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A pilot study on preferences from surgeons to deal with an innovative customized and connected prosthesis – A Discrete Choice Experiment

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Abstract

To address the increasing global demand for Total Knee Arthroplasty and reduce the need for revisions, several technologies combining 3D planning and artificial intelligence have emerged. These innovations aim to enhance customization, improve component positioning accuracy and precision. The integration of these advancements paves the way for the development of personalized and connected knee implant.

These groundbreaking advancements may necessitate changes in surgical practices. Hence, it is important to comprehend surgeons' intentions in integrating these technologies into their routine procedures. Our study aims to assess how surgeons' preferences will affect the acceptability of using this new implant and associated technologies within the entire care chain.

We employed a Discrete Choice Experiment, a predictive technique mirroring real-world healthcare decisions, to assess surgeons' trade-off evaluations and preferences.

A total of 90 experienced surgeons, performing a significant number of procedures annually (mostly over 51) answered. Analysis indicates an affinity for technology but limited interest in integrating digital advancements like preoperative software and robotics. However, they are receptive to practice improvements and considering the adoption of future sensors.

In conclusion, surgeons prefer customized prostheses via augmented reality, accepting extra cost. Embedded sensor technology is deemed premature by them.

1 Introduction

Total Knee arthroplasty (TKA) is continuously increasing for several decades and is expected to explode in the next years [1].

This increase is chiefly driven by the natural rise in the incidence of osteoarthritis, related in particular to the combined effects of population aging and obesity [2] and the broadening of TKA indications towards younger patients (<65 years) allowed by improvements in both surgical techniques and knee implants [3,4]. As a result, implanted for more than 20 years in active subjects, these prostheses are more frequently revised, leading to expensive and less effective procedures. A +182% growth in revision Knee Arthroplasty is, for example, expected in the USA by 2030 [5].

To address this major public health problem and improve primary TKA surgery, thereby preventing revisions caused by premature wear, loosening, and infection, several factors must be considered: implant design, surgical technique, and patient follow-up[6–8]. Their improvements will enable the development of customized and connected implants, as proposed in FollowKnee project [9].

However, these advancements also represent a breakthrough, and the implementation of this new care chain may necessitate adaptations and changes in surgical practices. Therefore, it is crucial to understand surgeons' intentions regarding the adoption of these technologies as part of their routine practice. By considering their preferences, we can better assess the impact of these technologies on patient care.

Our study aims to assess how surgeons' preferences will affect the acceptability of using this new implant and associated technologies within the entire care chain. To the best of our knowledge, no study on surgeons' choices has been reported thus far.

2 Material and Methods

Discrete Choice Experiment (DCE) represents a quantitative stated preference technique for eliciting individual preferences [30]. We assessed surgeons' preferences by using a questionnaire [10,11] with 16 choice set scenarios with an status quo option. Surgeons were asked to select the one they would prefer between the three possibilities. Based on literature review, experts' consultation and pre-testing questionnaire, we characterize four attributes (figure 1): customized prosthesis, prosthesis including sensors, augmented reality tools (AR) and extra cost. A status quo option (ie "no change with my usual practice") is included.

The answers were analyzed in accordance with McFadden's Random Utility Theory. To address the variability in preference among surgeons, a Mixed Logit Model was used.

The questionnaire was distributed in France via the French national association of orthopaedic surgeons and a regional orthopaedic congress.

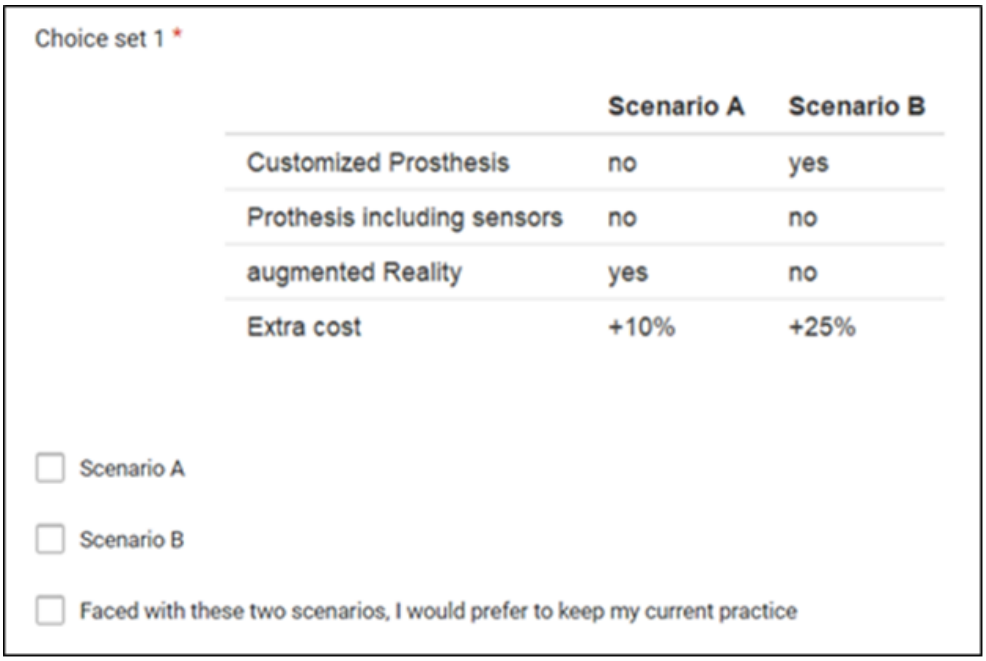

Figure 1: Example of a discrete choice experiment choice set. Four attributes where identify: (1) Customized Prosthesis (Prosthesis fitting to patient's morphology), (2) Prosthesis including sensors (Prosthesis integrating pressure, movement, temperature and pH sensors. Data will allow a better post-operation follow-up in order to avoid retrievals (due to wear, loosening and infections), (3) Augmented Reality (Use of augmented reality in the operating room to improve accuracy of the prosthesis placement) and (4) Extra-cost (How much extra cost (€) would you be willing to accept for yourself due to the use of an innovative prosthesis?)

3 Results

The questionnaire was return by 90 surgeons, that were all males. 60%±10% work in public hospital and 62.2%±10% performed over 51 prostheses per year. They mostly not used planning software (52.2%±10.3%), navigation systems or robots (68.9%±9.6%). Surgeons expressed interest in embracing technological innovations, indicating a willingness to extend surgical time by 10 to 20 minutes (74.4%±9%). Their specific interest lies in incorporating sensors to monitor patients, in addition to standard consultations (73.3%±9.1%).

Table 1 shows positive and statistically significant coefficients for all attributes. This implies that surgeons see value in incorporating these attributes into their current practices. However, the significant ASC underscores preference for maintaining their current practices despite their desire for benefits from the proposed technologies. Higher coefficients for attributes reflect greater utility, with AR and personalization emerging as the most significant factors. Use of sensors has the lowest importance compared to others attributes.

Personalized prostheses provide the highest utility in both subgroups based on experience. Among those conducting fewer than 51 procedures annually, AR holds an equal ranking with sensor usage.

Conversely, among surgeons performing over 51 procedures per year, AR is the second-highest preference, while sensors rank the lowest. Notably, significant standard deviations across all groups highlight statistically significant heterogeneity in surgeons' preferences for all attributes.

	All surgeons			50 and under procedures per year			51 and over procedures per year		
	Coeff	SE	p	Coeff	SE	p	Coeff	SE	p
ASC	0.503	0.069	***	0.264	0.110	*	0.649	0.089	***
Customized Implant									
Yes	0.829	0.069	***	0.949	0.116	***	0.853	0.088	***
No (ref)	-			-			-		
Connected Implant									
Yes	0.383	0.062	***	0.546	0.106	***	0.339	0.078	***
No (ref)	-			-			-		
Augmented Reality									
Yes	0.848	0.070	***	0.933	0.120	***	0.770	0.088	***
No (ref)	-			-3			-		
Over-cost									
+10%	0.580	0.064	***	0.590	0.106	***	0.602	0.081	***
+25% (ref)	-			-			-		
sd.Customized Implant	1.062	0.080	***	0.817	0.131	***	1.180	0.102	***
sd.Connected Implant	0.825	0.087	***	0.753	0.139	***	0.848	0.110	***
sd.Augmented Reality	0.850	0.085	***	0.789	0.146	***	0.849	0.104	***
sd.Over-cost	0.690	0.083	***	0.754	0.142	***	0.654	0.100	***

Table 1: Results from the random parameters mixed logit model. “ASC” stand for Alternative Specific Constant and “sd” for the standard deviation.
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

4 Conclusion

This pilot study reveals that surgeons are receptive to practices advancement. Depending on experience in practice, they express a preference for utilizing a customized prosthesis through augmented reality, even at an additional measured cost. However, it appears that embedded sensor technology is currently less appealing to them.

Personalized implants preserve patient anatomy, with practitioners optimistic about their potential benefits [12]. Preferences among surgeons may vary based on practical experience and the development stage of CI [8].

Accurate positioning is vital for individual patient morphology. Assisted technologies, developed over the past decade [13], enhance efficiency but may be complex and bulky in the operating room. Augmented Reality stands out as a promising innovation, with surgeons' high preference indicating openness to user-friendly technologies.

Smart sensors in implants show promise in monitoring parameters, aiding surgeons, and facilitating rehabilitation [7]. However, limitations and insufficient evidence persist, reflected in surgeons' preferences.

In economic terms, a substantial rise (+25%) would negatively impact technology utilization.

In conclusion, technologies in the emerging care chain exhibit varied maturity and usage levels, reflecting expressed preferences. Given differences in technology adoption among countries [15] comparing preferences can enhance our understanding of international adoption processes.

5 Aknowledgement

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