Application of Conjoint Analysis for Total Knee Replacement Surgery Alternatives

The objective of this report is to calculate the market share of the surgery options available for Total Knee Replacement. It uses choice based conjoint analysis to arrive at the market share of the surgeries. The scope of the report is that the primary research was conducted in US only. Hence the results of the report reflect the Total Knee Replacement Surgery market in US only. The attributes used for Conjoint Analysis were arrived at, using Secondary research, by reading literature on knee surgery. After finalizing the attributes for study, Orthopaedic Surgeons were given choices of various surgeries for Total Knee Replacement. Market share of these surgeries was then calculated using the responses of these surgeons.

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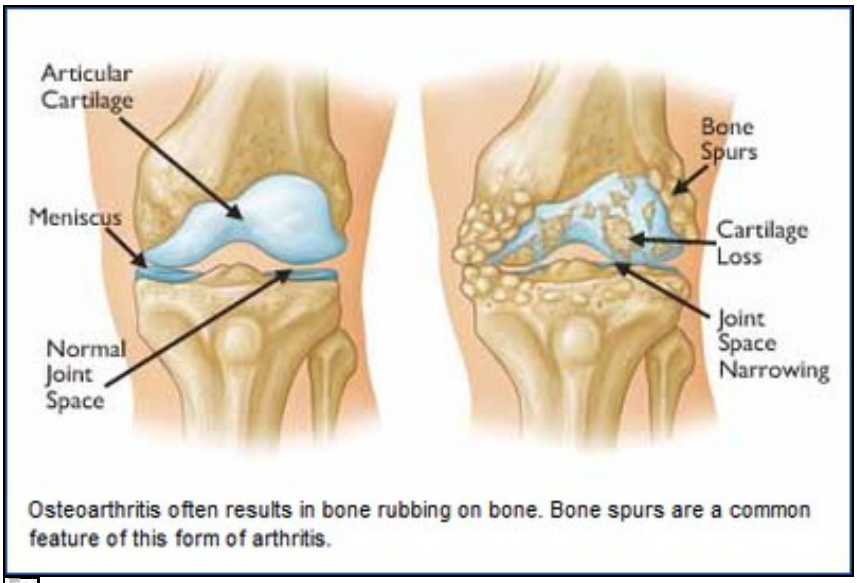
Introduction

Total Knee Replacement surgery is done when the patient?s knee is severely damaged by arthritis or injury. It is considered as an option by surgeons when non-surgical treatments like medication, usage of supports to walk are no longer useful to the patient. It is a safe procedure to relieve pain, correct leg deformity, and help the patient resume normal activities.

Causes of Knee Pain

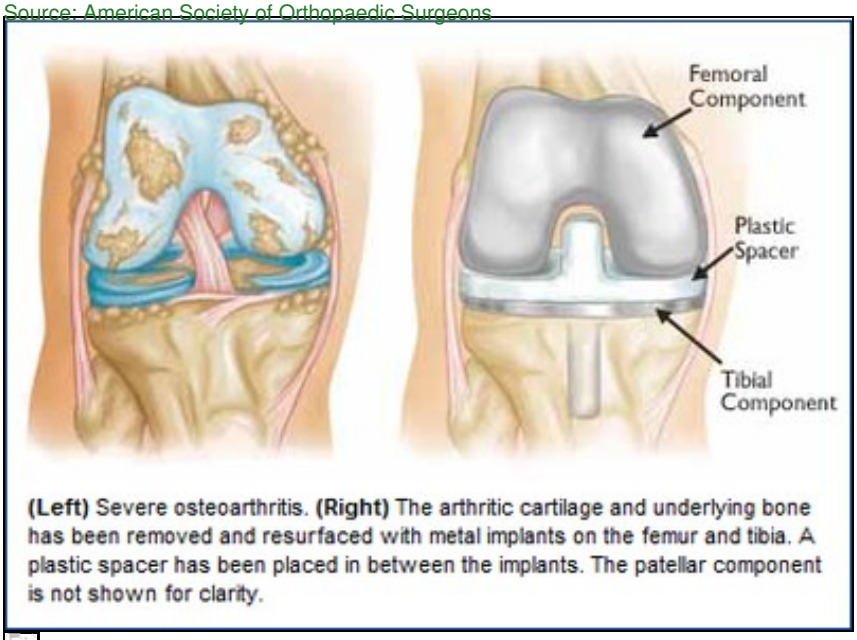
The most common cause of chronic knee pain and disability is arthritis. Although there are many types of arthritis, most knee pain is caused by just three types: osteoarthritis, rheumatoid arthritis, and post-traumatic arthritis.

- **Osteoarthritis** - This is an age-related "wear and tear" type of arthritis. It usually occurs in people 50 years of age and older, but may occur in younger people, too. The cartilage that cushions the bones of the knee softens and wears away. The bones then rub against one another, causing knee pain and stiffness.
- **Rheumatoid arthritis** - This is a disease in which the synovial membrane that surrounds the joint becomes inflamed and thickened. This chronic inflammation can damage the cartilage and eventually cause cartilage loss, pain, and stiffness. Rheumatoid arthritis is the most common form of a group of disorders termed "inflammatory arthritis."
- **Post-traumatic arthritis** - This can follow a serious knee injury. Fractures of the bones surrounding the knee or tears of the knee ligaments may damage the articular cartilage over time, causing knee pain and limiting knee function.



Osteoarthritis often results in bone rubbing on bone. Bone spurs are a common feature of this form of arthritis.

Source: American Society of Orthopaedic Surgeons



(Left) Severe osteoarthritis. **(Right)** The arthritic cartilage and underlying bone has been removed and resurfaced with metal implants on the femur and tibia. A plastic spacer has been placed in between the implants. The patellar component is not shown for clarity.

Source: American Society of Orthopaedic Surgeons

Reasons to go for Total Knee Replacement

There are several reasons for a surgeon to recommend Total Knee Replacement Surgery. Patients who would benefit from Total Knee Replacement Surgery would often have the following problems:

- Severe knee pain or stiffness that limits everyday activities, including walking, climbing stairs, and getting in and out of chairs. The patient might find it hard to walk more than a few blocks without significant pain and he might need to use a cane or walker
- Moderate or severe knee pain while resting, either day or night
- Chronic knee inflammation and swelling that does not improve with rest or medications
- Knee deformity ? a bowing in or out of your knee
- Failure to substantially improve with other treatments such as anti-inflammatory medications, cortisone injections, lubricating injections, physical therapy, or other surgeries

Candidates for Surgery

- There are no absolute age or weight restrictions for total knee replacement surgery
- Recommendations for surgery are based on a patient?s pain and disability, not age
- Most patients who undergo total knee replacement are age 50 to 80, but orthopedic surgeons evaluate patients individually

Types of Total Knee Replacement Surgeries

Traditional Total Knee Replacement Surgery

The accuracy of alignment in conventional TKAs depends on the skill of the surgeon and the anatomy of the femur and tibia. Correct location of crucial alignment landmarks (centers of the femoral head and ankle joint) for determination of the mechanical axis can be difficult to achieve.

Computer Assisted Navigation Surgery

Computer-assisted TKA has been developed to improve alignment and implant positioning, to increase accuracy and reproducibility of the operative technique, to enable real-time kinematic analysis and soft-tissue balancing, and to reduce the risk of fat embolism and blood loss by not entering the

intramedullary space.11,12 It is especially advantageous in obese patients or those with severe preoperative mal-alignment, in whom identification of anatomic landmarks and soft-tissue balancing can be particularly difficult.

Custom Knee Replacement Surgery

Custom Fit Total Knee Replacement Surgery is the newest technology in total knee replacement. The process starts several weeks before the surgery with an MRI scan. The MRI makes precise measurements of the knee. Computer software transforms that MRI image into a 3-D model of the arthritic knee and then virtually corrects any deformity to return the knee to its pre-arthritic state. A computerized 3-D image of the implant to be used at the time of surgery is then matched to the anatomically correct knee model. This helps determine the correct implant size and placement based on that patient?s normal knee alignment. Using all this information, a set of custom cutting guides is then created for use during the individual surgery. Each knee is unique and each set of MRI computer matched custom surgical guides is one of a kind.

Need gap

- Lack of Total Knee Replacement market share information available in secondary databases
- Need for surgeon?s preferences given the options available for Total Knee Replacement surgery

Model Explanation

Conjoint Analysis

Conjoint analysis is the optimal market research approach for measuring the value that consumers place on features of a product or service. This commonly used approach combines real-life scenarios and statistical techniques with the modelling of actual market decisions.

Choice-based Conjoint Analysis

The Choice-based conjoint analysis (CBC) (also known as discrete-choice conjoint analysis) is the most common form of conjoint analysis. Choice-based conjoint requires the respondent to choose their most preferred full-profile concept. This choice is made repeatedly from sets of 3?5 full profile concepts. This choice activity is thought to simulate an actual buy¬ing situation, thereby mimicking actual shopping behavior. The importance and preference for the factor features and levels can be mathematically deduced from the trade-offs made when selecting one (or none) of the available choices. The output of a Choice-based conjoint analysis provides excellent estimates of the importance of the features, especially in regards to pricing. Results can estimate the value of each level and the combinations that make-up optimal products. Simulators report the preference and value of a selected package and the expected choice share (surrogate for market share).

Methodology Used

Step 1 ? Determine key factors

The first phase involved the identification of the salient factors or that surgeons use to recommend the appropriate surgery method for a patient in need of a primary total knee replacement.

The factors identified during this study, takes into account all the major variables affecting the surgeons decision while recommending the appropriate surgery method for a patient in need of a primary total knee replacement. These factors have been considered after referring to academic and industrial research.

The factors identified affecting the surgeons decision for a total knee replacement surgery are:

- Time to recover
- Out of pocket expenses
- Knee Society Function Score
- Knee Society Knee Score

Step 2 ? Determine categories within the factors

After the factors were identified, an in-depth analysis was done using secondary research by our in-house subject experts, to determine the category levels under each factor. The scale used for the categories was ordinal scale, and 3 categories were identified for each of the 4 factors.

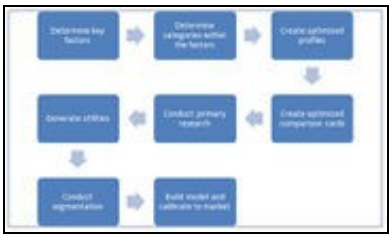
Step 3 ? Create optimized profiles

The maximum number of profiles possible in this case was 3^4=81, calculated using the already identified 4 factors and 3 categories for each of the factors. But, Latin Square Design method was used to optimize the number of profiles that have to be evaluated, while ensuring enough data is available for statistical analysis, resulting in a carefully controlled set of "profiles" for the respondents to consider, and a total of 12 profiles were finally arrived at.

Step 4 ? Create optimized comparison cards

The following points were taken into consideration while preparing the set of comparison cards for the respondents (surgeons) to consider:

- All the 12 profiles were equally distributed across the set of comparison cards
- A set of 20 optimized comparison cards were build
- Each comparison card had 3 profiles and the surgeons chose one profile based on the factors included in the profiles
- The optimization of comparison cards ensured that each profiles is included 5 times



Choice-based Conjoint Analysis - Steps

Step 5 ? Conduct primary research

The data for the study was collected using a mail questionnaire that contained the set of 20 comparison cards developed as previously described. The questionnaire was mailed to 10 orthopedic surgeons specializing in knee replacement surgeries. A mail survey was required because of the need to present the rather complex choice options to the surgeons so that they could make meaningful selections. The inclusion criteria for the respondents were:

- The surgeon specializes in orthopedics and has suitable knowledge in the field of total knee replacement surgery
- The patients in consideration experienced knee pain over the past month on most days and requires a primary total knee replacement
- The surgeon has all the possible treatment options (profiles) available to him and resource is not a problem

Step 6 ? Generate utilities

The 10 individual responses for the 20 comparison cards were then used to generate utilities for each of the categories associated with all the factors. The importance level for each of the 4 factors was also derived at using the analysis. Conjoint analysis allows us to evaluate the trade-offs that consumers make between product features. This is accomplished by evaluating and comparing sets of comparison cards and analyzing the choices made by the surgeons. Based on the choices made by respondent, it is possible to estimate the relative value or utility that the respondent must have associated with each level of each product factor to have made these choices.

Step 7 ? Conduct segmentation

The available alternatives for total knee replacement surgery are:

- Traditional Total Knee Replacement Surgery
- Custom Knee Replacement Surgery
- Computer Assisted Navigation Surgery

The above 3 market profiles were then assigned the categories for the previously identified factors using secondary research by our in-house subject experts.

Step 8 ? Build model and calibrate to market

The estimated utilities were then used to predict the percentages of consumers that would choose each profile from the comparison cards including any combination of all the unique profiles that can be constructed with the factors and factor levels employed for this study. The stimulation model estimates market share for each product by estimating the value that each surgeon associates with each profile included in the particular simulation. This enables us to predict market shares of various alternative surgeries.

Scope of the Study

The scope of the study is defined as following:

- The study is limited to United States of America
- The non-surgical alternatives to total knee replacement have not been considered in our study

Assumptions

The following assumptions have been made while carrying the study:

- The patients in consideration experienced knee pain over the past month on most days and requires a primary total knee replacement
- The surgeon has all the possible treatment options (profiles) available to him and resource is not a problem
- All treatments have equal access to the market
- All patients have equal access to the surgeons

Variables used in the Study

i) Out of the Pocket Expense: Out of pocket expense for the patient represents the share of the expenses that the insured party must pay directly to the health care provider, without a third-party (insurer, or state). In case of the 3 total knee replacement surgery alternatives considered in this study, only Traditional Total Knee Replacement Surgery is covered under all the major insurance in US. Out of the pocket expense was rated

ii) Knee Society Function Score: Knee Society Function Score allocates points for walking distance and stair-climbing ability and makes deductions for the use of a walking aid; 100 represents unlimited walking distance and normal stair-climbing without the use of an aid.

iii) Knee Society Knee Score: Knee Society Knee Score is given out of 100 points

Fifty of the 100 points in the knee score reflect pain assessment (a score of 50 points represents no pain). The Knee Society pain component requires the evaluator to rate the patient?s knee pain with one question that combines the frequency and severity of pain and has seven ordinal responses. The other 50 points reflect the clinical assessment of range of motion, stability, alignment, and muscle power; 50 points represents at least 0Â° to 125Â° of knee flexion with no active lag, no instability, and normal alignment.

iv) Time to recover: Time to recover represents the total number days taken by the patient post total knee replacement surgery, for the knee to function normally.

Note: All the variables used in the model are measured on a relative scale. The absolute values of each of these variables have not been considered.

Results Analysis

Utilities & Importance

Based on the responses obtained from panel of surgeons, conjoint analysis was performed to find following attribute importance table.

Surgery Attributes	Relative Importance
Time to recover	27.362
Out of pocket expenses	38.212

Knee Society Function Score	24.610
Knee Society Knee Score	9.815

As seen clearly from the table **out of pocket expenses** is the most important factor to make decision about surgery. Time to recover and Knee Society Function Score are the other important factors. Knee society Knee Score is seen as insignificant parameter.

Individual utilities in attribute

Following table lists average utilities observed for each of the attribute.

Source	Utilities	Standard deviation
Time to recover-Fast	0.044	0.115
Time to recover-Moderate	-0.008	0.122
Time to recover-Slow	-0.036	0.137
Out of pocket expenses-High	-0.160	0.131
Out of pocket expenses-Very High	-0.770	0.122
Out of pocket expenses-Very Low	0.930	0.131
Knee Society Function Score-High	-0.016	0.122
Knee Society Function Score-Low	-0.075	0.112
Knee Society Function Score-Moderate	0.091	0.131
Knee Society Knee Score-High	0.009	0.126
Knee Society Knee Score-Low	-0.037	0.118
Knee Society Knee Score-Moderate	0.029	0.123

Utility values for all levels of attribute add up to 0. Consequently utility values indicate relative utilities of individual options in an attribute

Market Share Simulation

Market share simulation is performed to see the relative performance of products given the choices made by survey participants. Following table lists the market share of each of the surgical method discussed in section

Product ID	Utilities	Market share (in %)
Computer Assisted Navigation Surgery	0.26	26.32
Custom Knee Replacement Surgery	0.13	13.27
Traditional Total Knee Replacement Surgery	0.60	60.41

Traditional Total Knee Replacement Surgery account for 60% of the market share followed by Computer Assisted Navigation Surgery(26.32%) and Custom Knee Replacement Surgery(13.27%).

Most Important criteria is found to be out of the pocket expenses. Consequently Traditional Total Knee Replacement Surgery dominates the market with huge market share.

Implications

Out of pocket expense for patient is a dominating factor for surgeon?s choice of surgery. Even though other two methods namely Computer Assisted Navigation Surgery and Custom Knee Replacement Surgery are better than traditional methods in all factors except for cost, their market share is still very low compared to Traditional Total Knee Replacement Surgery.

In US, both these methods are generally not covered by insurance so Out of pocket expense is extremely high compared to traditional method. In order to promote use of better methods, these methods need to come under insurance cover. Probably even then out of pocket expense would be higher for these methods but still comparable to traditional method. Utility values will be higher for these advanced methods due to benefits in other areas apart from cost.

Bibliography

Appendix

Factors Used

Following factors were used to judge surgeon?s preferences.

Factors	Categories

Time to recover	3
Out of pocket expenses	3
Knee Society Function Score	3
Knee Society Knee Score	3

Each factor is having following categories as shown in table.

Categories	Time to recover	Out of pocket expenses	Knee Society Function Score	Knee Society Knee Score
Category 1	Moderate	High	Moderate	Moderate
Category 2	Fast	Very High	High	High
Category 3	Slow	Very Low	Low	Low

Profiles Optimization

Following random profiles were made from factors. Profiles were made such that there will be some trade-off decision in every comparison.

Observation	Time to recover	Out of pocket expenses	Knee Society Function Score	Knee Society Knee Score
Profile1	Slow	Very High	Moderate	Low
Profile2	Moderate	Very High	High	Moderate
Profile3	Fast	Very High	Low	Moderate
Profile4	Slow	Very Low	High	High
Profile5	Fast	High	High	Moderate
Profile6	Fast	High	Moderate	High
Profile7	Slow	High	Low	Moderate
Profile8	Fast	Very Low	Low	Low
Profile9	Moderate	Very Low	Moderate	Moderate
Profile10	Moderate	High	Low	Low
Profile11	Fast	Very High	High	Low
Profile12	Moderate	Very High	Low	High

Comparison Cards

Every individual surgeon was asked to make 20 comparisons. In each comparison three profiles were compared to choose best combination. Following table lists the profile numbers used in every comparison.

Comparisons	Choice 1	Choice 2	Choice 3
Comparison 1	2	1	3
Comparison 2	5	4	6
Comparison 3	8	7	9
Comparison 4	11	10	12
Comparison 5	1	7	5
Comparison 6	4	8	2
Comparison 7	3	6	10
Comparison 8	11	12	9
Comparison 9	5	8	3
Comparison 10	7	4	10
Comparison 11	6	9	1
Comparison 12	12	11	2

Comparison 13	6	2	7
Comparison 14	9	3	4
Comparison 15	8	12	1
Comparison 16	10	5	11
Comparison 17	9	2	5
Comparison 18	7	3	11
Comparison 19	10	6	8
Comparison 20	4	1	12

Simulated Market

Three alternatives were rated on all the factors. Following table displays our assessment of various surgery options over given factors.

Total Knee Replacement Surgery - Alternatives	Time to recover	Out of pocket expenses for the patient	Knee Society Function Score	Knee Society Knee Score
Computer Assisted Navigation Surgery	Moderate	High	Moderate	Moderate
Custom Knee Replacement Surgery	Fast	Very High	High	High
Traditional Total Knee Replacement Surgery	Slow	Very Low	Low	Low

Market Share Analysis

Following table lists the market share analysis obtained after running simulation

Product ID	Utilities	Market share (in %)
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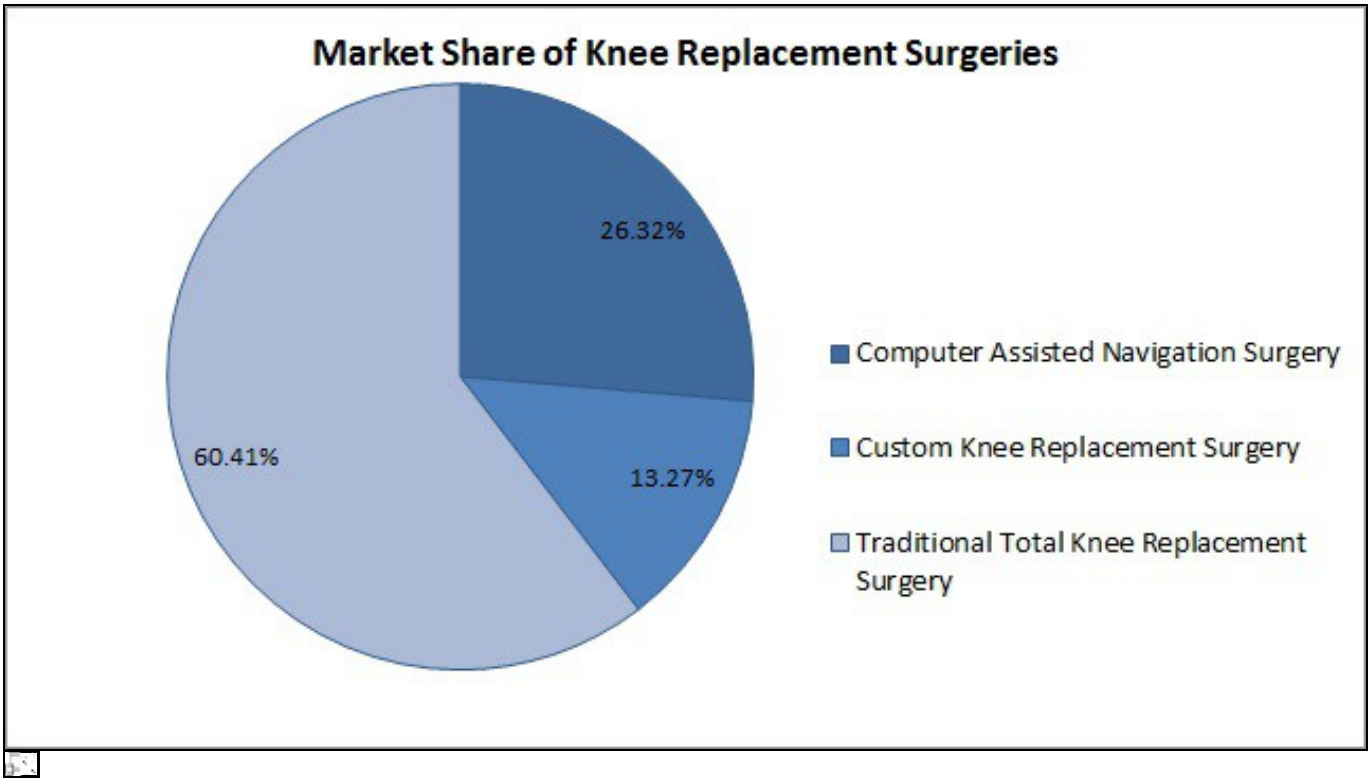

Pie chart indicating predicted market share of individual methods

Data used for the model

Attributes for the analysis were decided by extensive secondary research on three surgery methods.

i) Comparison of functional and radiological outcomes after computer-assisted versus conventional total knee arthroplasty: amatched-control retrospective study

ii) Results with initial experience with custom fit positioning total knee anthroplasty in a series of 48 patients