

Results

Phase 1 results: trauma and orthopaedic (General survey)

83 patients were examined in phase 1. Cases are described in the following in Table 1.

Procedure benchmarking

For each procedure in the TCC-CASEMIX® database, a benchmark of elapsed time broken down into productive and non-productive durations is provided. Productive time was defined as the viable time that was measured according to the designated subprocedure. Non-productive time was defined as the time in which time elapsed which had nothing to do with the subprocedure (waiting for implants, equipment malfunction, etc.) In the majority of surgeries, a significant amount of non-productive time was measured (Fig. 2).

For all procedures, 31.1 % of operation duration was non-productive. The procedure with the highest amount of non-productive time was intramedullary nail screw-alignment insert ($n = 3$) with 50.5 % non-productive. The lowest was 23.3 % for open reduction and fixation ($n = 25$). Twenty-two sub-procedures had collected sufficient data to be statistically reliable (threshold: thirty sub-procedures). During the pre-operative assessment, surgeons were asked to estimate the duration of sub-procedures. Generally, sub-procedure durations were overestimated by the operating team (Fig. 3).

Some sub-procedures were highly predictable: for example, the *application of dressing* ($n = 165$) had a standard deviation of 0.79 min, possibly explained by the simple nature of this procedure. Others were far less predictable, for example *fixation of fracture using screws* ($n = 64$) had a standard deviation of 12.14 min, likely as this is a complex procedure whose duration depends on the classification and severity of the fracture (Fig. 3).

Sub-procedure benchmarking was also completed for sub-procedures related to patient preparation. Just as with sub-procedures, the length of patient preparation activities was being overestimated significantly by the team. Each sub-procedure had a degree of variability, ranging from a standard deviation of 2.48 min for the *WHO Surgical Safety Checklist* ($n = 171$) to 1.36 min for *Application of Surgical Drapes* ($n = 174$).

The statistical analysis explored the relationship between surgeon experience and operation duration of *arthroscopy* ($n = 29$), finding a small deviation in elapsed time. For surgeons recorded with 8 - 9 years of experience, arthroscopies took an average of 37.75 min ($n = 4$) while for those with more than ten years of experience, arthroscopies took an average of 35.62 min ($n = 19$). The amount of non-productive time was also affected, at 34.1 % for the 8 - 9 years of experience group and 32.9 % for the 10+ years of experience group (Figure 5).

Risk factor cohorting

Using statistical analysis to correlate risk factors with operation duration, it was possible to create cohorts of comparable patients with similar degrees of procedure complexity and operation duration. Compared to procedure benchmarks, each risk factor cohort sees reduced variability measured by standard deviation. Examples can be seen in arthroscopic procedure data (Table 3).

Phase 2 results: high volume surgery

A total of 79 patients were studied and surveyed into TCC-CASEMIX®. Surgical steps were broken down into detailed subprocedures (Table 2) and also largely grouped into three major steps; skin incision to joint exposure (Exposure Time), prosthetic implantation (Implantation Time), and closure (Skin Closure Time). Total Duration (The time from when a patient arrives at the operation room until the end of the procedure) and Total Viable Time (the sum of each subprocedures). Individual factors were first assessed, followed by patient stratification, allowing us to find a pattern that contributes to better predicting intraoperative duration in Total Knee Arthroplasties.

Individual factors

Comorbidity and non-parametric factor assessment was assessed by evaluating the mean time, standard deviation, and their respective pearson's coefficients in algorithmic tree diagrams. Individual factors had minimal to moderate correlation with all steps of intraoperative durations. The height of patients ranged from 146 cm to 190 cm, with the mean of 165.8 cm and the median of 165 cm. The weight of patients ranged from 47 kg to 126 kg, with the mean of 88.8 kg and the median of

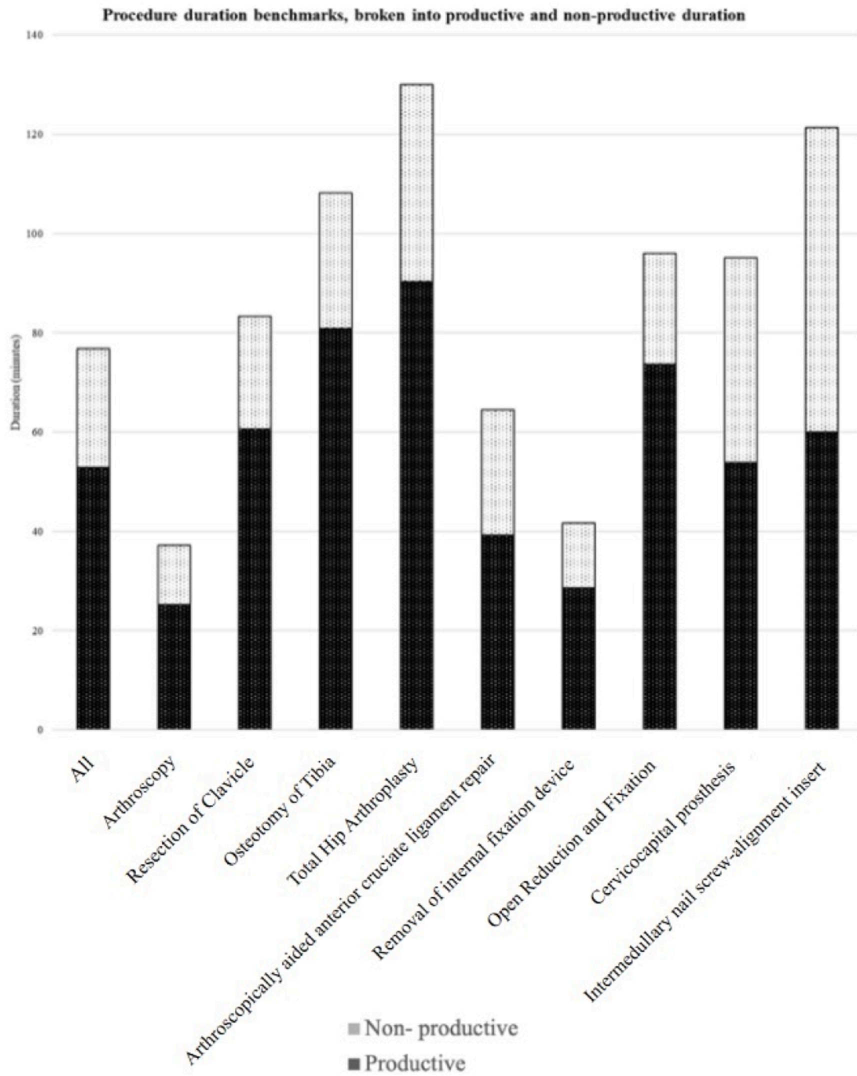

Fig. 2. Procedure benchmarks divided into productive and non-productive time for TCC-CASEMIX® data collected at University Clinic of Traumatology of Szeged.

Table 1
Procedure benchmarks for TCC-CASEMIX® data collected at University Clinic of Traumatology of Szeged. The high SD in ORIF procedures can be seen in contrast to the low SD in high volume procedures such as arthroscopy.

Procedural Intervention	n	Elapsed (min)		Productive (min)		Non- productive(min)	
		Mean	SD	Mean	SD	Mean	SD
All	83	76.77	46.1	52.92	53.28	23.86	19.73
Arthroscopy	29	37.23	12.02	25.29	8.51	11.94	6.99
Open Reduction and Internal Fixation	25	95.98	43.58	73.59	38.93	22.39	10.6
Total Hip Arthroplasty	9	130.07	37.75	90.31	27.94	39.77	17.03
Cervicocapital prosthesis of the hip	8	95.12	43.25	53.9	31.01	41.22	38.61
Arthroscopically aided ACL repair	5	64.47	28.3	39.19	15.56	25.27	14.06
Intermedullary nail screw-alignment insert	3	121.35	43.72	60.04	22.22	61.31	22.24
Removal of internal fixation device	2	41.72	11.68	28.65	14.62	13.07	2.93
Resection of clavicle	1	83.32	–	60.59	–	22.73	–
Osteotomy of tibia	1	108.13	–	80.85	–	27.28	–

88.0 kg. The BMI of patients ranged from 19.6 to 43.9, with the mean BMI of 32.3 and the median of 32.0. The BMI ranges were divided into 5 groups: less than 25 ($n = 9$), 25 to 30 ($n = 12$), 30 to 35 ($n = 31$), 35 to 40 ($n = 18$), and more than 40 ($n = 6$).

TAI had the most prolonged effect on total duration (118 min) and hemorrhage control (6.8 min), while compared to patients taking other anticoagulant therapy. However, according to our pre-operative protocol, all of our elective patients' anticoagulant therapies were converted to subcutaneous injections of Low Molecular Weight Heparin (LMWH) 2 days prior to the surgery; we find this result to be inconclusive.

The presence of hypertension did not significantly prolong IOD. On the contrary, we found that values were slightly smaller in the majority of subprocedures except for Implantation Time, concluding this to be a factor that does not influence IOD. This could be explained by the fact that because patients were taking their medication and their blood pressure was normalized, minimal influence was seen intraoperatively.

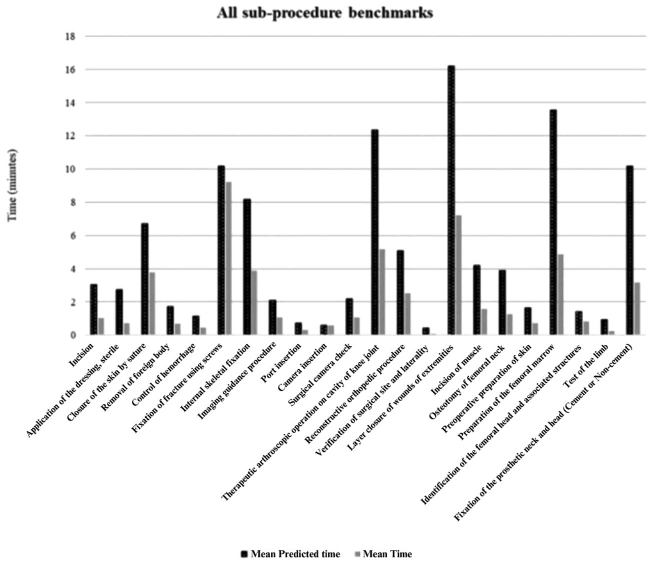

Fig. 3. Sub-procedure mean predicted and mean duration benchmarks surveyed in TCC-CASEMIX® data collected at University Clinic of Traumatology of Szeged.

Table 2
Arthroscopic procedures cross referenced with surgeon experience, age and other risks. While the procedures are similar, different factors seem to impact the duration of the surgery in an orderly fashion.

Name	Mean Time	SD	n	Surgeon Experience	Age	Risks-2 present
Arthroscopy	28.12	4.54	7	> 10 years	32	Blood Pressure
Arthroscopy	27.31	2.02	8	> 10 years	32	Age
Arthroscopy	27.31	2.02	8	> 10 years	32	BMI
Arthroscopy	26.71	4.84	5	> 10 years	32	ASA1:Normal Healthy
Arthroscopy	23.89	6.58	6	> 10 years	22	Age
Arthroscopy	23.89	6.58	6	> 10 years	22	BMI
Arthroscopy	28.63	7.08	7	> 10 years	42	Age
Arthroscopy	28.63	7.08	7	> 10 years	42	BMI
Arthroscopy	28.63	7.08	7	> 10 years	42	Blood Pressure
Arthroscopy	28.63	7.08	7	> 10 years	42	Ethnicity

To our surprise, patients with DM resulted in shorter Total Duration than non-diabetics (94.5 min and 100.5 min respectively), however the sample size for diabetics were significantly fewer, thus these results are inconclusive.

Patients with more severe OA (Grade 4) had prolonged mean IOD. This suggests that the severity of OA has a minimal but prolonging impact on IOD in all patient groups (Fig. 4). Correlations between the Total Viable Time, Implantation Time and the lateral JSW were moderate, where JLCA, and mJSW did not show significant correlation in any of the subprocedures.

Patient risk stratification

By better understanding the impact of individual risk factors, we identified two major factors that affect surgical durations; BMI and surgeon experience. We organized different cohorts from 1 to 4 according to surgeons with less than 5 years of experience, and more than 10 years of experience, grouped with patients with BMIs of below or over 25, and 30 (Table 3).

The mean Total Viable Time for cohort 1 was 73.8 ± 14.17 min, when in cohort 2 the mean increased to 115.3 ± 18.35 min. Also, while comparing cohort 3 and 4, the mean time prolonged from 85.38 min to 104.15 min, indicating that while all surgeon groups were affected by the higher BMI of the patients, surgeons with less experience were affected even more, showing a significant role of BMI in prolonging IOD.

According to our risk stratification cohorts, we generated a data chart in which predicted times can be calculated according to the mean times and SDs of subprocedure times.

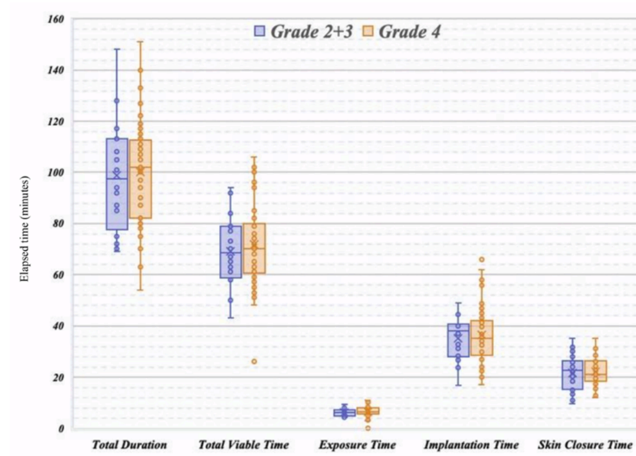

Fig. 4. A representation of the steady but unignorable increase in IOD in patients with KL grade 4 OA when compared with grades 2 and 3.

Table 3
Patient stratification according to the most influential individual factors. The mean time and its respective SD can be seen in Cohort 1 to Cohort 4.

Cohort Number	1	2	3	4
ASA Rating	2	2	2	2
Surgeon Experience	<5	<5	>10	>10
BMI	<=25	>25	<=30	>30
Risk Level	Low	High	Mid-Low	Mid-High
Sample Number	5	9	18	27
Median	79 (min)	114 (min)	83.5 (min)	107 (min)
IQR	[65.3 83.3]	[101.5 126.0]	[70.0 106.5]	[88.8 111.8]
Mean	**73.8**	**115.3**	**85.38**	**104.15**
Standard Deviation	**14.17**	**18.35**	**20.92**	**19.83**
95 % CI	[61.4 86.2]	[103.3 127.3]	[73.8 93.2]	[96.7 111.6]
90 % CI	[63.4 84.2]	[105.2 125.4]	[75.4 91.6]	[97.9 110.4]
75 % CI	[66.5 81.1]	[108.3 122.3]	[77.8 89.2]	[99.8 108.5]
50 % CI	[69.5 78.1]	[111.2 119.4]	[80.2 86.8]	[101.6 106.7]

Discussion

General considerations

Discussing procedure benchmarks in further detail, the results are plausible and verify the relationships between risk factors, procedure complexity and operation duration found in literature. Arthroscopies are typically a short, high-volume procedure performed by a surgeon, but there was a large difference between the surgeon's own estimates and the actual operation duration. In a survey, it can be difficult for a single surgeon to estimate the time required for a partial or full surgical procedure [9]. Likewise, risk factor analysis demonstrated that operation duration variability was greatly reduced when estimations were taken from cohorts of patients with similar degrees of procedure complexity, as identified by the algorithm. Compared to the surgeons' own estimates of operation duration which overestimated significantly, more reliable prediction was possible for arthroscopy using the algorithm. In fact, there are studies using machine learning approaches to predict IOD, which resulted in the highest predictive capability [10].

Acute trauma-related surgeries

On the other hand, open reductions and fixation procedures depended heavily on the presentation and classification of the fracture. Indeed, the operation duration depends more on the fracture being treated than patient risk factors, even where disparate, as evidenced by there being no clear correlations in the risk factors unlike for other procedures. Hence, as the surgeon has received an X-ray and other diagnostics of the fracture by the time of preoperative assessment, an accurate estimation of duration should be possible. Without acquisition for fracture presentation in the study, the risk factor cohorts found for arthroscopies were not observable for this procedure.

High volume surgery

In this prospective real time cross analysis of high volume TKA surgeries, we discovered that the IOD was impacted by more than one individual factor, namely BMI, degree of OA, and experience of the operating surgeon. These factors, though individual, are only moderately correlated to the prolonging of IOD; prolonging IOD in subprocedure steps such as prosthetic implantation and skin closure, therefore prolonging the duration of the entire surgery. The IOD of younger surgeons with less than 5 years of experience was drastically affected by the patients BMI, showing over 20 min of extra time in stratified groups, which could lead not just to the delay of the surgical program, but also to an increase in post operational infections [11]. While an increase in surgical time of only 15 min leads to 13 % higher chances of surgical site infection, most orthopedic prosthetic implantation surgeries last for more than an hour [12]. It is also known that prolonged operative duration leads to more complications, and the reduction of IOD is of crucial importance, especially in high volume surgeries, and should be a “Universal Goal” [13].

In contrast to some opinions saying that surgeries are highly unpredictable, the use of machine learning models and predictive models have brought fruitful results in predicting total surgical duration [14]. Information on pre-operative assessment and its effects on detailed subprocedure duration is sparse, and we have well understood that certain factors such as BMI and surgeon experience impact subprocedures [15,16]. We also believe that in high volume surgeries, predictability can be refined, and should be encouraged to be used in regular operating theater planning.

From our analysis, the average total time of surgery was 71 min, with a SD of 14 min. However, by better understanding the factors that impact surgery time, we concluded that BMI and surgeon experience immensely influence the duration of surgery. A surgeon with less than 10 years of surgical experience takes an average of 86–87 min to perform a TKA, where those with more than 10 years of experience complete the intervention in around 65 min, showing a difference of more than 20 min. The complete breakdown of subprocedures shows that the younger surgeons tend to have major problems in the prosthetic implantation steps, and tend to be slightly slower in wound closures. The differences between younger surgeons and experienced surgeons considering the skin incision until the joint exposure step were minimal. This seems to be a partially contradictory finding, where other studies have claimed that surgical exposure times differed significantly in non-high volume patients, especially in patients with high BMI [17]. While examining the correlation between the individual steps and BMI, we found a moderate correlation. When we included the surgeon’s experience to the analysis, we suspected that the IOT of younger surgeons who operated on higher BMI patients was significantly prolonged, by over 42 min on average. This pattern was similarly observed in experienced surgeons, where the mean duration was prolonged by 19 min. Since patients usually present with KL grade 3 or 4 arthritis for a TKA procedure, minimal correlation was observed while considering the degree of OA and IOT. Other studies also indicated BMI and ASA may contribute to surgical duration prolongation, its conclusions vary widely [18].

The use of BMI seems to be questionable, and though it seems to add some insight its use alone should not be encouraged, but should always be part of a stratified cohort for it to be a reliable predictor.

Strengths and limitations of the study

By understanding the defining impacts of individual factors by filtering the acquired data with the use of an independent cloud service made the preoperative assessment, intraoperative measurement and postoperative analysis fast and effective. The postoperative analysis undertaken by the two independent surgeons gave similar results. The use of TCC-CASEMIX® allowed us to guarantee the quality of the data analysis, using its data filtering algorithm. This methodology is only hindered by the fact that it always utilizes an independent surveyor, and we aim to endeavor to find other ways to acquire the necessary data.

While pre-operative biometrics and degree of OA were precisely recorded, comorbidities were very difficult to parametrize, since patients took different medications while having different problems caused by different stages of their respective comorbidities. For example only 2 patients answered that they do not smoke, this was epidemiologically not likely, considering the prevalence of smokers in Hungary [19]. The effects of smoking were also difficult to mathematize, and we intend to apply the Brinkman Index in future research, to assess the quantifiable impact of smoking.

TCC-CASEMIX has the function to register equipment, and cross analyze the impact of the equipment to a dedicated step or total surgical time. This allows us to understand the time/cost benefits of new equipment, especially preoperative planning tools and intraoperative navigation tools, and should be included in further research.

Implications in surgical planning

By better understanding the effects of patient characteristics and comorbidities, we can utilize the values given by our data acquisition to “simulate” the surgery with predictive values. By pre-operatively acquiring the patient biometrics, comorbidities, etc., we can predict the subprocedure time with high precision according to our database (Table 4). This allows the surgery team to plan the operating schedule not only based on the surgeons’ estimated values, but also according to the pre-operative assessment, thus maximizing the use of limited work hours in the clinics. A simulation-based study parallel to the actual planning may provide better insight in the future, in line with benchmarking surgical scheduling [20].

Implications in education and training

The knowledge obtained can be utilized in education as well. Younger surgeons seem to have more difficulty operating patients with high BMI, thus, if possible they could start their career with lower BMI patients to include more surgeries in a certain amount of time. In future studies, the number of surgeries included with the surgeon’s years of experience, together with the trend of surgical time, could be cross analyzed for better understanding of the learning curve in a given surgery.

Future considerations

Because surgery room planning is crucial in relieving the physical, psychological, and financial burden of waiting lists, we intend to research our predictive values to “virtually simulate” the surgery in the preoperative stage, and compare it to the actual relapsing operative time. We expect these high volume surgeries to be highly predictable to the minute, and the evaluation of the precision of the prediction should be the question next in line. Surgeon and anesthesiologist unavailability can also play a crucial role in the scheduling of surgeries, and individual rosters can also be registered - where surgical team adherence should be focused on [21].

Conclusion

Patient biometrics and years of surgeon experience are significant factors when predicting IOD. Surgical durations are moderately affected by the BMI of patients, but those with less experience are markedly affected by the BMI of the patients, prolonging their IOD mostly at the level of prosthetic implantation phase. Patient stratification according to BMI and years of surgeon experience were the greatest predictors of intraoperative duration. Non-parametric factors like history of smoking, presence of HT or DM, and use of anticoagulants showed minimal or no correlation with IOD prolongation. A detailed breakdown and evaluation of components such as patient characteristics, device management, and surgical teams aid in a better understanding of surgical sub-procedure times spent in the operating theater, thus leading to significantly more accurate forecasting.

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Intellectual property

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publications, including the timing of publication, with respect to intellectual property. In doing so we confirm that we have followed the regulations of our institutions concerning intellectual property.

Research ethics

The study was conducted in accordance with the Declaration of Helsinki. Our research haroved the local medical ethics commise Univerity of Szeged (Regional Institutional Review Board of investigation, Chair person prof. Tibor Wittman under reference number 1/2022-SZTE RKEB). /more, all patients have given written consent to enter the current study.

Authorship

a. All listed authors meet the ICMJE criteria We attest that all authors contributed significantly to the creation of this manuscript, each having fulfilled criteria as established by the ICMJE.
b. We confirm that the manuscript has been read and approved by all named authors.
c. We confirm that the order of authors listed in the manuscript has been approved by all named authors.

Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper. There has been no significant financial support for this work that could have influenced its outcome.

Ethical statement

Participants have been fully informed and a written form of consent was acquired in accordance with the declaration of Helsinki. This study has been accepted by the Human biological ethical committee of the University of Szeged by the number 1/2022-SZTE RKEB.

CRediT authorship contribution statement

Takayuki Kurokawa: Conceptualization, Data curation, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. **Yujin Kaneko:** Writing – original draft, Writing – review & editing. **Ashish Varughese Mammen:** Data curation. **Victoria Walls:** Visualization. **Ivan Diogo Queiros:** Data curation. **Federica Corbo:** Data curation. **Mais Azaizah:** Data curation. **Matthew Bacon:** Conceptualization, Supervision. **Endre Varga:** Supervision. **László Török:** Supervision.

Declaration of competing interest

There are no conflicts of interest.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.injury.2024.111528.

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