Innovation

Surgeon opinion on new technologies in orthopaedic surgery

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(Received 21 September 2010; revised 23 December 2010; accepted 9 January 2011)

Technological advances such as computer navigation systems and robotics, including support systems for minimally invasive surgery, have the potential to revolutionise how orthopaedic surgery is carried out. However, uptake has so far been limited. Increased awareness of user requirements in adoption decision-making will be useful. In this regard, the opinion of the individual surgeon regarding his or her willingness to engage in a novel technology has rarely been garnished. This paper analyses the opinions of orthopaedic consultants from the UK and USA about technological advances in hip and knee arthroplasty, factors contributing to successful short-term and long-term surgical outcome, and patient preferences. The survey, using a web-based questionnaire, was carried out in 2006–2007 and followed up in 2010. The results of this research give a greater insight into why surgical technologies that have the potential to improve patient outcome are not more speedily adopted in the health service.

Keywords: Medical device; Computer aided surgery; Orthopaedics; Healthcare technology

1. Introduction

A central issue concerning wider acceptance of technological advances such as computer-assisted orthopaedic surgery (CAOS) systems [1, 2] is the difficulty of proving effective benefits in an evidence-based environment. Specific issues that need to be addressed include: ongoing developments of conventional methods that already have a very high degree of success; evidence of clinical outcome as benefits from an innovation may only be obtained several years after its introduction; capital and procedure costs are generally higher for technologically driven procedures; and variation in outcomes from the procedure can depend on several other factors that are not directly related to the actual choice of the technology.

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The 2003 US NIH Consensus Development report on Total Knee Replacement [3] stated that ‘Computer navigation may eventually reduce the risk of substantial malalignment and improve soft tissue balance and patellar tracking. However, the technology is expensive, increasing operating room time, and the benefits remain unclear’. In a similar manner, in 2004, the Ontario Health Technology Advisory Committee [4] following a review of navigation and robotic technologies for orthopaedics, whilst noting that short-term outcomes were encouraging, decided that it was still in an investigational phase.

This hesitation in embracing the role of new technologies is mirrored by statistics from the UK National Joint Registry (NJR) [5], which show that there has been a slow uptake in the use of some new technologies by surgeons. Successive
annual reports from the NJR group (covering years 2003–2009) record an almost steady 1% of operations for hip replacements performed in each year for the category ‘Image guided surgery’ and a modest range of 4–7% for ‘Minimally invasive surgery’ (5% in the last two years). The picture for knees shows only a modest increase from 1% to 3% for image guided surgery (which includes up to 6% of cementless primary total arthroplasties) and around 6–8% for MIS (which includes over half of unicompartmental knee arthroplasty [6] episodes performed in most years).

This paper provides an overview of the new technologies involved in orthopaedic surgery at the time of the study (2006–2007) and reports on the results of a questionnaire that recorded the opinions of surgeons to the introduction of new technologies, with specific relevance to computer-assisted surgery using navigation and robotics. Reference is also made to updates in these technologies since 2007 and responses from the 2010 follow up of the surgeons who completed the original questionnaire.

2. Technology Overview

Picard et al. [7] classified computer-aided orthopaedic surgery (CAOS) systems according to the use of imaging and the degree of autonomy of the machine to produce assistance with respect to the surgical procedure. This classification is used in the following brief technology overview.

A number of current CAOS systems use imaging methods to acquire information about bone geometries of the joint and limbs, especially from preoperative computerised tomography (CT) and/or intraoperative fluoroscopy [1,2]. These are then generally termed image-guided surgery (IGS). A CT scan is usually carried out preoperatively in a separate facility than the operating room (OR). All IGS systems require registration of the images obtained with the patient’s anatomy in order to be effective.

An increasingly prevalent alternative to IGS is image-free (or imageless) CAOS where the joint geometry is acquired during surgery. This technique starts with a computer model of a default joint that is modified (morphed) in a step-by-step process whereby the surgeon selects anatomical points and/or surfaces on the patient’s joint. The acquired points then allow the default model to be represented as a graphical image of the joint concerned. This is then used as a guide. It should be noted that only the acquired points and rendered surface can be relied on to provide guidance to the surgeon.

In contrast to such navigation technologies that leave control fully in the hands of the surgeon, an array of robotic systems have also been devised [8]. These are classified as either active or semi-active according to the degree of autonomy of the robot. In a review of robotic surgery systems Howe and Matsuoka [9] described automated forming of the femoral cavity for total hip arthroplasty (THA) with cementless implants by ROBODOC, which is an active robotic system based on an industrial robot first trailed in 1992. In this approach preoperative CT scans are loaded pre-surgically into software to allow the selection of implant and to plan its placement. Then, in the operating room, the femoral head is removed by the surgeon as per a normal manual operation. The femur is clamped to a reference point (fixator) on the robot base, and previously implanted metallic fiducial pins are located by the robot to complete registration. After a safety check by the surgeon, the robot forms the femoral cavity using a high-speed milling machine whilst a separate system alerts to any excessive bone shifting that would require re-registration. Once the cavity is formed, the surgery again proceeds as per a manual operation. Siebert et al. [10] described a similar type of semi-automated procedure, termed computer-assisted surgical planning and robotics (CASPAR), for bone preparation for total knee arthroplasty (TKA). Both companies involved in these two systems are now in liquidation, however OrthoMIT (www.orthomit.de) as it comes from a German project named Schonenbeds Operieren mit innovativer Technik (SOMIT), is a new modular milling system in development with tool heads that are interchangeable for hip, knee and spine surgery.

Semi-active robotic systems are another class of CAOS system where the robot typically assists the surgeon in placing jigs and supporting instruments but the surgeon is still responsible for reaming and cutting. Such robots can help the surgeon avoid nerve and ligament areas by excluding them from the workspace [9]. A more recent commercial example of the semi-active approach is Acrobot™, which uses ‘active constraints’ to prevent the surgeon accidently moving a bone cutting tool outside a specified area [11]. The Robotic Arm Interactive Orthopedic System (RIO) is being used to support partial knee resurfacing [12]. Troccaz and Merlot have cited two additional prototype ‘synergistic’ robotic assistants: PADyc™ and Cobot™, and point to future possibilities for miniature and disposable robots [13]. A number of other robotic systems, both historical and in development, are described by Bargar [14] and Guven and Barkana [15].

A selection of the CAOS systems commercially available at the time of the surgeon survey in 2006–2007 is given in table 1. Some of these are implant specific systems arising from partnerships between implant manufacturers and navigation system developers. Others are available as generic components for either radiological imaging or surgical navigation and tracking.

It should be noted that regulatory differences have an effect on the availability of CAOS in different countries. For example, CAOS equipment manufacturers have generally acquired US FDA clearance for navigation software products via the 510(k) pre-market notification route since these are deemed to be substantially equivalent to devices already in use for neurology [16]. This is important, since robotic systems have generally had more difficulty
Table 1. A selection of commercially available computer aided orthopaedic surgery (CAOS) systems and components up to and during year of study.

<table>
<thead>
<tr>
<th>Company</th>
<th>System name</th>
<th>Classification and description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aesculap</td>
<td>Orthopilot</td>
<td>Image-less TKA and ACL, planning and navigation.</td>
</tr>
<tr>
<td>BrainLAB</td>
<td>VectorVision</td>
<td>Image-free and CT-based planning and navigation.</td>
</tr>
<tr>
<td>CASurgica, Inc.</td>
<td>HipNav KneeNav</td>
<td>CT-based. Preop. planning, RoM simulation, acetabular placement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for hips. Navigation for TKA.</td>
</tr>
<tr>
<td>DePuy/BrainLAB</td>
<td>iOrthopaedics Ci System</td>
<td>Image-less, TKA and THA planning and navigation.</td>
</tr>
<tr>
<td>GE Healthcare</td>
<td>FluoroTrak/Flexview</td>
<td>Fluoroscopy navigation system/Mobile C-arm.</td>
</tr>
<tr>
<td>Integrated Surgical Systems (ISS)</td>
<td>ROBODOC/ORTHODOC</td>
<td>Active robotic system/associated planning system.</td>
</tr>
<tr>
<td>Medivation Synthes</td>
<td>SurgiGATE</td>
<td>CT-based navigation system.</td>
</tr>
<tr>
<td>Medtronic SNT (Surgical Navigation Technologies)</td>
<td>StealthStation</td>
<td>Image-based navigation system, TKA and MIS knee working with various third party C-arms, CT or MRI.</td>
</tr>
<tr>
<td>Northern Digital, Inc.</td>
<td>Optotrac/Aurora</td>
<td>Generic IR tracking system/electromagnetic tracker.</td>
</tr>
<tr>
<td>PI Systems</td>
<td>PiGalileo</td>
<td>Image-free navigation system, TKA and THA, plus electromechanical positioning 'mini-robot' for TKA.</td>
</tr>
<tr>
<td>Siemens Medical Solutions</td>
<td>SIREMOBIL Iso-C/Iso-C3D</td>
<td>2D/3D C-arm fluoroscopy working with various third party navigation systems.</td>
</tr>
<tr>
<td>Smith &amp; Nephew/ORTHOfit</td>
<td>AchieveCAS, Navitrack</td>
<td>Image-less navigation for TKA and THA (models derived from CT).</td>
</tr>
<tr>
<td>Stryker Orthopaedics/Leibinger</td>
<td>Navigation System/Knee Navigation System</td>
<td>Image-free THA/TKA, with wireless tracking technology (can be image-based for other procedures).</td>
</tr>
<tr>
<td>Universal Robot Systems (URS)</td>
<td>CASPAR</td>
<td>Active robotic system for bone preparation in TKA.</td>
</tr>
<tr>
<td>Ortho</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

obtaining approval in the USA, for which the more stringent pre-market approval (PMA) routes to compliance have been applied. Since the USA is a major market for CAOS technology, as well as one of its developers, delayed approval in the USA might tend to affect general acceptance of any such technology.

3. Methodology

A cross-sectional online survey of orthopaedic surgeons was conducted. The aim of the survey was to collect the opinions of orthopaedic surgeons on a number of issues relating to hip and knee joint replacement surgery, associated care and technologies. The questionnaire was developed by the authors based on a number of semi-structured interviews with orthopaedic surgeons in Belfast and Nottingham. The interview data were used to inform the questions and the responses. The design of the questionnaire was refined slightly following a pilot study of a small number of orthopaedic surgeons and then launched online in April 2006 (at http://www.match.ac.uk). Details of the web-based questionnaire were emailed to all the members of the British Orthopaedic Association as well as other research active surgeons known to the researchers and international contacts. Surgeons were asked required to answer a maximum of 27 questions depending on whether or not they performed hip or knee replacement surgery or both, as well as on how research active they were. The questionnaire consisted of both closed and open questions. Sample questions can be seen in Appendix I.

Responses to the questionnaire were initially collected over a 10-month time frame from May 2006 to February 2007. The majority of those who took part in the 2006–2007 survey were then contacted again in late 2010 via email and asked the same questions to determine if there was any change or shift in their earlier opinions on this topic.

The qualitative and quantitative responses were analysed using Microsoft Excel and the open-ended questions were analysed using thematic analysis. The main findings from the questionnaire are discussed in the following sections.

4. Results

The surgeons who responded were from 28 different orthopaedic centres, the majority of the responses were from centres in the UK (92%), from as far north as the Aberdeen Royal Infirmary to as far south as the Royal Devon & Exeter Hospital. The other two responses were from The Hospital for Joint Diseases, New York, USA. The demographics of the respondents show the advantages of a web based questionnaire as outlines in Appendix I.

A total of 27 surgeons (several working more than one centre) completed the initial questionnaire in 2007. Of these 18 (67%) performed both hip and knee replacements, one performed only hip replacements and one performed only knee replacements. A further seven respondents did not perform either hip or knee replacement surgery and completed just the technology section.

The mean number of primary hip replacements performed annually by each surgeon was 80. The mean number of revision hip operations was 20. The mean number of knee replacements per surgeon per year was 48 and that of revision knee operations was 6.
In 2010 the mean number of hip replacements performed annually by each of the respondents was 58 and the mean number of knee replacements was 70. The responses for hip and knee data are initially discussed together in order to compare and contrast responses.

4.1. Surgical factors

For some of the questions pie charts are presented to allow visual comparison of the relative frequencies of high-ranked responses (ranked 1 or 2) and mid-ranked responses (ranked 3 or 4). Other factors, elicited from the respondents, are included in the charts if they resulted in one or more high-ranked or mid-ranked responses. For brevity, ranking results only are presented for later questions.

The results for pre-surgical factors were as follows:

- prosthesis design is a high-frequency high-ranked response for hips;
- prosthesis design and instrumentation are high-frequency high-ranked responses for knees;
- prosthesis material and cement are high-frequency mid-ranked responses for both hips and knees;
- skills/experience/training and patient selection/motivation were added as other factors with medium-frequency high-ranked responses for both hips and knees;
- surgical and rehab team skills were added as other factors with low-frequency mid-ranked responses; and
- other factors mentioned only once were: alignment, bearings for hips and kinematics for knees.

In 2010 the pre-surgical factors that were deemed to be of importance were patient history, examination and pre-op education; correct implant selection, good quality X-ray (preferably digital), pre-op planning and position of patient on table.

For knees, weight, Body Mass Index (BMI) and degree of deformity (intra-articular as well as extra-articular) were found to be important; it was also said that range of movement can be a factor.

The results for questions concerning important factors during surgery were:

- prosthesis placement is a high-frequency high-ranked factor for hips;
- prosthesis placement and balancing/care of soft tissues are high-frequency high-ranked factors for knees;
- managing blood loss and balancing/care of soft tissues are high-frequency mid-ranked factors for hips;
- managing blood loss and cement placement are high-frequency mid-ranked factors for knees;
- cement placement is a medium-frequency high- and mid-ranked factor for hips;
- other factors mentioned once for hips were: decision to operate, surgical exposure, optimal preparation of the bone, cysts, etc., patient selection, surgical technique, infection prophylaxis, bearings, understanding the procedure and maintenance of sterility; and
- other factors mentioned once for knees were: removing third bodies, bone treatment/cysts grafting, patellar tracking, obtaining full extension and surgical technique.

In 2010 the important factors for hip replacements during surgery were considered to be correct implant sizing, acetabular placement and position; anteversion of neck and depth of femoral stem. For knee replacements important factors were also implant sizing, posterior angulation of tibial component, and soft tissue balance in flexion and extension, which requires careful attention to femoral component rotation.

4.2. Patient data

Figure 2(a) shows the patient information that surgeons generally collect prior to carrying out a primary hip replacement operation. All of the surgeons questioned recorded the disease history and an X-ray of the pelvis; the majority of surgeons also recorded patient weight (94%), height (83%), medial–lateral X-ray (67%) and anterior–posterior X-ray (61%); 56% of the surgeons also recorded an estimation of the expected post surgery activity.

The patient data that were recorded prior to knee replacement surgery is shown in figure 2(b). The study revealed that 94% of the surgeons questioned recorded the patients’ height, weight, disease history and short leg medial–lateral X-ray. The majority of surgeons (88%) also used a short leg anterior–posterior X-ray in their assessment, but only 38% requested a long leg anterior–posterior X-ray and 13% a long leg mediolateral X-ray. It should also be noted that in this case 75% of surgeons recorded the patients’ expected post surgery activity and 63% recorded mobility score prior to primary knee replacement surgery. These results indicate that there is a greater emphasis on recording activity data for knee replacement patients than for hip replacement patients.

There were no significant differences noticed in the patient data collected prior to surgery in 2010 as opposed to 2007.

4.3. Patient priorities

Surgeons were asked about the issues that their primary hip or knee replacement patients say are most important to them. For hip replacement patients long-term freedom from pain was ranked as the most important factor, with all 19 surgeons ranking this as either the first or second priority. Achieving normal function was ranked as the second most important factor, followed by post-operative freedom from pain and then achieving normal function. Acceptable scar
appearance was deemed to be of least importance for hip replacement patients. For primary knee replacements there was also a high level of agreement between respondents that long-term freedom from pain was the most important factor for these patients with 18 of the 19 surgeons ranking this as the top priority. Achievement of normal function was
ranked as the second most important factor followed by post-operative freedom from pain and finally acceptable scar appearance.

In 2010 relief of pain and returning to full function were also deemed to be the most important issues for patients. It was also stated that patients had a fear of not knowing what to expect and of complications, especially infection and dislocation. This may indicate a more knowledgeable patient group as a result of healthcare information becoming more widely available via the internet.

Figure 2. Patient data collected prior to (a) hip replacement surgery; (b) knee replacement surgery.
4.4. Technology

Table 2 shows the responses of surgeons with regard to new technologies and techniques. Five of the 27 respondents reported that they routinely used navigation or computer assisted surgery systems with a further three reporting that they had tried it. Eight surgeons had tried computer systems for pre-operative planning but none reported that they used these routinely. Of the 27 respondents, 19 reported that they had experience of minimally invasive surgery, however only four reported that they used this routinely.

Surgeons were asked an open question of how they thought the current technology used for joint replacements could be improved. Of the responses to this question 33% related to prosthesis-bearing materials and 20% to the need for improved instrumentation. One surgeon commented that ‘The current technology is merely being recycled waiting for the next breakthrough’ and another surgeon stated ‘Reduce the effect of market driven change—the wholesale introduction of new prostheses and changes to existing prosthetics to keep ahead of the competition’.

In 2010 the responses about how the current technology used for joint replacements could be improved were as follows: ‘avoid the release of new implants every four years’; ‘more user friendly and quicker navigation’; ‘ergonomic instruments’; ‘getting the tibial rotation right’; and ‘more reliable integration of hydroxyapatite coatings to bone’.

The respondents were asked about the ‘technology related factors’ that would improve the clinical success of joint replacement surgery. Improved prosthesis design was ranked as the most important factor followed by improved prosthesis material. Use of computer-assisted pre-operative planning was ranked the 3rd most important factor followed by use of computer-assisted navigation. There was a high degree of variation in the rankings of the option use of robots to perform parts of surgery. Two surgeons were of the opinion that this was the most important factor in improving clinical success of joint replacement; however others rated this as the least important or not important at all. Indeed one surgeon went so far as to state in the other comments section, ‘Surgical robots—shall we perform surgery from home then. Get a grip these are people we are operating on’.

In contrast to this when one surgeon was asked about the ‘technology related factors’ that would improve the clinical success of joint replacement surgery he states, ‘Navigation!—it is the most consistent and accurate way to make the bone cuts. It precludes intra-medullary penetration and restores mechanical axis more consistently’.

When asked about the information that they considered to be most important in decision-making on new equipment for use in knee or hip replacements, clinical evidence was ranked as the most important by 23 of the 27 respondents (85%). The second most popular response was personal experience of new equipment, which was ranked by 17 surgeons as either the most important or 2nd most important factor. One surgeon in 2010 stated that ‘Management needs “business case” and implant companies reluctant to change if not doing enough volume’. Another stated ‘COST – need a proper business case and agreement of colleagues as we wish to always use same implants/techniques’.

When asked what barriers they faced when wanting to change the equipment used for hip and knee replacement, lack of money was the most popular answer with 20 of the 27 surgeons reporting this. This was closely followed by getting agreement from management to do so, which was reported by 17 surgeons. Lack of long-term supporting clinical evidence was reported by 11 surgeons and getting agreement from other colleagues was reported by nine.

One surgeon stated in 2010 that he felt that an ideal new technology in this area needed to be cost-effective, user-friendly and ergonomic in order to overcome the barriers to acceptance.

It is interesting to note that in 2010 the necessity to demonstrate cost effectiveness and proof of a new technology was deemed to be of the utmost importance.

There was an equal split in the decision-making powers that surgeons believed they had with 52% saying that they were involved in the decisions on what equipment (prostheses and other surgical equipment) they used and 48% saying that they were not. This may reflect a spread in the grade of the surgeon respondents with more senior surgeons being able to wield a greater influence on the technologies that are employed within their operating theatre. In the 2010 results all of the surgeons who participated believed that they had a role in the decisions of which equipment they used.

<table>
<thead>
<tr>
<th>Computer systems for pre-operative planning</th>
<th>Navigation systems/Computer-assisted surgery</th>
<th>Surgical robots</th>
<th>Minimally invasive surgery</th>
<th>Hip re-surfacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use routinely</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Have tried</td>
<td>8</td>
<td>3</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>No experience</td>
<td>16</td>
<td>16</td>
<td>22</td>
<td>5</td>
</tr>
<tr>
<td>No answer</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>
5. Discussion

Care must be taken when interpreting the results of this surgeon questionnaire due to the relatively small number of respondents. As is common with online surveys the response rate was relatively low with just 2% of those contacted completing the questionnaire. In addition to this, it is possible that the surgeons who responded had particularly strong views (either positive or negative) about new technologies for orthopaedic surgery and therefore their responses may not be entirely representative of the opinions of all orthopaedic surgeons. However, the results do provide us with an insight into a range of opinions.

This survey found that orthopaedic surgeons believe that prosthesis design is the most important factor in the success of hip and knee replacements. The responses also suggest that, given a good prosthesis and a highly skilled and well-trained surgeon, the particular instrumentation used to insert the device is considered to have little effect on the long term success of the implant.

When surgeons were asked about the issues that are most important to patients undergoing primary hip or knee replacement, they reported pain reduction and achieving an improved range of motion as the primary considerations. The ability to achieve accurate alignment with minimum scar size is cited as one of the principal benefits of CAOS, however latest statistics from the National Joint Registry (NJR) [5] show that only 5% of hip operations were categorized as minimally invasive surgery (MIS), which is a reduction from its peak in 2007 of 7%. This apparent reduced overall demand for MIS in light of other factors may be one of the key reasons for the slow uptake of new computer aided technologies.

A decision to adopt a new technology is unlikely to be made solely by an individual surgeon but rather with peers and other stakeholders who may have differing opinions on what contributes most to successful outcomes. Since new technology is expensive it may not be surprising that lack of money was cited to be the main barrier that surgeons faced when wanting to change the equipment that they used. The issue of cost is likely to become increasingly important in the current economic climate; with health service managers faced with budget shortages there is a growing need to demonstrate that a new product is superior to an existing one in terms of value. The majority of the surgeons in the 2010 survey stated that a proper business case in needed by all stakeholders in order for new innovations to be adopted in the health service. A business model’s great strength as a planning tool is that it focuses attention on how the elements of the system fit into a working practice as a whole, especially in terms of how perceived value is created.

Health economic models can be useful in the absence of long-term outcome data to show whether the increased benefit on a new technology is financially justifiable for a procedure that already has a high success rate. Dong and Buxton [17] applied a Markov model to compare cost-effectiveness of total knee replacement using computer-assisted surgery with that using a conventional manual method in the absence of formal clinical trial evidence. Their model predicted that computer-assisted total knee replacement is a cost-saving technology in the long term and may offer small improvements in quality of life as it is likely to reduce revision rates and complications through more accurate and precise alignment. If surgeon opinion is quantified at an early point in the life-cycle of a new technology, when no or limited clinical trial data is available, it can be used in Bayesian models to predict the success or otherwise of a new technology.

The results of this survey indicate that surgeons are more willing to adopt technologies that help them to accurately position a joint prosthesis, but are unlikely to trust computers or robotics actually to carry out any critical operative functions. This may be because of the ultimate responsibility of duty of care that surgeons have for patients, so they are more likely to rely on their medical training and can respond to minute differences in patients’ anatomy directly. Therefore for any new technology to be successful it must not hint at devaluing the need for high surgical skill and must show itself to be a cost-effective means of improving clinical practice.

It can be concluded that the opinion of the surgeon is central in not only evaluating the utility of a new surgical technology but also in developing models to predict its long-term effectiveness.

Acknowledgements

The authors would like to thank Mr David Adams, Chief Executive of The British Orthopaedic Association and members of the BOA for their cooperation in distribution and completion of the web questionnaire.

Declaration of Interest: The Multidisciplinary Assessment of Technology Centre for Healthcare (MATCH) research programme (http://www.match.ac.uk) is core funded by the UK Engineering and Physical Sciences Research Council (EPSRC) through grant EP/F063822/1 and at the time of the 2006–2007 survey by grant GR/S29874/01, the Department of Trade and Industry (DTI), Invest Northern Ireland (INI), NHS National Patient Safety Agency (NPSA), and subscriptions from the medical devices industry. The surgeon survey was suggested by DePuy International as part of their subscription to MATCH at the time of the 2006–2007 survey.
References


Appendix 1: Sample questions from web-based surgeon questionnaire

Section A: Hips

1. Do you perform hip replacements? (if no redirected to knee questions)
2. Approximately how many hip replacements do you perform per year?
3. In your opinion, what are the critical pre-surgical factors that influence the success of a primary hip replacement?
4. During surgery, what in your opinion are the most important factors to get right in primary hip replacement?
5. How common are the following problems with primary hip replacement patients? Loosening of prosthesis; Dislocation of hip joint; Instability of the joint; Pain; Problems with full weight bearing; Failure to achieve expected range of motion; Infection; Other (please specify).
6. In your opinion, in the FIRST YEAR following a hip replacement, how common are the following problems with primary hip replacement patients? Loosening of prosthesis; Dislocation of hip joint; Instability of the joint; Pain; Problems with full weight bearing; Failure to achieve expected range of motion; Infection; Other (please specify).
7. In your experience, what are the most common reasons for having to perform a revision of a primary hip replacement?
8. What issues do your primary hip replacement patients say are most important to them?
9. Before primary hip replacement surgery, what patient information do you collect?
10. Are you currently involved in any research projects concerned with hip replacements?

Section B: Knees

1. Do you perform knee replacements?
2. Approximately how many knee replacements do you perform per year?
3. In your opinion, what technology related factors would improve the clinical success of joint replacement surgery?
4. Can you see any way in which the current technology used for joint replacements could be improved?
5. What barriers do you face when wanting to change the equipment that you use for knee or hip replacements?
6. Are you involved in the decisions on what equipment (prostheses and other surgical equipment) you use for knee or hip replacements?
5. What information do you consider most important in decision-making on new equipment for use in knee or hip replacements?

6. What experience do you have of new techniques and technologies for use during knee and hip replacement surgery?

7. Please feel free to add your comments on any aspect of the questionnaire.

**Demographics recorded**

Name, contact email, primary hospital/workplace, other hospitals/workplaces, year of becoming orthopaedic consultant/likely year of completion, orthopaedic speciality.