Pre-operative Planning Using the Traumacad™ Software System

Ely L Steinberg, MD[1] and Eitan Segev, MD, FCS-ORTH[2]

1. Director, Orthopedic Trauma Service, and Deputy Director, Orthopedic Department; 2. Director, Limb Lengthening and Deformity Correction Service, Department of Pediatric Orthopedics, Dana Children's Hospital, Sourasky Tel-Aviv Medical Center, Tel Aviv University

Abstract

Templating is now the standard approach for pre-operative planning of total joint replacement, fracture fixation, limb deformity repair, and pediatric skeletal disorders. The progression from standard celluloid films to digitalized technology in most medical centers in industrialized countries led to new software programs to fulfill the needs of pre-operative planning and to lessen the mismatch between the scanned or digitalized images and the transparent templates. TraumaCad™ software was developed to meet these requirements by enabling the import and export of all picture archiving communication system (PACS) files (i.e. X-rays, computed tomograms, magnetic resonance images [MRIs]) from either the local working station or from any remote PACS. The short learning curve, user-friendly features, accurate prediction of implant size, and low-cost maintenance make TraumaCad™ software an attractive option among the other software programs that are currently in use.

Keywords

TraumaCad™, pre-operative planning, templates, picture archiving communication system (PACS)

Disclosure: The authors have no conflicts of interest to declare.
Received: February 15, 2010 **Accepted:** March 15, 2010 **Citation:** *US Radiology*, 2010;2(1):87–90
Correspondence: Ely L Steinberg, MD, Director, Orthopedic Trauma Service, Tel-Aviv Sourasky Medical Center, 6 Weizmann St, Tel-Aviv, Israel 64239.
E: steinberge@tasmc.health.gov.il

Pre-operative planning and templating currently comprise the standard stages for total joint replacement and fracture fixation.[1–5] Surgical planning was traditionally performed by means of conventional radiography with a consistent radiographic magnification, which allowed templating for the selected prosthesis with prepared component overlays.[6] Computed tomography (CT) scanning is another option for improving pre-operative planning accuracy, but at the cost of the patient's exposure to a relatively higher dose of ionized irradiation.[7,8] Questions have been raised about the accuracy of the standard templating system in terms of magnification mismatches between the radiograph and the templates.[3] A number of factors may affect this mismatch, among them the patient's body size, the tube to film distance, and the accuracy of the template's magnification. Digitalized radiography has become the standard modality in most orthopaedic centers in industrialized countries over the past decade, creating the need for digitalized templating for the purposes of surgical planning.

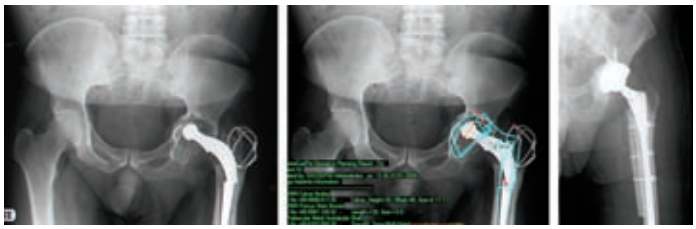
The TraumaCad™ software system was developed for the orthopaedic community to be used in a filmless working environment. This software enables the import and export of all picture archiving communication system (PACS) files (i.e. X-rays, CTs, magnetic resonance images [MRIs]) from the local working station or from any remote PACS. The image is retrieved by a spherical marker placed at the level of the bone so that it can be automatically detected in the image by the software for the purpose of scale calibration. The next step is positioning the template such that it mimics the intended procedure. These data are stored in each patient's file.

The TraumaCad software system is used for pre-operative planning in various fields of orthopaedic surgery, such as joint replacement, fracture treatment, limb deformities in the pediatric and adult populations, spine surgery, and foot and ankle surgery. TraumaCad can be used intra-operatively by incorporating the Digital Lightbox© from BarinLAB. The picture can be edited and refined directly on a large touch-screen display. The TraumaCad template library contains more than 47,000 templates, each with an anteroposterior (AP) and a lateral view, derived from more than 32 leading companies worldwide.

Pre-operative Planning for Joint Replacement

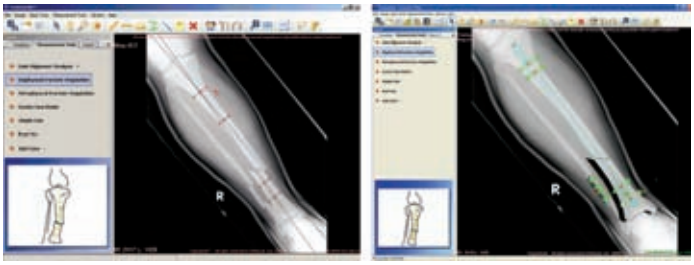
Pre-operative planning for joint replacement in the hip, knee, shoulder, elbow, and ankle has become an integral stage of surgical preparation. It is an effective tool for training the surgeon by pre-operatively deciding the type and size of the implant, and probably reduces the intra-operative complication rate. In the past, pre-operative radiological planning was performed by applying the transparent template onto standard film. Progression to digitalized technology led to the need for software that can perform digitalized templating. One of the new programs is TraumaCad, a system that combines importing from and exporting properties to all kinds of digitalized imaging technologies. This allows the attainment of precise implant size and accurate

Figure 1: Anteroposterior Pelvic View of a Failed Total Hip Replacement



Pre-operative planning and the post-operative result (from left to right).

Figure 2: Pre-operative Planning of a Fracture of the Distal Tibia



The distal fragment was traced to the desired position and a nail with screws template was applied on the image.

measurements, and the number of mismatches between the transparent template and the digital reprint is decreased. The TraumaCad system (see *Figure 1*) has the properties of digitalized radiography calibration and versatile templating software that can be adapted to accommodate various types and sizes of prostheses.

The earlier application of transparent templates on a standard non-digital film had a predicted accuracy of 62–99% of the acetabular cups and 78–99% within two sizes of the femoral stems.[3,6] Magnification differences were found to have affected the choice of the implant in 17% of cases.[3] Similar or even better results—i.e. a predicted accuracy of 86–92% of the acetabular cups and 95–96% within two sizes of the femoral stems—were achieved by shifting to the digitalized technology that uses digitalized radiographs and template software.[1,5,9,10]

A study conducted in our department using the TraumaCad software for total hip replacement found that the acetabular component, measured within ±1 size, was accurate in 65 patients (89%), and that the femoral stem design component was accurate in 70 patients (97%).[10] TraumaCad successfully predicted the sizes of femoral and acetabular components and was easily integrated with all PACS files. The same approach of pre-operative planning with TraumaCad can be applied for total knee replacement and other joints as well.

Pre-operative Planning for Fracture Treatment

Understanding the fracture pattern is a crucial step in the surgeon's pre-operative planning of the proper approach and the type of hardware needed for fracture fixation. In addition to knowledge of the mechanism of a given injury, appropriate imaging modalities will be needed in order to correctly assess the fracture type. A view of the unaffected limb is recommended to serve as a reference for the surgeon during the pre-operative process as well as during the operation. The image is processed by the TramaCad software to achieve a better fracture reposition and to determine the best placement of hardware type and size. The outlines of the various broken components are marked separately, after which each one is shifted to achieve a straight alignment of the bone. Estimating hardware size is critically important, especially in cases in which the fracture is too close to the joint line, thereby limiting the amount of hardware to be inserted (see *Figure 2*).

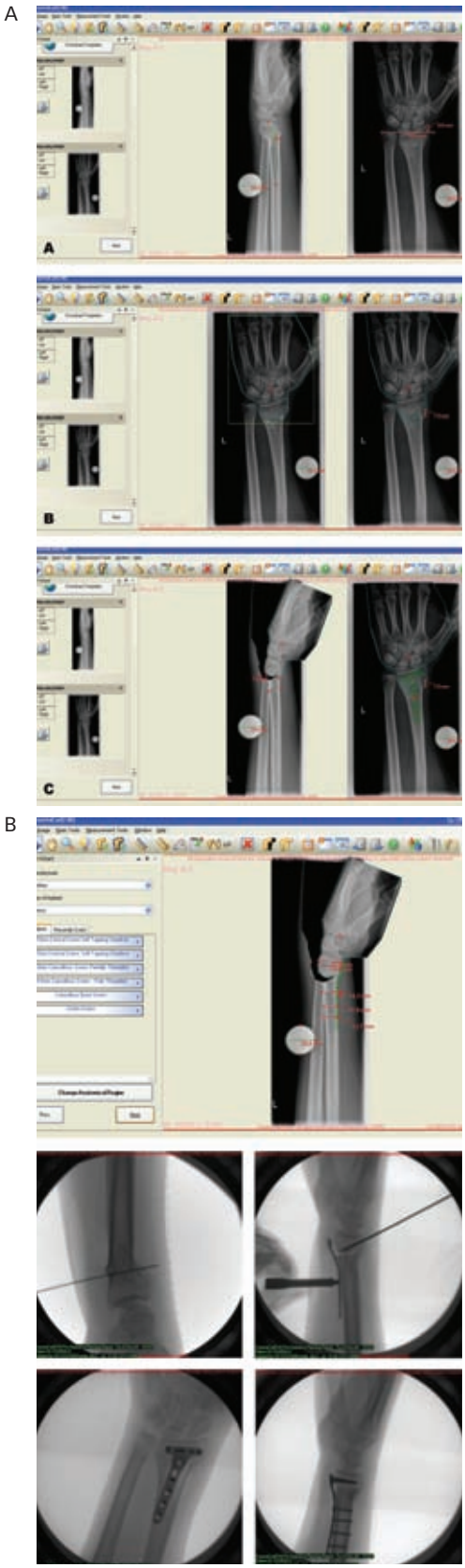
Limb deformities are mainly congenital or developmental and post-traumatic malunions. The first two etiologies will be discussed in the section on pediatric orthopaedics below. Accurate estimations in the pre-operative planning for the correction of a malunion deformity require AP and lateral views of the bone, CT scans, or MRI studies, and 3D reconstruction in order to differentiate between a simple and a complex deformity. Specifically, a simple deformity is visible in only one plane while a complex deformity occurs in at least two planes (e.g. a shortening, angular, and rotational deformity). Images of both the normal and the deformed limb are needed to adjust the plan for performing the osteotomy, repositioning as close as possible to that of the normal limb. TraumaCad integrates all of the recorded images and the pre-operative planning is similar to that for fracture repair. The deformity outline is drawn and the bone is split into two fragments at the level of the desired osteotomy. The two fragments are then lined up to obtain the required corrected position. The TraumaCad archive is used in the ensuing step for selecting the proper available fixation device (see *Figure 3*). When these steps are completed to the surgeon's satisfaction, the planned program is saved to be used at the time of the actual surgery.

Pre-operative Planning for Lower Limb Deformities in the Pediatric Population

Patient management in pediatric orthopaedic surgery relies on the interpretation of radiographs and the measurement of skeletal anatomical sizes, angles, and indices as important supplements to the clinical examination. Conditions that may appear at birth, such as bone dysplasia, developmental dysplasia of the hip (DDH), and scoliosis, or that develop later in life, such as Perthes' disease, slipped capital femoral epiphysis, limb deformities due to trauma, infection, or metabolic condition, and others are classified according to radiographic parameters. The severity of these conditions, their natural history, indications for surgery, and the follow-up of surgical results are based on specific radiographic measurements between defined landmarks for assessing hip joint development, lower limb length differences and alignments, scoliosis curves, and more.

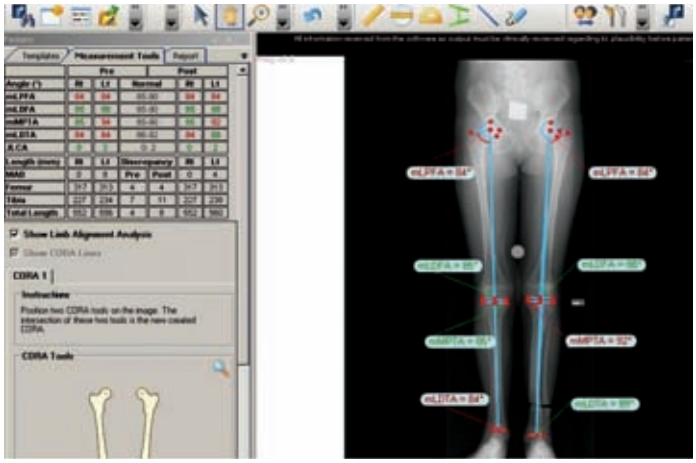
The key point for performing all of these measurements is defining the anatomical landmarks necessary for producing the line drawings.[11] Recent studies comparing inter- and intra-observer agreement for various measurements on conventional and digital radiographs showed digital measurements to be equal or more accurate.[12–14] The pediatric section of the TraumCad software (TraumCa version 2.2, OrthoCrat™) was designed so that an illustration corresponding to various conventional measuring tools would appear at the bottom of the page

Figure 3: Pre-operative Planning of a Malunion of a Distal Radius Fracture



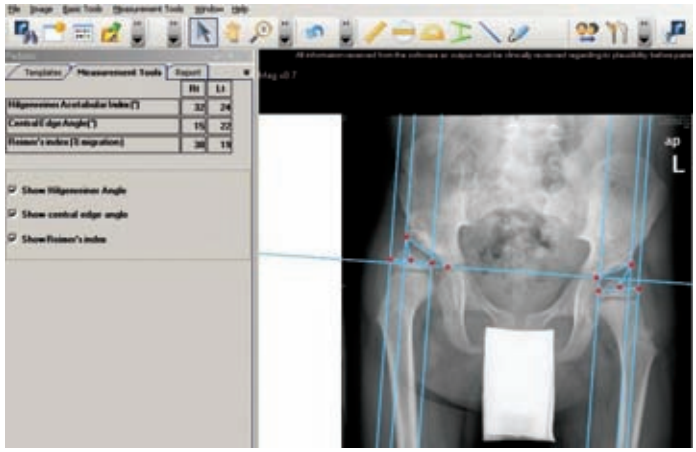
Pre-operative planning (A) and intra-operative radiographs (B).

Figure 4: Standing Radiograph of the Lower Limbs in a Patient with Deformity of the Left Lower Limb



A simulated osteotomy of the distal tibia is shown in the image.

Figure 5: Pelvic View of Developmental Dysplasia of the Right Hip and an Analysis and Measurement Table for the Patient



when the anatomy of the hip, long leg, spine, or foot and ankle was analyzed, thereby facilitating the location and positioning of markers at specific anatomical sites (see *Figure 4*). Some of the illustrations contain a short text for providing a more exact definition of the anatomical landmarks.

In addition, a dedicated wizard was developed to guide the marking of anatomical landmarks for carrying out the various measurements during acetabular, hip joint, lower limb length and angle, scoliosis, and foot analysis. This technique created a reproducible method of carrying out measurements on digital radiographs of various anatomical parameters (see *Figure 5*).

Hip morphology analysis using TraumaCad can be performed for a non-, partially, or fully ossified femoral head. The acetabular index, central edge angle, Reimer subluxation index, and other more specific parameters can be measured for conditions such as DDH, cerebral palsy, Perthes' disease, and other acquired hip pathologies.[15]

The deformity wizard tool enables the surgeon to perform bone length and mechanical axis analysis, measure hip knee and ankle joint orientation in the frontal and sagittal planes, and trace the center of rotation angulation (CORA) for each bone segment. After the CORA has been defined, a simulated 'osteotomy' for deformity correction and lengthening can be carried out on the radiographs (see *Figure 4*).[16]

Scoliosis analysis by the TraumaCad software is performed by placing the Cobb angle tool on the appropriate vertebrae, while other parameters such as frontal and sagittal spinal balance and pelvic inclination can be traced using special tools. All angle and length measurements as well as the final radiographs can be stored in the patient's PACS page or in any other file in the form of a report page for future reference.[15]

Other Applications of the TraumaCad Software

TraumaCad software can be used for various measurements of the spine, such as the Cobb angle, pelvic radius angle, sacral obliquity, coronal balance spondylolisthesis, and kyphotic or lordotic angle. It provides the values required for foot and ankle surgery by using the foot osteotomy wizard for growth calculation, hallux valgus deformity correction, limb measurements, and talar tilt after ankle injury. New applications include the incorporation of an implant template into a 3D configuration using the TeraRecon's Aquarius iNtuition program and intra-operative assistance by software system integration with BrainLAB navigation system.

Conclusion

The transition from hard-copy radiographic films to the digital technique has brought with it increasing numbers of software programs, some using applications similar to those of the TraumaCad. A considerable amount of time will be saved by using PACS-compatible software: the various built-in tools have been constructed according to common orthopaedic consensus and in collaboration with software developers, the PACS producers, and the orthopaedic community at large. The short learning curve, user-friendly features, accurate prediction of implant size, high versatility, and options in various fields of orthopaedic surgery together with low-cost maintenance make TraumaCad software an especially attractive choice. ■

Ely L Steinberg, MD, is Director of the Orthopedic Trauma Service and Deputy Director of the Orthopedic Department at Sourasky Tel-Aviv Medical Center. He is also a Lecturer at the Sackler Faculty of Medicine at Tel Aviv University. Dr Steinberg is a member of the Orthopedic Trauma Association and the American Academy of Orthopaedic Surgeons (AAOS) and is on the Editorial Board of *Injury*.

Eitan Segev, MD, FCS-ORTH, is Director of the Limb Lengthening and Deformity Correction Service in the Department of Pediatric Orthopedics at Dana Children's Hospital. He is President of the Israeli Pediatric Orthopaedics Society and a Senior Lecturer at the Sackler Faculty of Medicine at Tel Aviv University.

1. Davila JA, Kransdorf MJ, Duffy GP, Surgical planning of total hip arthroplasty: accuracy of computer-assisted EndoMap software in predicting component size, *Skeletal Radiol*, 2006;35:390–93.
2. Eggli S, Pisan M, Müller ME, The value of pre-operative planning for total hip arthroplasty, *J Bone Joint Surg*, 1998;80:382–90.
3. Knight JL, Atwater RD, Pre-operative planning for total hip arthroplasty. Quantitating its utility and precision, *J Arthroplasty*, 1992;(Suppl. 7):403–9.
4. Krettek C, Blauth M, Miclau T, et al., Accuracy of intramedullary templates in femoral and tibial radiographs, *J Bone Joint Surg*, 1996;78:963–4.
5. Wedemeyer C, Quitmann H, Xu J, et al., Digital templating in total hip arthroplasty with the Mayo stem, *Arch Orthop Trauma Surg*, 2008;128:1023–9.
6. Della Valle AG, Slullitel G, Piccaluga F, Salvati EA, The precision and usefulness of pre-operative planning for cemented and hybrid primary total hip arthroplasty, *J Arthroplasty*, 2005;20:51–8.
7. Noble PC, Sugano N, Johnston JD, et al., Computer simulation: how can it help the surgeon optimize implant position?, *Clin Orthop Relat Res*, 2003;417:242–52.
8. Viceconti M, Lattanzi R, Antonietti B, et al., CT-based surgical planning software improves the accuracy of total hip replacement pre-operative planning, *Med Eng Phys*, 2003;25:371–7.
9. Kosashvili Y, Shasha N, Olschewski E, et al., Digital versus conventional templating techniques in pre-operative planning for total hip arthroplasty, *Can J Surg*, 2009;52:6–11.
10. Steinberg EL, Shasha N, Menahem A, Pre-operative planning of total hip replacement using the TraumaCadTM system, *Arch Orthop Trauma Surg*, 2010; Epub ahead of print.
11. Nelitz M, Guenther K, Gunkel S, Reliability of radiological measurements in the assessment of hip dysplasia in adults, *Br J Radiol*, 1999;72:331–4.
12. Sailer J, Scharitzer M, Peloschek P, et al., Quantification of axial alignment of the lower extremity on conventional and digital total leg radiographs, *Eur Radiol*, 2005;15:170–73.
13. Hankemeier S, Gosling T, Richter M, Computer-assisted analysis of lower limb geometry: higher intraobserver reliability compared to conventional method, *Comput Aided Surg*, 2006;11:81–6.
14. Halanski MA, Noonan KJ, Hebert M, et al., Manual versus digital radiographic measurements in acetabular dysplasia, *Orthopedics*, 2006;29:724–6.
15. Herring JH (ed.), *Tachdjian's Pediatric Orthopaedics, 4th Edition*, Philadelphia, Saunders Elsevier Inc., 2008:358–9.
16. Paley D (ed.), *Principles of Deformity Correction, 1st Edition*, Berlin, Heidelberg, Springer-Verlag, 2002:8–9.

European Medical Imaging Review

Now available on subscription

Published annually, *European Medical Imaging Review* endeavors to support radiologists and related healthcare professionals in continuously developing their knowledge, effectiveness, and productivity.

Directed by an Editorial Board comprising internationally respected physicians, *European Medical Imaging Review*'s peer-reviewed articles aim to assist time-pressured physicians to stay abreast of key advances and opinion within radiology.

Ensure that researchers, students, and fellow physicians at your institution enjoy the educational benefits:

- Concise review articles detail the most salient developments in technology and practice.
- Latest opinion and practice guidelines.
- Detailed bibliographies make it a valuable reference and research tool.
- Breadth of coverage helps professionals to stay abreast of developments beyond their core specialties.

Subscription Rates

	Online and print	Online only
Full Institutional (the Americas)	$225	$210
Full Institutional (Europe)	€180	€170
Full Personal (the Americas)	$100	$85
Full Personal (Europe)	€80	€70

Print and online subscriptions cover one print edition per annum and full online access to the electronic version of the journal for a 12-month period.

European radiologists and other professionals within this field qualify for free subscriptions.

Order online or download a pdf subscription form at:

www.touchbriefings.com/subscriptions