TKA Navigation Using the Medacta System

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Since its inception over a decade ago, the goal of more accurate prosthesis placement has routinely been met (Bäthis et al. 2004a, 2004b; Bohling et al. 2005; Chauhan et al. 2004a, 2004b; Chin et al. 2005; Krackow et al. 2003; Oberst et al. 2003; Saragaglia et al. 2001; Sparmann et al. 2003; Stulberg et al. 2000, 2002). Although the original prediction of higher longevity with more accurate placement and even distribution of forces has not yet been proven, a meta-analysis of 29 studies of computer-assisted surgery (CAS) vs. standard mechanically instrumented total knee arthroplasty (TKA) showed that errors of 3° occurred in 9% of the former procedures vs. 31.8% of the latter. The controversy over the importance of ±3° mechanical alignment owing to varying midterm reports still does not change the consequences of performing a reconstruction inaccurately nor the ability for CAS to be more accurate (Alden and Pagnano 2008; Berend et al. 2004; Haaker et al. 2005; Mason et al. 2007; Nuno-Siebrecht et al. 2000; Ranawat and Boachie-Adjei 1988; Ritter et al. 2004; Sharkey et al. 2002; Stern and Insall 1992; Teter et al. 1995; Wiese et al. 2004; Wixson 2004). However, this focus may miss the most significant issue remaining in influencing the functional outcome of the new knee. As results have improved, patient expectations have increased. Today's patients, independent of age, expect to live more active lives. This author works in one of the world's »blue zones.« (A *blue zone* is a region of the world where people commonly live active lives past the age of 100 years.) Thus, while the statistics show that the mortality rate after TKA is 3% per year, most of today's patients are not only encouraged but also expect to live physically active lives. This aims the focus toward longevity and stability. While instability remains one of the top three leading causes of early TKA revision (Fehring et al. 2001; Haaker et al. 2005), it also remains one of the leading causes of dissatisfaction in recipients of TKA. After accomplishing the initial goal of fewer mechanical alignment outliers, the real advantage of navigation involves the ability of the system to aid the surgeon in obtaining well-balanced knees throughout the functional range of motion (ROM). We will discuss this further as we describe the surgical technique. During the early 1990s, minimally invasive surgery (MIS) techniques were shown to improve early ROM, reduce blood loss, and decrease hospital stay (Boerger et al. 2005; Haas et al. 2004; Han et al. 2008; Karachalios et al. 2008; Laskin 2007; Pagnano and Meneghini 2006; Schroer et al. 2008) but the complication rate also increased. The major issues have been component malposition, cement removal, and soft tissue injury with malposition being the major occurrence (Dalury and Dennis 2005; Huang et al. 2007) This is exactly where a marriage between navigation and MIS can help significantly.

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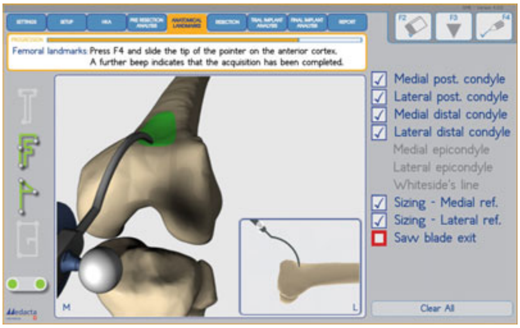
As with other systems, the CAS instruments are specifically designed to decrease the stress on the soft tissues. In over 5 years of MIS–CAS–TKA, to date we have not had an avulsed patellar tendon but have had a 0.5% incidence of partial or complete medial collateral ligament (MCL) injuries.

The Medacta system is provided cost free to the hospital, but there is a small fee for the disposable reflective balls. Otherwise there is no additional cost. The system is based on the Medacta cutting blocks and as such is tied to their prosthesis. As with most systems, there is an addition of 7–10 min to the overall surgical time once the surgeon is familiar with the system (on average <10 cases). The shorter learning curve is in part related to a strong educational program with visiting surgeons on location and to the way the system is designed. The system has purposely streamlined and simplified the steps as well as the visual presentation of data so as to provide only that information which is needed and can be readily used by the surgeon. The flow and options are also customizable to the surgeon's preference, making the learning curve much shorter. All these subtile issues become more important when we ask the non-CAS and non-MIS surgeon to not only add CAS but also MIS techniques to their skill set.

8.1 System Specifics

The Medacta CAS system is an imageless system using optical balls on the trackers and an infrared camera. There are several features designed to make the system easier to use. The flow is customizable and can be saved in multiple set-ups for each surgeon so that he/she can have the freedom to adjust their technique to fit the patient without having to go through a tedious set-up each time.

The layout of the screens provides a consistent visual feedback with all the necessary information


Femoral landmarks: Press F4 and slide the tip of the pointer on the anterior cortex.
A further beep indicates that the acquisition has been completed.

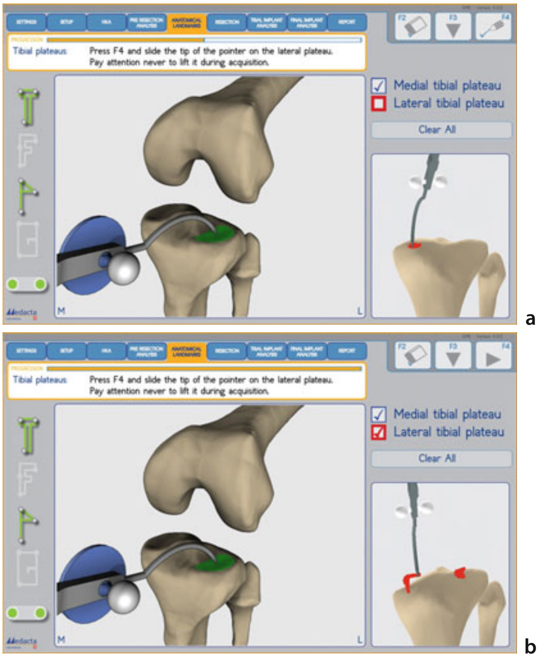
☑ Medial post. condyle
☑ Lateral post. condyle
☑ Medial distal condyle
☑ Lateral distal condyle
Medial epicondyle
Lateral epicondyle
Whiteside's line
☑ Sizing - Medial ref.
☑ Sizing - Lateral ref.
☐ Saw blade exit

Fig. 8.1 Screenshot of Medacta CAS system showing external rotation of 3° and the estimate of distal resection high at the condyles

and intentionally no more (Fig. 8.1). The left-hand side of the screen has a visual of the trackers that are green if seen by the camera. If the surgeon is in the process of acquiring data and the tracker is not recognized by the camera, the tracker image is no longer green and an audible signal alerts the surgeon to the problem. Since femoral and tibial tracker stability is essential for accurate outcomes with CAS systems, the femoral and tibial trackers can be checked at any time on any screen simply by touching the mobile tracker back to the initial reference point established at the beginning of data collection. A number appears next to the tracker image on the left-hand side of the screen to show if, and how much, the tracker has moved.

The mobile trackers are double sided making it easier for the surgeon to obtain the data without having to do as much manipulation of the trackers to obtain camera visualization. The graphics are in real time and modified based on the data provided by the surgeon. This feature provides rapid visual feedback so the surgeon can see if he has accidentally entered an erroneous data point (Fig. 8.2). The disparity from what the surgeon is seeing on the patient and on the screen is readily apparent so that re-registration of the data can be done if necessary. All data collection steps are independent (a specific registration can be recollected at any time without affecting the rest of the registrations). This is very useful when anatomical variations become apparent and/or recollection of a particular data point becomes desirable.

The lower right-hand side of the screen shows the current surgical step and the instruments needed so that the surgical team can better assist the surgeon. The center of the screen provides the surgeon with the information needed for the current step (this is discussed in more detail in Sect. 8.2, »Surgical Technique«). ROM and ligament stability grafts are collected before resection, optionally at the time of trial component placement, and at the conclusion of the case. Any additional information can be added to the case report provided at the end of the case digitally for storage or entry into the medial record. One can record as much or as little as the surgeon desires including any or all steps of the case as well as the grafts. This system collects the results of the cuts not just the jig alignment, not only to be as accurate as possible but because the information is used for the calculations in the following surgical steps. This system was specifically designed to be MIS compatible. Most patients can have an MIS navigated knee with an arthrotomy from the superior pole of the medial tibial tubercle to 2 cm above the superior pole of the patella. The navigation trackers require an additional 1–1.5 cm arthrotomy over the same procedure done conventionally. The technique is designed so that the surgeon can con-


a

Tibial plateaus: Press F4 and slide the tip of the pointer on the lateral plateau.
Pay attention never to lift it during acquisition.

☑ Medial tibial plateau
☐ Lateral tibial plateau

b

Tibial plateaus: Press F4 and slide the tip of the pointer on the lateral plateau.
Pay attention never to lift it during acquisition.

☑ Medial tibial plateau
☑ Lateral tibial plateau

Fig. 8.2 a,b Double-sided mobile trackers vert to conventional intramedullary femoral and extramedullary tibial aligned cutting guides at any time throughout the procedure with the same guides to maintain the same feel and flow.

8.2 Surgical Technique

8.2.1 Pin Placement: Tibia

The mobile trackers are calibrated at the beginning of each case by the surgeon or the surgical team to make sure they have not been damaged since the last surgery. The tibial pins can be placed anywhere that facilitates camera visualization while not interfering with the tibial extramedullary guide. I prefer mid-tibial through two 2-mm stab wounds. If the pins are placed at 45° to the sagittal plane mid-tibia, they work out well. We have not had any fractures with this technique so far.

8.2.2 Incision and Exposure

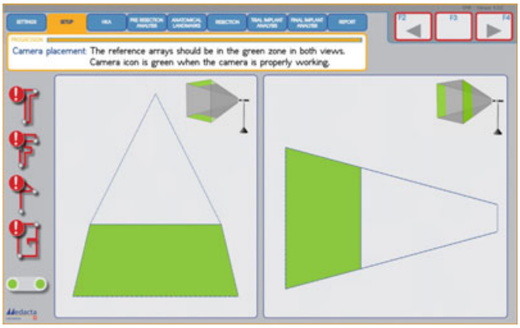
The incision is linear over the middle one-third of the patella with the medial parapatellar MIS arthrotomy the surgeon prefers. The proximal tibial dissection is usually limited to 1 cm below the articular surface, except for the anterior–medial tibia that extends in a triangle to the top of the tibial tubercle.

8.2.3 Pin Placement: Femur

The femoral tracker holder, or pins, are placed wherever the surgeon prefers, but usually such that they exit the wound anterior medially and allow the patella to be displaced laterally.

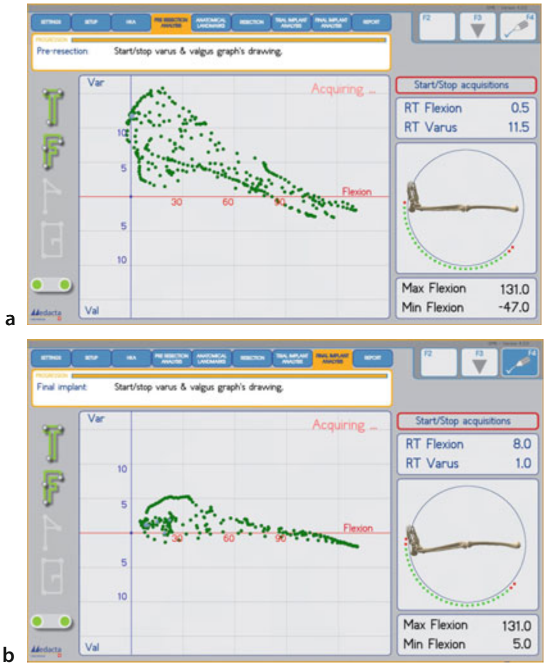
8.2.4 Screen Display

Once the femoral and tibial trackers are placed, the screen shows the camera field of vision and the trackers to assist in ideal camera placement (◘ Fig. 8.3). If necessary, the camera position can be changed any time. Next, the reference points for the »F« and »T« trackers are established. These will be used to check the accuracy of the trackers if needed. This is followed by collecting the following: the most prominent aspect of the medial malleoli, the tip of the lateral malleoli, the center of the tibia proximally, and center of the femur distally. The center of the hip is based on two sets of three data points (hip adducted, abducted, and flexed). A stop sign-like symbol on the screen, with numeric values, gives information on the confidence and accuracy of the hip center. This is followed by establishing the sagittal plane based on limb alignment with the knee extended and flexed. Registration of the tibial plateaus, the posterior and distal femoral condyles, and the anterior femoral cortex as well as the optional registration of the femoral epicondyles, femoral width, and Whiteside's line can be made at the surgeon's discretion. This is especially important in soft tissue balancing. Careful attention to the information allows one to achieve a tight well-balanced knee with ROM of 0–125+ in most cases (◘ Fig. 8.4a, b). In addition to understanding the initial graft, this system has incorporated the use of kinematic measurements of the femoral condyles (◘ Fig. 8.5) and the ability to establish the tibial axis of rotation about the femur, which has been shown to not be the same as the epicondylar line (Churchill et al. 1998; Eckhoff et al. 2005, 2007; Hollister et al. 1993; Howell et al. 2010) It has been my experience that with accurate mechanical alignment, soft tissue releases outside of the posterior capsule in fixed flexion contracture have become rare.



Camera placement: The reference arrays should be in the green zone in both views.
Camera icon is green when the camera is properly working.

◘ **Fig. 8.3** Screenshot with advice for placement of the infrared camera in the operating theater



a

Pre-resection: Start/stop varus & valgus graph's drawing.

RT Flexion 0.5
RT Varus 11.5

Max Flexion 131.0
Min Flexion -47.0

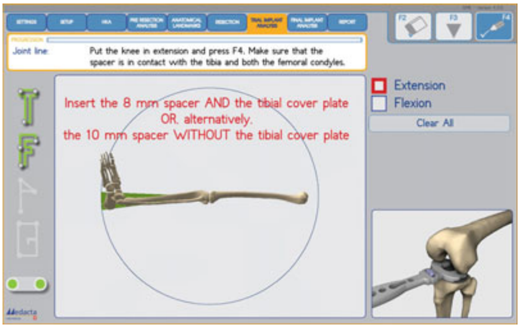
b

Final implant: Start/stop varus & valgus graph's drawing.

RT Flexion 8.0
RT Varus 1.0

Max Flexion 131.0
Min Flexion 5.0

Fig. 8.4 a,b A tight well-balanced knee with a range of motion of 0–125+ can be achieved in most cases



Joint line: Put the knee in extension and press F4. Make sure that the spacer is in contact with the tibia and both the femoral condyles.

Insert the 8 mm spacer AND the tibial cover plate
OR, alternatively,
the 10 mm spacer WITHOUT the tibial cover plate

☐ Extension
☐ Flexion

Fig. 8.5 Kinematic measurements of the femoral condyles are incorporated in the system

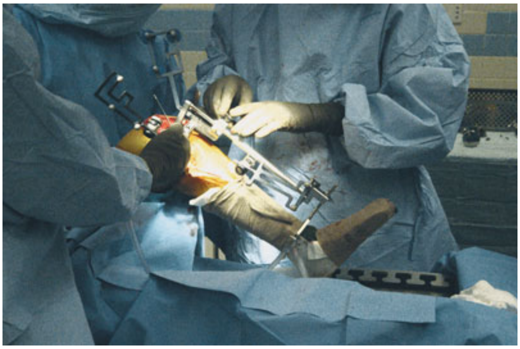


Fig. 8.6 The initial fixation threaded pin is removed from the anterior cruciate ligament footprint with the rest of the extramedullary guide left in place

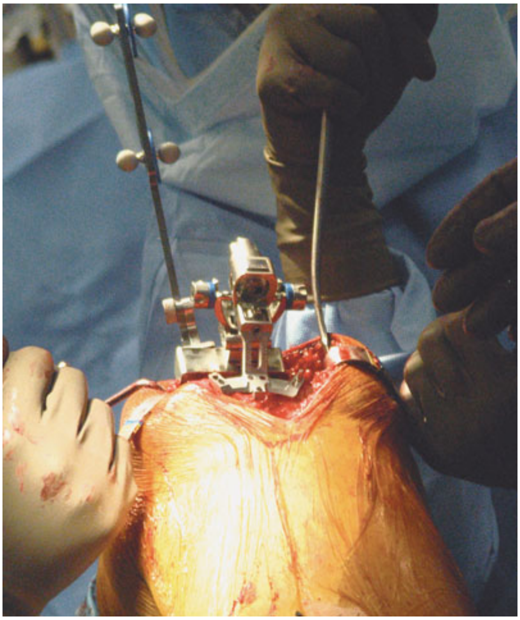
8.2.5 Placing Cutting Guides

Proximal Tibia

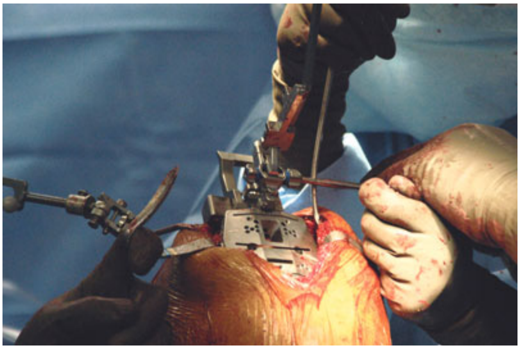
The surgeon can select a distal femoral cut or a proximal tibial cut first. The extramedullary tibial cutting guide is designed to be temporarily pinned with one central pin in the anterior cruciate ligament (ACL) footprint area. The surgeon then navigates the medial-sided cutting guide (or larger cutting guide for a non-MIS approach) into place and pins the cutting block. The initial fixation threaded pin is removed from the ACL footprint and the rest of the extramedullary guide is left in place (Fig. 8.6). This allows the slope and axial alignment to be further adjusted after pinning. It also adds considerably to the stability of the cutting block. The postcut proximal tibial surface is registered.

Distal Femur

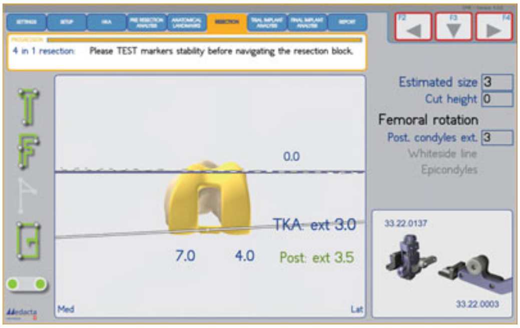
The distal femoral micrometric cutting guide is temporarily pinned to the distal condyles. The distal femoral cutting guide is navigated into place using the micrometric guide and pinned (Fig. 8.7). Each of the cutting blocks can be hand positioned and pinned, but the micrometric guides make it much easier and quicker in most surgeons' hands. Once the distal femoral cutting block is pinned, the micrometric guides are removed and the cut is made with or without a saw capture. The femoral cut is registered and used to match the anterior cut length to the component size. This helps prevent long cut run-out in the anterior cortex of the femur past the flange that can lead to bone resorption/notching. At this point, I like to go back and recapture the posterior femoral condyle, because with an MIS technique it is easier to be more accurate at this time. As previously mentioned, any part of the registration can be done independently of the others. The 4-in-1 femoral cutting guide is attached to the distal femoral cutting block with another micrometric guide and the block navigated into the desired



■ **Fig. 8.7** The distal femoral cutting guide is navigated into place using the micrometric guide



■ **Fig. 8.8** Close-up of navigated 4-in-1 cutting guide



4 in 1 resection: Please TEST markers stability before navigating the resection block.

Estimated size 3
Cut height 0
Femoral rotation
Post. condyles ext. 3

■ **Fig. 8.9** Navigation screen corresponding to the 4-in-1 cutting guide of Figure 8.8

femoral rotation and the anterior cut set at the anterior distal femoral cortex (■ Fig. 8.8). The block is pinned and the micrometric guide removed or alternately hand positioned, again depending on the surgeon's preference. With the 4-in-1 cutting guide pinned in place and the knee at 90° flexion, the flexion gap can be inspected relative to the rotation of the cutting block to confirm your selection and the distal femoral condylar cuts vs. the purposed posterior cuts. The amount of posterior condyles to be removed is displayed on the screen numerically under the graphic of the posterior condyles. There is also both numeric rotation information as well as a target line to set the rotation to. The target line is set by the surgeon as to his/her preference prior to the case (■ Fig. 8.9). The tibial and femoral trials are placed in the usual fashion and a graft can be obtained before commitment to the final components. A final graft is then obtained and any additional notes are added. Surgeons can retain as much or as little information as they like. It can be stored in a variety of digital formats.

8.3 Discussion

The specific focus of this system is the surgeon. The necessary information is easily seen on an uncluttered screen. The graphic display of the ROM and laxity provides the surgeon with the information required to make soft tissue balancing decisions with clarity. Surgeons can use measured resection and gap balancing, and they can kinematically establish the tibial axis of rotation about the femur or any combination they desire with the same flow surgically and on graphic displays. The joint line can be monitored pre- and postoperatively for comparison. Registering of the actual cut surfaces and not assuming the cut was the same as the guide all help the surgeon perfect the surgery. Micrometric guides for cutting block positioning alleviate some of the frustrations and improve the fine adjustments. In the end, navigation is a tool to assist the surgeon in obtaining the desired outcome consistently. It is often said that the best system for a surgeon is the one they are most familiar with. The goal of a navigation system should be to accommodate the surgeon and not vice versa. The navigation system should also provide objective information to the surgeon so that they can continually advance the art of total knee replacement. This has been my experience to date with the systems I have used for a decade, including the current system.

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