VISIONAIRE® Patient-Matched Instrumentation for Total Knee Arthroplasty: Improving Efficiency and Reducing Costs Through Technology

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Summary
Total knee arthroplasty (TKA) is a well-established and frequently performed procedure for patients with end-stage knee osteoarthritis. The increasing demand for TKA will place a strain on hospital and surgical resources. Interventions aimed at decreasing cost, increasing hospital efficiency and reducing complication and revision rates are becoming critically important. The objective of this paper is to analyze the potential financial impact of utilizing VISIONAIRE® patient-matched TKA instrumentation (Smith & Nephew, Inc., Memphis, TN, USA) compared to standard instrumentation. Recently published evidence demonstrates that VISIONAIRE Instrumentation can reduce length of hospital stay by 0.3-0.9 days, decrease operating room time by 7-29 minutes, and reduce surgical tray utilization by 3.2 trays. Results of the current analysis suggest that this increased efficiency could reduce the costs typically associated with TKA.

Introduction
Total knee arthroplasty (TKA) is a well-established and frequently performed procedure for patients with end-stage knee osteoarthritis. The high demand for TKA can be attributed to its clinical success. Specifically, more than 90% of patients with TKA are expected to have a good or excellent result for ten years or more, including a significant improvement in pain, functional status, and overall health-related quality of life [1, 2]. As the population of the US increases and grows older, it is likely that more patients will seek TKA as a means of treating painful arthritic knees. It is anticipated that there will also be a substantial increase in the demand for primary TKA among patients < 65 years of age with the greatest growth being in the 45-54 year age category [3]. If the number of procedures performed continues at the current rate, the demand for primary TKA is projected to grow by 673% from 450,000 procedures in 2005 to 3.48 million procedures by 2030 (Figure 1) [4]. This increasing demand is expected to place considerable strain on hospital resources, creating pressure to contain costs. Therefore, interventions aimed at decreasing costs, increasing efficiency, and improving patient outcomes by reducing surgical complication and revision rates are becoming critically important.
Patient-Matched Instrumentation

While traditional TKA has a high success rate, there is always opportunity to increase procedure efficiency and effectiveness, resulting in better patient outcomes. VISIONAIRE™ patient-matched instrumentation (Smith & Nephew, Inc., Memphis, TN, USA) allows a set of surgical cutting blocks to be designed based on a patient’s individual anatomy. An MRI of the patient’s knee and a full length X-Ray of the leg are used to create a three-dimensional model of the distal femur and proximal tibia [5]. Following visualization, proprietary software is utilized to virtually map all bone resections, and to accurately size and position the implant. Disposable femoral and tibial cutting blocks are then manufactured to fit the patient’s unique articular deformity (Figure 2) [6]. The customized cutting blocks allow the surgeon to make the precise bone cuts needed to position the knee implant in optimal mechanical alignment, and to minimize the likelihood of bone cutting errors. VISIONAIRE instrumentation is less invasive than that of conventional TKA because there is no need for an intramedullary alignment guide.

Economic Value of VISIONAIRE Instrumentation

Room and board, operating room (OR) time, and supply costs (medical, surgical and implants) represent approximately 73% of hospital expenses for a primary TKA [7]. Therefore, decreasing length of hospital stay and OR time may be considered key factors in reducing hospital expenses. VISIONAIRE Instrumentation has the potential to decrease hospital costs and improve TKA efficiency as a result of the following:

- Reduces OR time and set-up by eliminating 20-22 surgical steps, as compared to a standard GENESIS II Knee System TKA [8].
- Eliminates need to access the intramedullary canal, potentially reducing the incidence of postoperative complications [9].
- Reduces the number of surgical trays, potentially decreasing the costs associated with sterilization.
- Improves productivity as a result of less room set-up and clean up time, resulting in improved turnover time.

The purpose of this analysis is to quantify the potential financial impact of utilizing VISIONAIRE patient-matched TKA instrumentation compared to standard instrumentation.

Figure 1: Projected Primary TKA procedures [4]

Figure 2: VISIONAIRE Patient Matched Instrumentation (Smith & Nephew, Inc., Memphis, TN, USA)
Materials and Methods

In a recently published single center, prospective, randomized clinical study, twenty-nine (29) primary TKA patients underwent surgery utilizing either VISIONAIRE™ (VIS) (N = 15) or standard surgical instrumentation (STD) (N = 14) [6]. The authors reported no significant differences in patient age, BMI, or preoperative knee alignment between treatment groups (p > 0.05). The surgical technique for all cases was a medial parapatellar approach with an initial distal cut. All patients were implanted with the LEGION™ Total Knee System (Smith & Nephew, Inc., Memphis, TN, USA). Surgeries were performed in two southern US community hospitals with 200 beds or less.

Length of stay, surgical tray utilization and skin-to-skin OR time data collected on these 29 patients were the primary variables analyzed to quantify the impact of utilizing VISIONAIRE patient-matched instrumentation. In addition, the data from the VIS and STD groups were compared against national data for TKA. To calculate costs, the following assumptions and calculations were utilized:

- Cost per minute of orthopaedic operating room time established as $25.00 USD [10, 12].
- Processing cost per surgical tray for preparation and sterilization is $60.00 USD [17].
- Average total hospital cost for TKA is $14,947 USD [11].
- Average cost per day is calculated by dividing the average total hospital cost for TKA by the TKA national average length of stay ($14,947/3.4 days) [11].

Results

TKA patients who underwent surgery utilizing VISIONAIRE instrumentation had statistically significant reductions in hospital stay (Mean: 59.2 vs. 66.9 hours; p = 0.043), skin-to-skin operative time (Mean: 121.4 vs. 128.1 minutes; p = 0.048) and surgical tray utilization (Mean: 4.3 vs. 7.5 trays; p<0.0001) compared to standard surgical instrumentation [6].

Cost for VIS and STD hospitalizations were calculated by multiplying the respective length of stays by the average cost per day.

Costs for VIS and STD surgical tray utilization were calculated by multiplying the processing cost per surgical tray by the number of trays utilized.

Cost for VIS, NTKA and STD OR procedures were calculated by multiplying the number of procedure minutes by the cost per minute of orthopaedic operating room time.

Cost for this analysis is defined as the amount of hospital expenditure required to deliver medical care, as compared to the term charge, which is the amount of money the hospital bills for the services provided. For this analysis, the total cost represents the surgical episode of care. Therefore, it does not include requisite outpatient MRI and X-Rays performed 2-3 weeks prior to surgery in the VISIONAIRE group.

Table 1: Comparison of TKA Economic Outcomes

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<tr>
<td>Length of stay – Days</td>
<td>2.5</td>
<td>2.8</td>
<td>3.4</td>
<td>0.3</td>
<td>0.9</td>
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<tr>
<td>Total operative time – Minutes</td>
<td>121.4</td>
<td>128.1</td>
<td>150.0</td>
<td>6.7</td>
<td>28.60</td>
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<tr>
<td>Surgical tray utilization – Trays</td>
<td>4.3</td>
<td>7.5</td>
<td>N/A</td>
<td>3.2</td>
<td>N/A</td>
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</tbody>
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N/A: No Data Available

Table 2: Potential Economic Value of VISIONAIRE Instrumentation (USD)

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<tr>
<td>Length of stay</td>
<td>$10,990.00(a)</td>
<td>$12,309.00(b)</td>
<td>$14,947.00(c)</td>
<td>$1,319.00</td>
<td>$3,957.00</td>
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<tr>
<td>Total operative time</td>
<td>$3,035.00(d)</td>
<td>$3,203.00(e)</td>
<td>$3,750.00(f)</td>
<td>$168.00</td>
<td>$715.00</td>
</tr>
<tr>
<td>Surgical tray utilization</td>
<td>$258.00(g)</td>
<td>$450.00(h)</td>
<td>N/A(i)</td>
<td>$192.00</td>
<td>N/A(i)</td>
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a $14,947 / 3.4 x 2.5 days; b $14,947 / 3.4 x 2.8 days; c $14,947 / 3.4 days; d $25.00 x 121.4 minutes; e $25.00 x 128.1 minutes; f $25.00 x 150 minutes; g $60 x 4.3; h $60 x 7.5; i N/A: No data available.
Results continued

Findings from an analysis of admission and discharge dates showed a decreased length of stay for patients who underwent a TKA utilizing VISIONAIRE® instrumentation as compared to standard instrumentation and national data. Eight VISIONAIRE patients were found to have a two-day length of stay, as compared to only three patients in the standard group. Compared to standard TKA and NTKA, VISIONAIRE instrumentation decreased the average hospital length of stay by 0.3-0.9 days [6, 10-12]. This decrease in length of stay may support cost savings ranging from $1,319-$3,957 per case, while a 6.7-28.6 minute decrease in OR time could result in savings of $168-$715. Finally, because fewer instruments are required when intraoperative sizing and intramedullary alignment guide placement are unnecessary, a decrease of 3.2 surgical trays was demonstrated with a potential savings of $192 per case. These theoretical savings are extrapolations that will vary from site to site. However, the results do highlight inefficiencies that may be addressed with the utilization of patient-matched instrumentation.

Discussion

Preliminary evidence suggests that VISIONAIRE instrumentation can improve procedure efficiency, resulting in potential cost savings for the hospital. The primary limitation of the current analysis is that these results are derived from a single-center study with a small sample size. Furthermore, there are many factors to consider when comparing TKA costs between groups of patients. Patient characteristics, operating room efficiency, cost allocations, fixed overhead costs, labor costs, implant selection, and surgical technique can all vary by hospital.

As compared to standard TKA and NTKA, VISIONAIRE instrumentation may decrease the costs associated with length of hospital stay by $1,319-$3,957 per case. A hospital that utilizes VISIONAIRE instrumentation on 250 cases per year could potentially realize savings in the range of $330,000-$989,000 annually. Regarding operative time, VISIONAIRE patients experienced a decrease of 6.7-28.6 minutes per case. In addition, patients who received patient-matched instrumentation utilized 3.2 less surgical trays. This reduction in surgical tray utilization could result in potential cost savings of $192 per case associated with maintenance, storage and sterilization of fewer instruments, and may improve overall productivity as a result of increased operating room turn-around time.

In addition to the economic cost benefits, there is also a potential clinical benefit to utilizing VISIONAIRE instrumentation. Procedure duration could be shortened with the use of more efficient surgical instrumentation. Longer procedure times have been identified as risk factors for various complications associated with TKA, including increased mortality, infection, venous thromboembolism, and postoperative neurological dysfunction [13-16]. Proper alignment of the prosthesis appears to be critical in minimizing long-term wear, risk of osteolysis, and loosening of the prosthesis [1]. Noble et al [6] reported that mechanical alignment in the VISIONAIRE group was significantly closer to neutral zero, as compared to standard TKA (1.7° vs. 2.8°; p = .03). It is possible that aligning the knee closer to neutral zero could support improved long-term outcomes [6]. However, additional research with a statistically powered sample size is needed to confirm this hypothesis.

Conclusion

Recently published evidence demonstrates that VISIONAIRE patient-matched instrumentation may decrease operative time, hospital length of stay, and surgical tray utilization [6]. Results of the current analysis suggests that this increased efficiency could reduce short-term costs associated with TKA. Moreover, the potential for improved long-term clinical outcomes and reduced revision rates could potentially reduce costs further. A statistically powered, multicenter, randomized clinical study is currently underway to confirm these initial single center findings, and to establish the long-term efficacy of patient-matched instrumentation (ClinicalTrials.gov Identifier: NCT01084772).
References

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