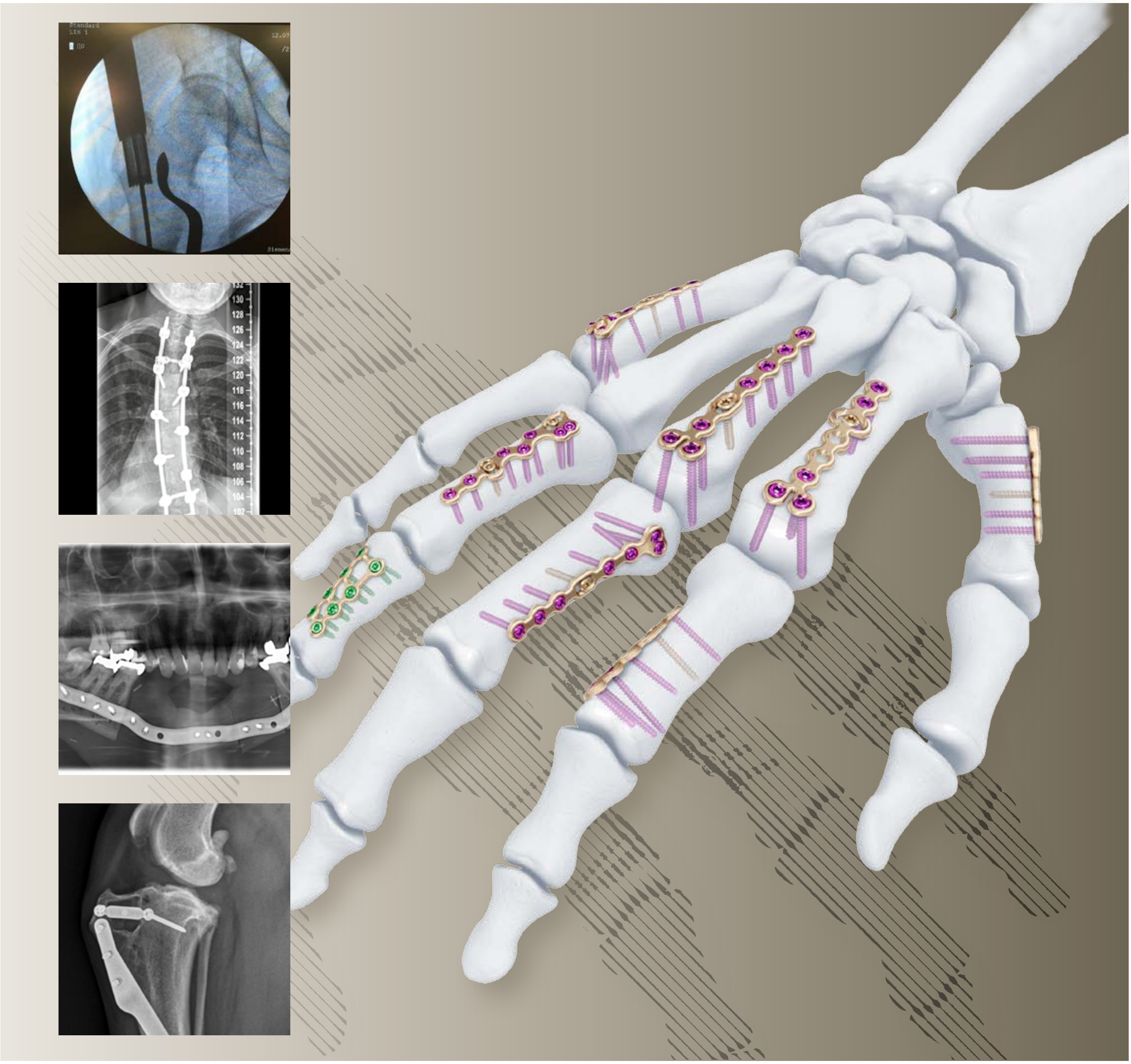
AO Foundation

AOTK System

Innovations 2016



AOTK System "Innovations"
is compiled by the AOTK team.

Production by AO Education Institute.

Typeset by Nougat.

approved by AOTK

APPROVED BY AO Foundation

TRADEMARKS "APPROVED BY AOTK" AND "APPROVED BY AO FOUNDATION"
The innovations presented in this magazine are subject to trademark protection by the internationally registered figurative brands "approved by AOTK" and/or "APPROVED BY AO Foundation" as shown, but not limited to the colors or size presented here. The use of these brands is regulated by licensing agreements between the AO Foundation and the producers of these products obliged to use such trademarks to declare the products as AOTK or AO Foundation approved solutions. Any unauthorized or inadequate use of these trademarks is subject to legal action.

HAZARDS AND LABELING
Due to varying countries' legal and regulatory approval requirements please consult the appropriate local product labeling for approved intended use of the products described in this brochure. All devices in this brochure are AOTK approved. For logistical reasons, these devices may not be available in all countries worldwide at the date of publication.

TABLE OF CONTENTS

EDITORIAL 1

VARIABLE ANGLE LOCKING HAND SYSTEM 4
For fragment-specific fracture fixation with locking and variable angle locking technology

TRAUMA, THORACIC 10
MatrixRIB and the Chest Wall Deformity Reconstruction System

TRAUMA, LOWER EXTREMITY 13
VA-LCP Condylar Plate 4.5/5.0 in titanium alloy
TFN-Advanced Proximal Femoral Nailing System—additional instruments

NEWS FROM THE RIA TASK FORCE 20
Focus and update from the Reamer Irrigator Aspirator Task Force

SPINE 23
Expedium Verse System
Power For Spine—the benefits of power tools in surgery

NEURO 33
A new AO Technical Commission for Neurosurgery

CRANIOMAXILLOFACIAL 38
Biplanar plug-on tandem cutting guide for raising and contouring bone flaps from the lateral scapular border and tip

VETERINARY 44
Tibial Tuberosity Advancement (TTA) System

AOTK MEET THE EXPERTS 49
Meet the Experts Sessions 2015

NEWS FROM ARI 53
Impact of bone cement augmentation on the fixation strength of TFNA blades and screws
Three-dimensional statistical modelling of the upper cervical spine based on quantitative computed tomography to evaluate bony corridors and screw position

A FOCUS ON INFECTION 58
New TK Focus on Anti-Infection Strategies
Surgical site infection following internal fixation of open or closed tibial fractures in India: a multicenter observational cohort study
Clinical Priority Program on Bone Infection
AOTrauma to launch first orthopedic infection publication

NEWS FROM AOTK 68
3rd AOTrauma Asia Pacific Scientific Congress and AOTK Experts' Symposium
AOTK System: What is it, what does it do, and who is it comprised of?
New AOTK Approved Solutions Website

STRATEGY FUND 74

PORTRAIT: FRED PIERACCI 76

EDITORIAL

Dear reader,

Welcome to the 2016 edition of the AOTK System Innovations magazine. Following the success of last year's revival and the positive feedback received with regard to content, AOTK is excited to deliver another insightful magazine. Besides highlighted AOTK innovations, this issue contains contributions from the AO Research Institute and AO Clinical Investigation and Documentation, as well as a special focus on the hot topic of orthopedic infection management.

In our lead article we introduce the Variable Angle Locking Hand system. This innovation from the Hand Expert Group was designed to address clinical challenges faced in the current fixation of fractures and osteotomies and represents a complete overhaul of the LCP Compact Hand system.

Following the successful launch of the Trochanteric Fixation Nail–Advanced last year, the Lower Extremity Group brings you an overview of the system's improved instrumentation. In this article you can read about assisted reduction techniques and instrument capabilities in complex fracture patterns.

AOTK Spine has approved the Expedium VERSE with new features of pedicle screw, reduction techniques, and tools for pediatric and adult deformity correction. Power for Spine is an innovation with a particular focus on reduction of OR time in deformity spine surgery.

In a study overview by Carl-Peter Cornelius, this year's contribution from AOTK CMF provides an insight into a new surgical approach for craniofacial reconstruction. While techniques for craniofacial reconstruction using fibula flaps are well established, the use of flaps from the lateral scapular border is less well defined and depicted here through case study review.

In this year's magazine, the Small Animal Vet Expert Group provides a comprehensive insight into the Tibial Tuberosity Advancement system indicated for the treatment of cranial cruciate ligament disease in canines. Authors of this article successfully highlight the intricacies of this system through the provision of two detailed cases.

The AOTK is especially happy this year to introduce an exciting new addition with the initiation of a Neuro TK division, and which exemplifies mutual alignment with our industrial partner. Guided by Dr Stephen Lewis, Associate Professor of Neurosurgery at Joondalup Health Campus in Perth Australia, the newly established division promises to further enhance our knowledge and expertise in this area.

Our portrait piece this year features Dr Fred Pieracci, Assistant Professor of Surgery at the University of Colorado School of Medicine and member of the Thoracic Expert Group. Dr Pieracci joined the AOTK system earlier this year and shares his experience of thoracic surgery in Denver as well as his aspirations for AOTK membership as he begins his three year term.

With all of this and more, the 2016 edition of AOTK System Innovations promises to be an informative issue. We hope that you enjoy it.

We would like to reiterate that none of the articles in this magazine substitute for AO's surgical techniques and teaching tools. You can obtain more information about AOTK on the AO Foundation website. Please do not hesitate to contact AOTK at any time as we welcome your feedback and involvement.

Yours faithfully

Tim Pohlemann
AOTK (Trauma)

Daniel Buchbinder
AOTK (CMF)

Maarten Spruit
AOSpine TK

Doug Campbell, Thomas Fischer

VARIABLE ANGLE LOCKING HAND SYSTEM

For fragment-specific fracture fixation with locking and variable angle locking technology

The Variable Angle (VA) Locking Hand system (Fig 1) is the next generation of small implants for the hand consisting of plates that are anatomic, both fracture and procedure-specific, and available in stainless steel and titanium. The system was designed to address clinical challenges faced in the current fixation of fractures and osteotomies and represents a complete overhaul of the LCP Compact Hand system.

The Variable Angle Locking Hand system offers a solution for fracture fixation, arthrodesis, nonunions, and the reconstruction of small bones and small bone fragments particularly in adults with osteopenic bone. The system also offers instrumentation to aid in fracture reduction, provisional fixation, implant adaptation, and construct creation.

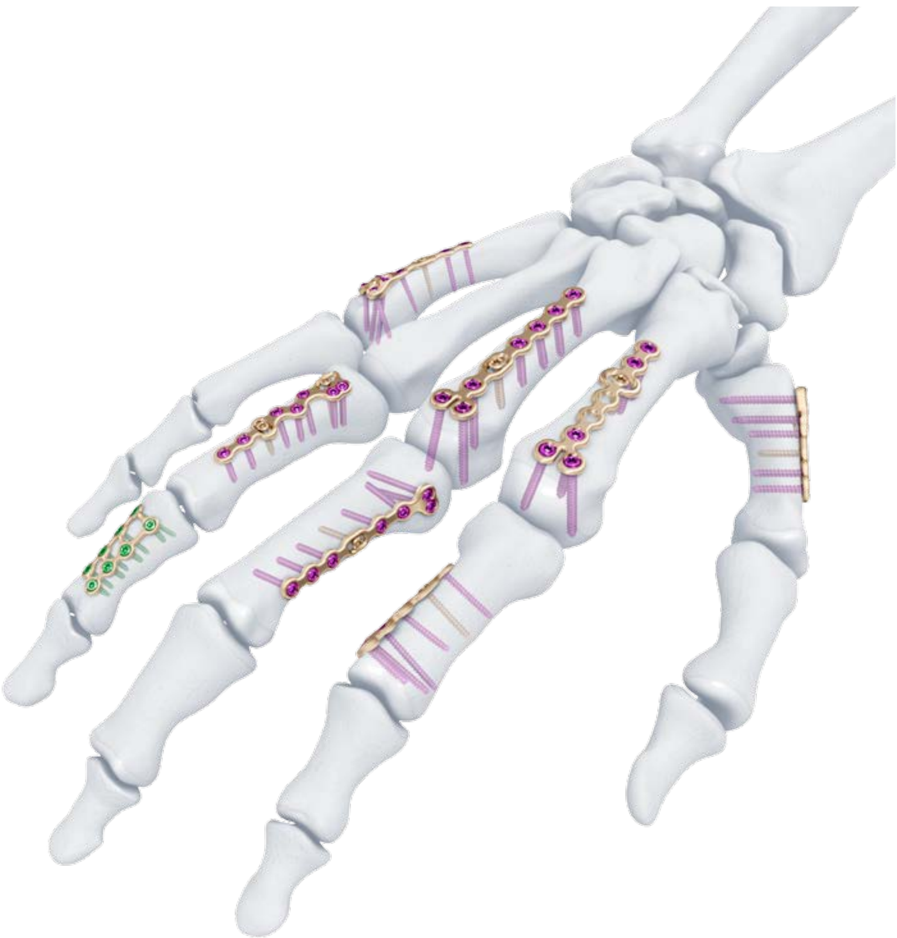


Fig 1
The new VA Locking Hand system represents true innovation in fracture fixation.

Fig 2
The variable angle locking hole provides freedom of screw placement within a 30° cone.

Fig 3
Low profile preanatomically preformed plates.

Evolution of Hand Fixation

The previously developed mini fragment and compact hand system's standard plates were designed to meet the needs of small bone fixation. The evolution of such internal fixation in the hand to now include variable angle technology (Fig 2), which provides a perfect display of the variety of fixed angle devices that are more anatomically adapted with a lower profile design to accommodate the gliding structures of periarticular zones of the hand. The volume of implant beneath the extensor apparatus has been reduced both through plate design and the inclusion of smaller dimension implants (1.3 mm system).

The only fixed angle devices available in earlier systems were blade plate designs. In the new VA Locking Hand system there exists a greater choice of implants, which enables the application of axial stability and fixed-angle constructs in challenging fractures. Anatomically preformed plates also result in less bulk and a lower need for plate adaptation (Fig 3). A greater selection of fixed-angle implants will allow for a wider range of applications in osteopenic bone.

For reconstruction applications, a variety of implants that provide precise rotational adjustment have been added. Small rotational deformities of the digits are common and have a greater functional impact than other long bone deformities. These implants provide fine adjustment capabilities.

Integration of variable angle locking technology (VA-LCP) into the 1.5 mm and 2.0 mm systems allows for improved placement of screws in metaphyseal bone. Safer and more accurate screw placement in periarticular and juxtaarticular positions is realized with the VA-LCP (Fig 4).

Fig 4
Locking holes enable the placement of screws at either a nominal or variable angle.

Fig 5
Self-retaining screwdriver.

Fig 6
Forceps that aid in fracture reduction and lag screw application.

Not only has the VA Locking Hand system delivered a significant advancement in implant development, but the technology behind the instrumentation has also been advanced to overcome specific problems such as screwdriver retention (Fig 5), plate contouring and cutting, and fracture reduction (Fig 6). The system also includes improvements in the following areas:

- Provisional fixation
- Plate adaptation–implant cutting and bending, better accuracy, and surface/contour retention
- Refined bone preparation.

A comprehensive revitalization of the system was undertaken to provide implants that improved upon the teaching principles of the AO. Devices and designs were evaluated and improved to achieve stable fixation, anatomic reduction, accommodation of soft tissues, and early functional aftercare. The VA Locking Hand system contains implants that extend the possibilities of stable fixation where none could be provided before (osteoporotic bone, small fragments).

This new system was developed to include the best practices in fracture care and to present a system that revolutionized both implant design and instrumentation in a complete overhaul of previous designs. Through a successful collaboration with the Hand Expert Group and numerous surgeons including AO faculty, the goal of creating a system that meets current daily clinical needs was achieved. In December 2015, the VA Locking Hand system was officially presented at a TK Meet the Experts session during the annual Davos Courses (Fig 7). The system received great feedback and has since proved to be a clinical success in the operating room.

Fig 7
Thomas Fischer and Doug Campbell from the AOTK Hand Expert Group proudly demonstrate the new system to an inspired audience during the 2015 December Davos Courses.

Cases provided by Esther Vögelin, Bern, Switzerland

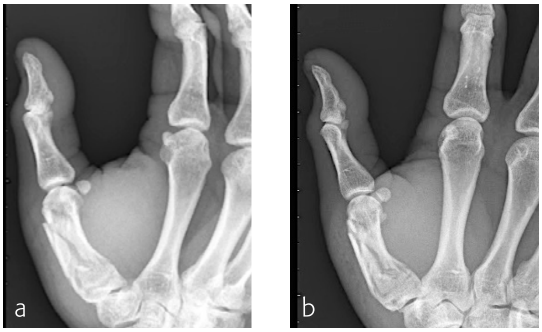


Fig 8a–b
Preoperative images.

Case 1: Multifragmentary thumb fracture

A 64-year-old man suffered a multifragmentary fracture of his right thumb metacarpal (Fig 8). An adapted 12-hole strut plate from the VA Locking Hand system was the implant used for fixation (Figs 9–11).

The strut plate provided good stability in a comminuted extraarticular fracture pattern and enables immediate mobilization. Bone callus formation was not witnessed during the healing process.

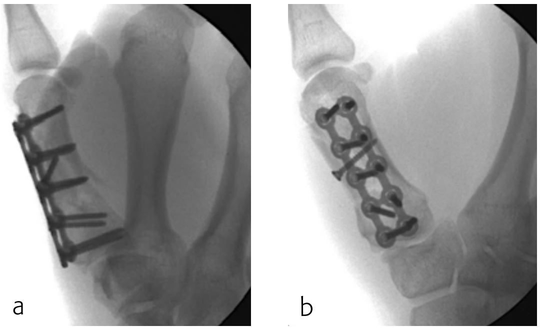


Fig 9a–b
Intraoperative images.

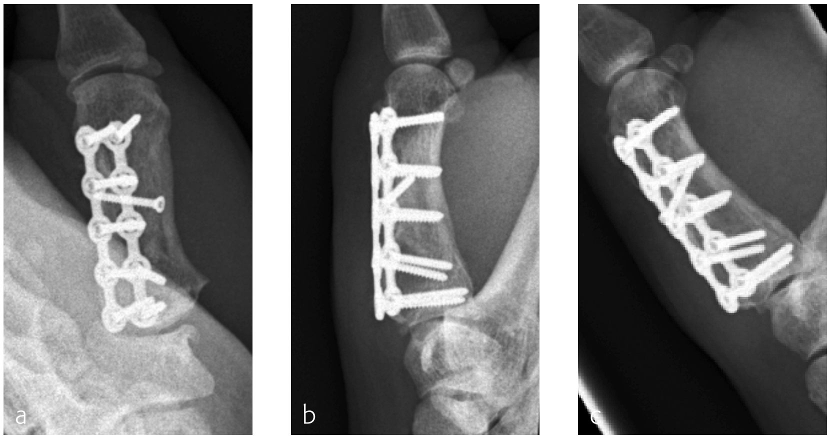


Fig 10a–c
The postoperative images at the 5-month follow-up revealed secondary bone healing.

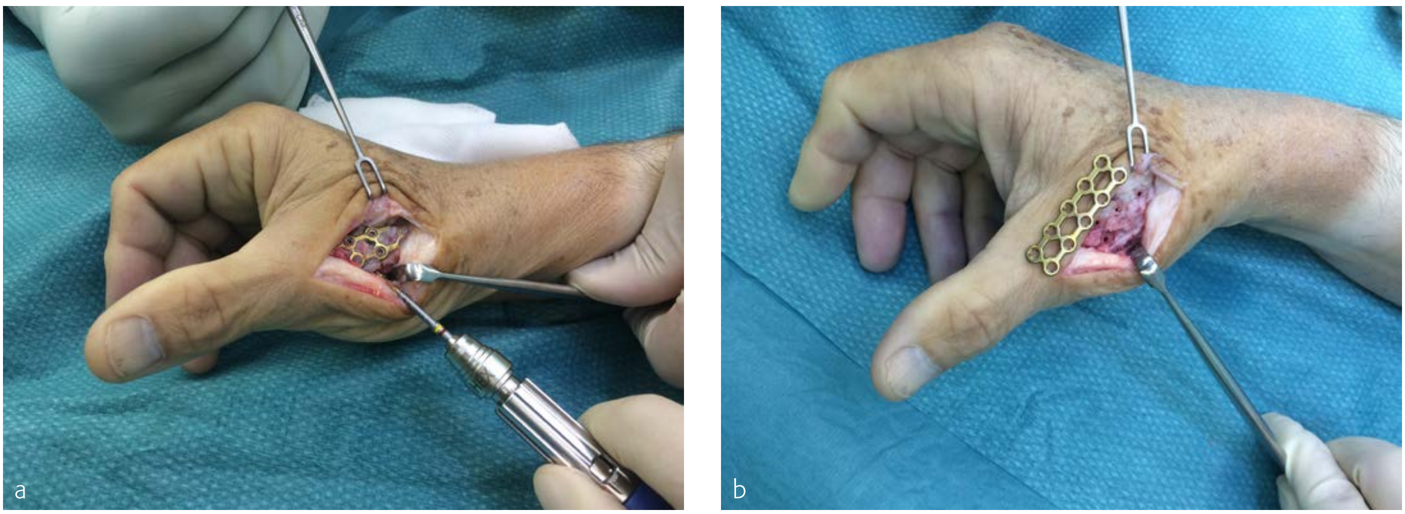


Fig 11a–b
Plate removal at the 5-month follow-up.

Case 2: Complex multidigit injury

A 20-year-old man suffered a complex multidigit injury of the right hand requiring revascularization and stabilization of both proximal phalanx and PIP joint fractures (Figs 12–15). Multiple plates, including the rotation correction plate from the 1.5 module of the VA Locking Hand system were used for fixation. The Variable Angle Locking system is ideal when only two screws, either proximal or distal, are able to be inserted due to space limitation.

One major advantage of variable angle technology in very distal phalangeal fractures is the ability to be extremely flexible with a wide range of fixation options. Freedom of implant placement assists early mobilization, vital in these complex fractures with associated soft-tissue trauma.

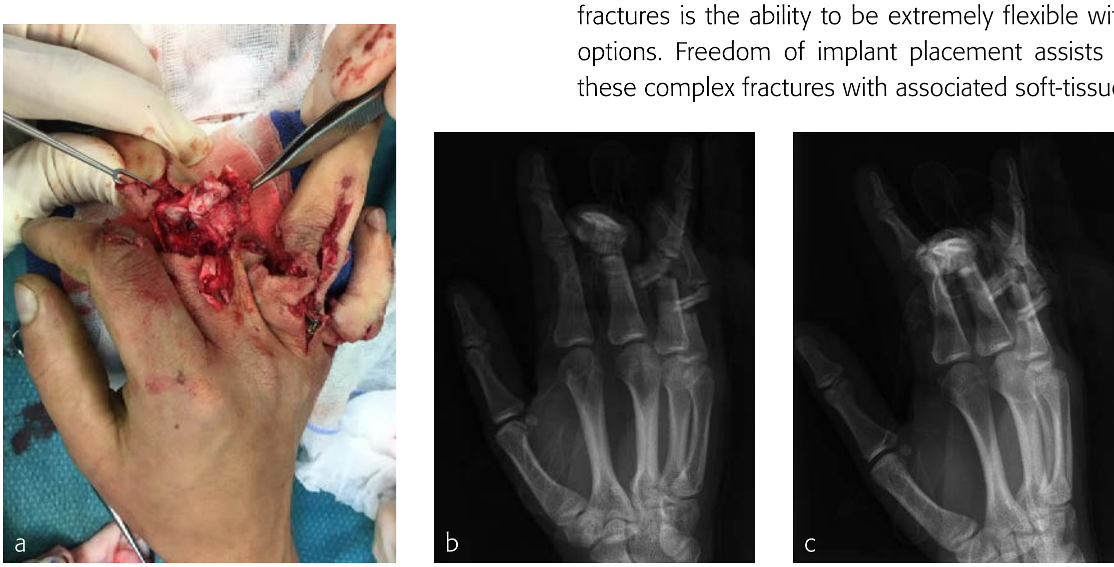


Fig 12a–c
Preoperative images.

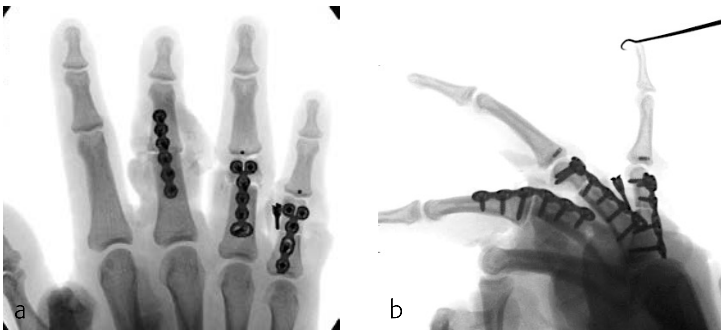


Fig 13a–b
Intraoperative imagery of stabilization achieved using rotation correction plates and straight plate 1.5.

Fig 14a–b
Imagery at the 2-month postoperative follow-up.

Fig 15a–c
The x-rays at the 2-month follow-up.

Case 3: Arthrodesis

A 60-year-old male patient required an arthrodesis of the thumb carpometacarpal (CMC) joint after an implant arthroplasty in conjunction with the implantation of cortico-cancellous bone graft following a proximal row carpectomy and a previous arthrodesis between trapezium-trapezoid and the 2nd CMC joint (Fig 16). The first metacarpal dorsal plate from the VA Locking Hand system was selected for the procedure (Figs 17–18).

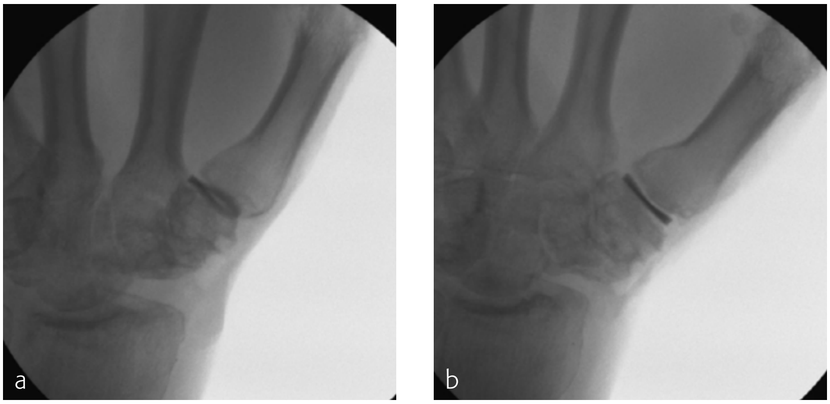


Fig 16a–b
Cortico-cancellous bone graft implantation at the thumb CMC following proximal row carpectomy and previous trapezium-trapezoid and 2nd CMC joint arthrodesis.

Fig 17a–c
Intraoperative images of the dorsal plate on the thumb metacarpal.

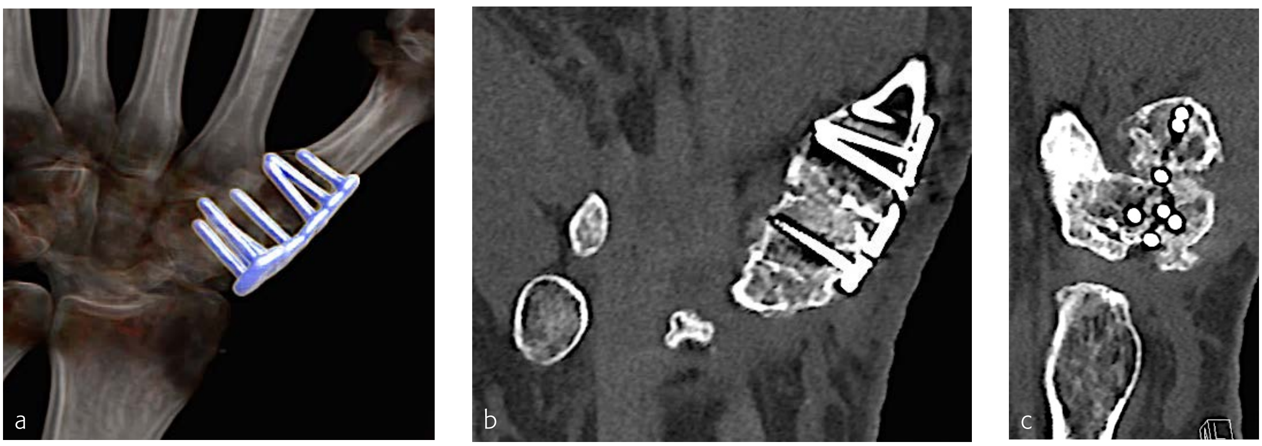


Fig 18a–c
The 2-month postoperative CT scans. Consolidation can be achieved with the variable angle implants even when presented with small bone fragments and minimal bone stock.

Mario Gasparri, Stefan Schulz-Drost

TRAUMA, THORACIC

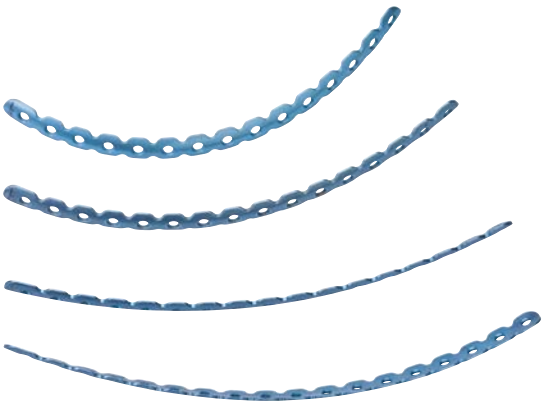


Fig 1
The MatrixRIB system supports the chest wall following resection.

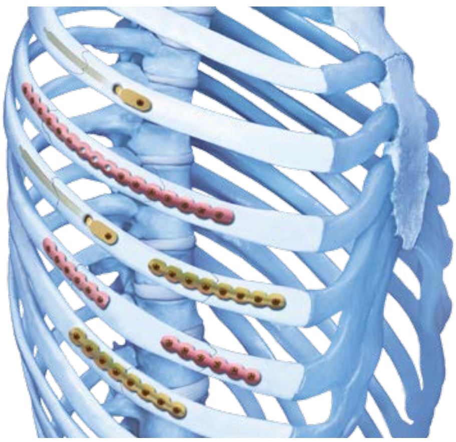


Fig 2
MatrixRIB precontoured locking plates.

MatrixRIB and the Chest Wall Deformity Reconstruction System

Reconstruction of the chest wall using metallic rib systems is gaining popularity. The MatrixRIB fixation system involves the use of plates and screws to bridge any defect and provide support for the chest wall following resection (Fig 1). It is a unique system offering stable fixation of normal and osteoporotic ribs combined with a minimally invasive technique.

The MatrixRIB fixation system consists of precontoured locking plates, locking screws, and intramedullary splints for the fixation and stabilization of ribs (Fig 2). Although many rib fractures are treated nonoperatively, some patients benefit from surgical stabilization. The potential benefits of surgical intervention include reduced duration of mechanical ventilation support, shortened ICU stays and hospitalization, better secretion management through efficient cough, and minimized chest wall deformities resulting from trauma. Furthermore, even complex deformities, both congenital and acquired, can be managed comfortably and effectively with this system.

In May 2015, the MatrixRIB long straight plates (24 and 30-hole) were launched as part of the Chest Wall Deformity Reconstruction system (Figs 3 and 4). This year has witnessed the launch of the new sternal plates (Figs 5 and 6), which complete the system and provide users with a comprehensive and varied portfolio for chest reconstruction.

Fig 3
The 24-hole straight plate.

Fig 4
The 30-hole straight plate.

Fig 5
Sternal T-plate.

Fig 6
Sternal I-plate.

Cases provided by Stefan Schulz-Drost, Berlin, Germany

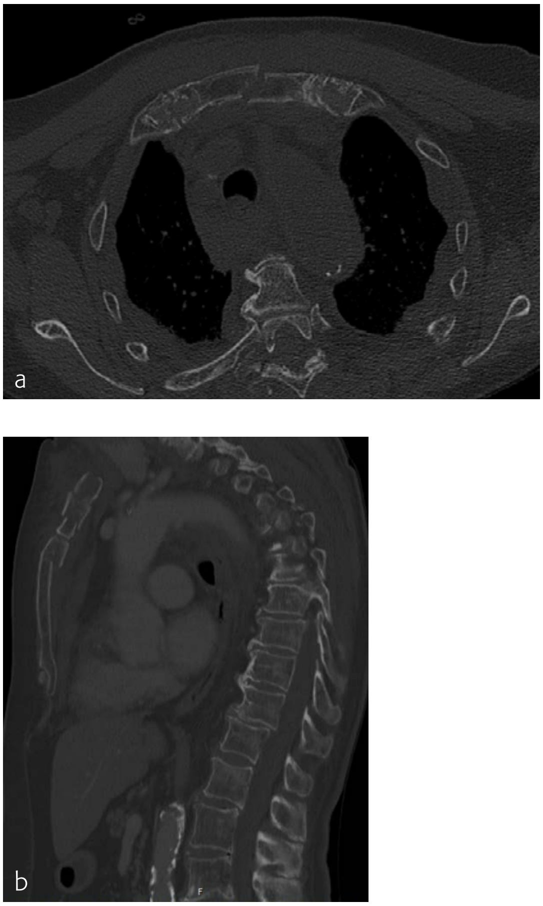


Fig 7a–b
a Complex sternal fracture with multidirectional instability; a longitudinal fracture.
b Transverse fracture involving 3 levels of manubrium and corpus sterni.

Case 1: Fall from 4-meter height

Mechanism of injury

An 81-year-old woman fell onto her back from a height of 4 meters (Fig 7). She sustained a multiple sternal fracture concomitant with a fracture of the 5th thoracic vertebra resulting in an unstable injury of the trunk. However, there were no signs of neurologic deficit or paraplegia.

Diagnosis

Complex sternal fracture with multidirectional instability (longitudinal fracture of the manubrium, and transverse fracture involving 3 levels of manubrium and corpus sterni). Concomitant to this was a fracture of the 5th thoracic vertebra (AOB2.1).

Treatment

The sternal fracture had been managed by open reduction and internal fixation with a locked plate osteosynthesis (MatrixRIB I-plate) through an anterior approach in the midline [1,2]. The thoracic spine had been managed employing dorsal instrumentation (internal fixator T4–T6).

Outcome

The wounds and bone healed uneventfully. Breathing was possible spontaneously without any restrictions. The patient reported a significant reduction in pain immediately after the operative procedure. Mobilization within the ward started on the first day after the procedure. No complications such as secondary failure, nonunions, pain, or deformity of the chest wall could be seen during the follow-up examinations of 6 and 12 weeks and 6 and 12 months.

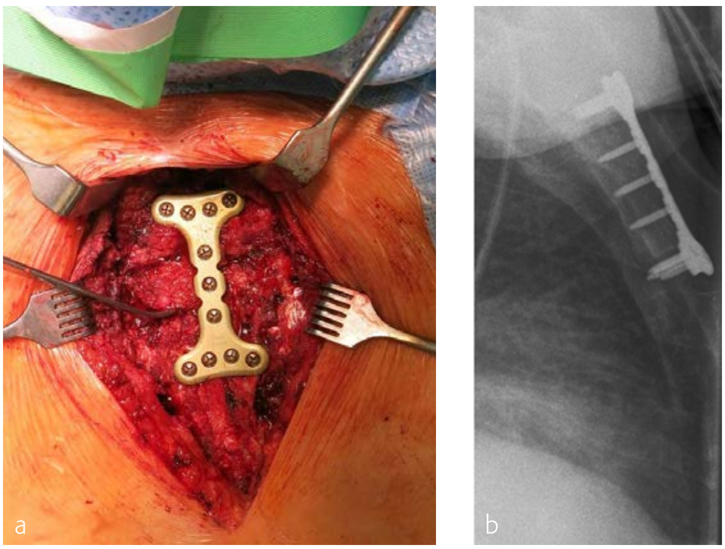


Fig 8a–b
a Intraoperative view: fixation "all in one" with I-plate (during MPE).
b Postoperative result: sufficient reduction and fixation of the sternum. A concomitant fracture of the 5th thoracic vertebra had been fixed during the same procedure.

Fig 9
Recurrent deformity.

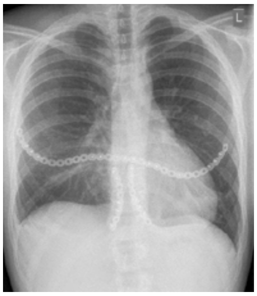


Fig 10
Chest x-ray showing transverse and sternocostal plates.

Fig 11
Anatomic reconstruction of the anterior chest wall.

Case 2: Pectus excavatum

Clinical problem

A 21-year-old man suffered from a recurrent pectus excavatum (Fig 9). Two years prior, he underwent an open procedure to manage the deformity, including the insertion of one transsternal metal bar to stabilize the anterior chest wall. Upon removal one year postoperatively, the anterior chest wall collapsed again and showed instability at the sternocostal junction involving ribs at the 4th–7th level.

Diagnosis

Recurrent pectus excavatum. Unstable and dislocated sternocostal junction at the 4th-7th level.

Treatment

Another open approach was necessary (Fig 10). The anterior chest wall was mobilized and stabilized with the MatrixRIB 30-hole straight plate, adopting a rib to sternum to rib approach at the 4th level. A bilateral sternocostal fixation at the 7th level was also performed using the MatrixRIB 8-hole straight plate. The transverse plate was fixed to the anterolateral aspect of the ribs through additional limited incisions bilaterally. The 5th and 6th pairs of ribs were reduced to the sternal level alongside the 7th rib. Strong sutures (PDS 1 mm, BPT-3) were placed sternocostally to fix the ribs to the sternum [3,4].

Outcome

The patient recovered well (Fig 11). Wound healing was uneventful. Both cosmetic and functional results were excellent. Mobilization could occur immediately after the operation. No complications have been seen in more than 5 years of follow-up.

References

1 **Schulz-Drost S, Oppel P, Grupp S, et al.** Surgical fixation of sternal fractures: preoperative planning and a safe surgical technique using locked titanium plates and depth limited drilling. *J Vis Exp.* 2015 Jan; (95):e52124. doi:10.3791/52124.

2 **Schulz-Drost S, Mauerer A, Grupp S, et al**. Surgical fixation of sternal fractures: locked plate fixation by low-profile titanium plates–surgical safety through depth limited drilling. *Int Orthop.* 2014; 38(1):133–139.

3 **Schulz-Drost S, Syed J, Besendoerfer M, et al.** Elastic stable chest repair as a means of stabilizing the anterior chest wall in recurrent pectus excavatum with sternocostal pseudarthrosis: an innovative fixation device. *Thorac Cardiovasc Surg.* 2015 Aug; 63(5):419–426.

4 **Schulz-Drost S, Syed J, Besendoerfer M, et al.** Sternocostal dislocation following open correction of pectus excavatum-"stairway phenomenon": complication management by means of sternocostal locking titanium plate osteosynthesis. *Thorac Cardiovasc Surg.* 2014 Apr; 62(3):245–252.

Michael Blauth, Hiroaki Minehara, Rodrigo Pesantez, Etsuo Shoda, Christoph Sommer

TRAUMA, LOWER EXTREMITY

Fig 1
The VA-LCP Condylar Plate 4.5/5.0 in titanium alloy.

a

b

Fig 2a–b
VA positioning pins for cable system (a) and the VA periprosthetic locking screw (b).

VA-LCP Condylar Plate 4.5/5.0 in titanium alloy

The VA-LCP Condylar Plate 4.5/5.0 is part of the VA-LCP Periarticular Plating system and has been designed to provide variability in screw trajectory. This allows surgeons to direct the locking screw at a specific angle to grab a specific fracture fragment or to bypass previously placed implants and respond to periprosthetic fractures.

The stainless steel version of this plate was introduced in 2011 and its design features are described in detail in the AOTK System Innovations magazine 2/2011. While stainless steel implants are mainly used in the USA, there is a preference for titanium alloy implants in Europe and Asia. The modulus of elasticity of titanium alloy is markedly lower than the one of stainless steel. This means that titanium alloy is less stiff compared to stainless steel and the elastic deformations on titanium implants are a closer reflection to that of bone. Although there are various aspects involved when selecting the implant material (eg, construct stiffness, allergic patient response, bone and soft tissue adhesion, ease of implant removal) there is no clinical evidence that one or the other implant material provides a clear clinical advantage with regard to patient outcome. The choice of the implant material therefore continues to be driven mainly by regional practice.

To complete the implant portfolio and to address the various surgical preferences with regard to implant material, a titanium alloy version of the VA-LCP Condylar Plate 4.5/5.0 has been developed (Fig 1) that can be used together with the OPTILINK screw technology, as described later.

The main benefit of the VA-LCP Condylar Plate 4.5/5.0 is the ability to place variable angle locking screws to create a fixed-angle construct while also providing the surgeon with the freedom to choose the most optimal screw trajectory according to the fracture pattern. This feature is also advantageous for placement of locked screws around femoral prostheses. Since placing screws at their nominal angle provides maximal connection strength between plate and screw, off-axis angles should only be chosen when clinically indicated.

To increase bone anchorage in the presence of prostheses, locking attachment plates can be mounted to the VA combi-holes in the shaft component of the plate. Further periprosthetic treatment options include VA periprosthetic locking screws with blunt tip and VA positioning pins for cable system in cruciform design (Fig 2) to fit in the VA locking hole.

a

b

c

Fig 3a–b
The universal aiming arm (a), and the insertion handle with (b) and without (c) guide block.

Broad instrument options including minimally invasive instrumentation for limited soft-tissue trauma are provided for the plating system. There is one universal aiming arm for both left and right plates, which allows, together with dedicated instrumentation, minimally invasive targeted predrilling and screw insertion in the plate shaft. The universal aiming arm is supposed to be attached to insertion handles with or without guiding block (Fig 3). The insertion handle with guiding block (left and right versions) can be used for targeted predrilling and screw insertion in the plate head if this is beneficial.

The plate is compatible with several screw types, fulfilling diverse functions including use for locking, VA locking, and cortex screws:

- Every VA locking hole accepts VA locking screws; the central hole in the head of the plate is a fixed angle locking hole and accepts 5.0 mm VA locking screws in nominal angle
- Every VA locking hole and the central fixed angle plate head hole accepts non-VA locking screws; they must be inserted in nominal angle but it is recommended to use the available guiding tools to assist insertion in nominal angle
- 4.5 mm cortex screws can be used in the DCU portion of combiholes and the central plate head hole to compress the plate to the bone (increasing rotational stability) or create axial interfragmentary compression.

Fig 4
To differentiate a screw with OPTILINK screw technology from a 'normal' stainless steel VA locking screw, a golden color coding has been added on top of the screw..

OPTILINK screw technology

Special VA locking screws in stainless steel that have undergone carburizing are required for the VA-LCP Condylar Plate 4.5/5.0 in titanium alloy (Fig 4). Carburizing is a low temperature heat treatment process (around 500 degrees Celsius) applied to metals in an environment enriched with carbon atoms. The metal surface absorbs carbon in the outer surface of the screw (33 µm layer thickness) and increases in hardness and strength. The brand name of this technology applied to stainless steel VA locking screws is called OPTILINK technology.

The advantages of screws with OPTILINK screw technology are as follows:

- Safe mixing of a titanium alloy plate with a stainless steel screw due to equivalent corrosion resistance properties as nonmixed-metal plate-screw constructs made of stainless steel
- The plate-screw construct combines the stability and smoothness of stainless steel screws with OPTILINK technology with the elasticity of titanium alloy plates
- High stability at plate-screw interface due to increased surface hardness
- Reliable insertion and removal due to low deformation of the stardrive recess

- Potential for low cell adhesion characteristics that are comparable to stainless steel due to a similarly smooth surface topography as untreated stainless steel, which is beneficial for ease of screw removal.

The OPTILINK screw technology allows the use of stainless steel screws with titanium alloy plates without any potential drawbacks of mixing metals in fracture treatment. However, it is currently only applied for 5.0 mm VA locking screws, which are supposed to be used with the VA-LCP Condylar Plate 4.5/5.0 in titanium alloy. This technology is planned to be extended to other screw sizes and to be offered also in combination with stainless steel plates in the future.

Case provided by Christoph Sommer, Chur, Switzerland

Fig 5a–c
Images from the accident. AP view of the unicondylar lateral split fracture (a). Medial condyle intact? Axial view (b). Lateral view (c).

Case: Fall downstairs

A 79-year-old woman fell downstairs at home and sustained a low-energy distal intraarticular femoral fracture. On conventional x-rays, the fracture seemed to be a unicondylar lateral split-type in rather osteoporotic bone (Fig 5). For detailed fracture analysis, a CT scan was performed that demonstrated a displaced lateral and nondisplaced medial condylar fracture (AO-33C1) (Fig 6). The fracture was very distal and therefore difficult to address with one lateral plate. Using VA technology in this situation provided the advantage of angulating the most distal anterior screw very close to the intercondylar notch in order to address the nondisplaced but fractured anteromedial condyle (Fig 7). Due to poor bone quality, a long plate was used to prevent a future periimplant fracture. Early follow-up showed uneventful healing with good function.

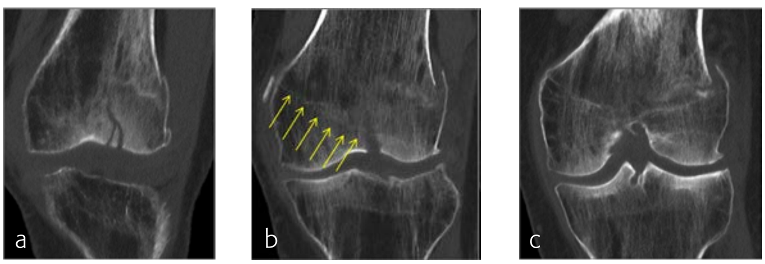


Fig 6a–c
The CT scans with frontal reconstructions. Displaced lateral and nondisplaced (but fractured) medial condyle (yellow arrows).

Fig 7a–b
Postoperative AP (a) and lateral (b) views.

TFN-Advanced Proximal Femoral Nailing System—additional instruments

The TFN-Advanced (TFNA) proximal femoral nailing system has been designed to solve a wide range of unmet needs for surgeons, OR staff, and administrators. The features and advantages of this nailing system (improved anatomical fit, reduced procedural complexity, comprehensive surgical options) have been described in detail in the 2015 AOTK System Innovations magazine.

Screw-only aiming arm

The TFNA offers surgeons the option to insert either a blade or a screw head element. The TFNA helical blade is designed to compress bone during insertion, which enhances implant anchorage and can reduce the risk of cut-out. As such it is regarded as particularly advantageous under osteoporotic bone conditions. However, there are still many surgeons that prefer to use the TFNA screw as the head element regardless of bone quality. Since these surgeons do not necessarily need the instrumentation that allows the insertion of either the blade or the screw, a screw-only aiming arm has been developed to further reduce instrument complexity and cost.

The screw-only aiming arm is offered for CCD angles of 125° and 130° (Fig 1). It has a coaxial locking mechanism that reduces the size of the aiming arm and decreases its foot-print in the instrument case. It presents the possibility of inserting the screw-only sleeve and locking it with just one hand. Interfragmentary compression is possible by means of a compression nut (Fig 2).

a

b

Fig 1a–b
The screw-only aiming arm, which can be attached to the insertion handle (a). The screw only guide sleeve is locked by a quarter turn of the locking mechanism (b).

a

b

Fig 2a–b
Once the TFNA screw has been locked in rotation, interfragmentary compression can be obtained by mounting a compression nut onto the TFNA screw inserter (a), advancing it until it abuts the guide sleeve (b), and then turning the buttress/compression nut clockwise.

a

b

c

Fig 3a–c
Opening options to prepare the nail entry path. All drill bits are also offered in longer versions for use with the percutaneous radiolucent insertion handle.

a 16 mm drill bit, flexible, cannulated, for quick coupling for DHS/DCS.
b 16 mm drill bit, cannulated, for quick coupling for DHS/DCS.
c 16 mm hollow reamer, cannulated, for quick coupling for DHS/DCS.

Fig 4
A cylindrical bone plug was removed from the insertion area.

Hollow reamer

When the TFN-Advanced proximal femoral nailing system was launched in 2015, flexible and solid drill bits were offered to prepare the entry path of the nail. When fracture lines are located in the area of the intended nail insertion point, fracture fragments can be pushed apart when introducing these drill bits through the fracture lines causing a varus malreduction of the head-neck fragment. In order to avoid this clinical problem, an optional hollow reamer has been developed (Fig 3). When using the hollow reamer, fracture fragments are not displaced because the instrument facilitates the removal of a cylindrical bone plug from the insertion area (Fig 4) without causing radial displacement forces to the surrounding bone.

Case provided by Hiroaki Minehara, Sagamihara, Japan

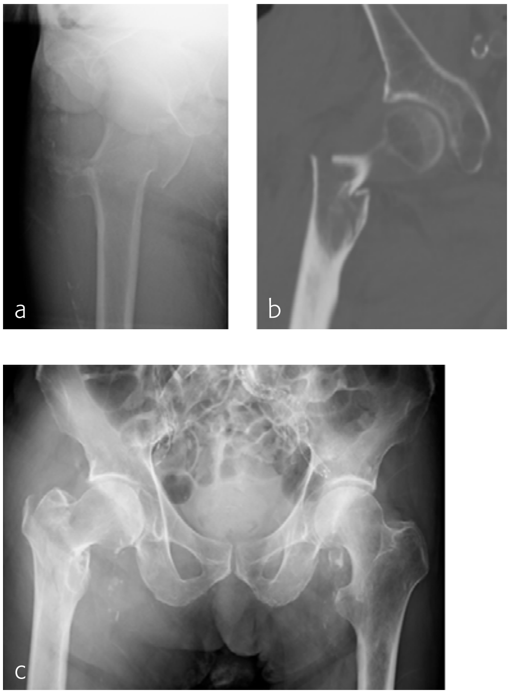


Fig 5a–c
Preoperative images of the patient.

Use of the hollow reamer in a clinical case

It is widely reported in the literature in Japan that there are many missed unstable femoral trochanteric fracture cases diagnosed only by x-ray, yet CT scans can clearly reveal the unstable fracture pattern.

A 77-year-old man suffered a right femoral trochanteric fracture (Figs 5–8). This case can be diagnosed as AO31-A1. However the CT shows the detachment of the lesser trochanter (AO31-A2). Precise information of dangerous fracture patterns in advance might simplify the imaging of intraoperative reduction maneuvers and the use of the implants.

In this case, the fracture lines are located in the area of the intended nail insertion point. The 3-D reconstruction images distinctly show that the hollow reamer prevented the fracture fragments from being pushed apart when introducing the hollow reamer close to the fracture line.

Fig 6
Intraoperative picture of the use of the hollow reamer.

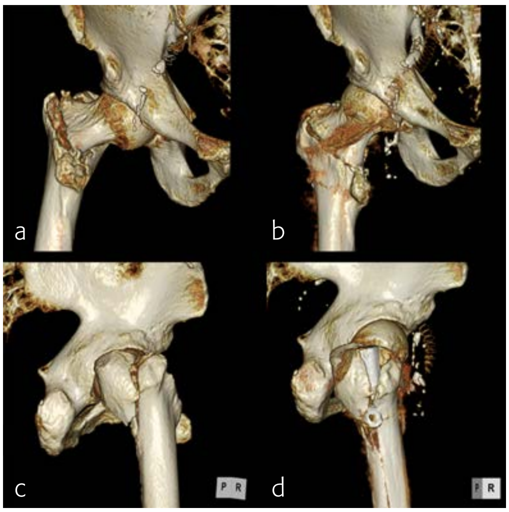


Fig 7a–d
Preoperative (a,c) and postoperative (b,d) 3-D CT images.

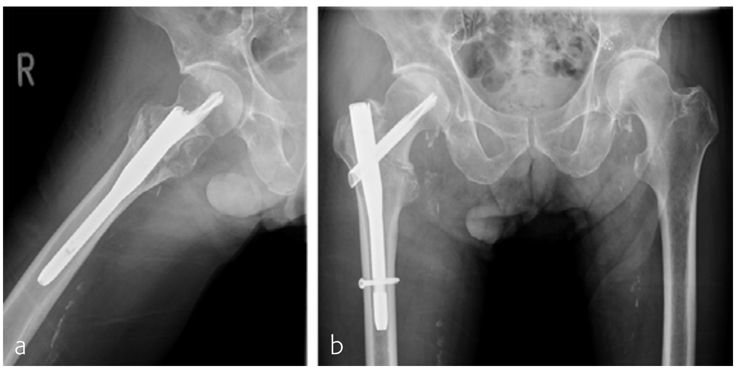


Fig 8a–b
Postoperative x-ray images.

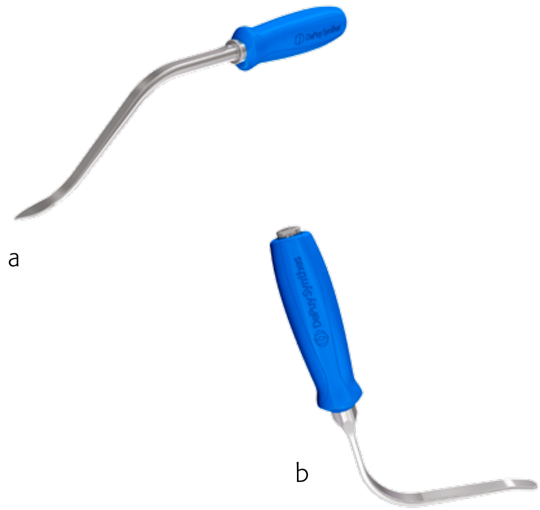


Fig 9a–b
Curved elevator (a) and L-shaped elevator (b).

Curved elevator and L-shaped elevator

Reduction in certain proximal femoral nailing cases still remains a clinical challenge. Surgeons from Japan especially emphasize the importance of anatomical reduction of the medial and anterior cortices to improve the stability of the fracture and the efficacy of the nail. With no bone support at the medial and anterior cortices there is a higher risk for shortening of the femoral neck and fixation failure.

Because of the need for dedicated reduction instruments to facilitate the required reduction maneuvers, two new instruments have been developed: the curved elevator and the L-shaped elevator (Fig 9).

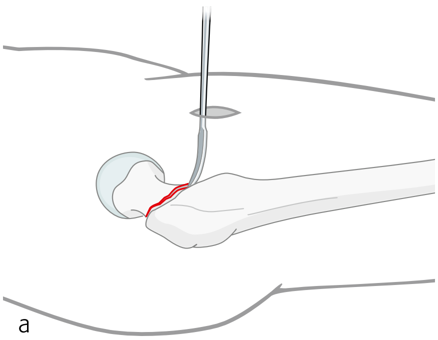
The curved elevator is intended to align shifted fragments in the proximal femur through a lateral or an anterior approach (Fig 10). The recommendation is to obtain an extramedullary type of reduction with good bone support.

The L-shaped elevator is radiolucent. This elevator is usually applied for the reduction of strong anteversion in the lateral view (Fig 11).

The elevators are currently only available in Japan. The provision of these instruments in other countries is under consideration.

References

1 OS Nexus No 4. *Surgical Treatment for Traumatic Injuries of the Hip and Pelvis*. Tokyo: Medical View Co Ltd; 2015.



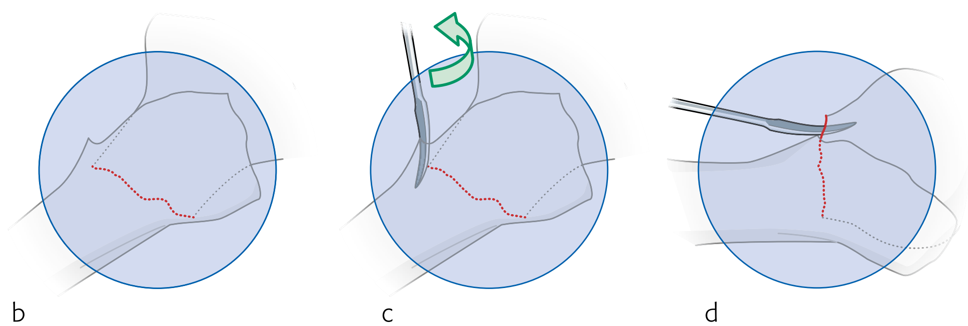


Fig 10a–d
Anterior approach (a) for use with the curved elevator. The lower pictures depict the fracture before (b), during (c), and after (d) reduction [1].

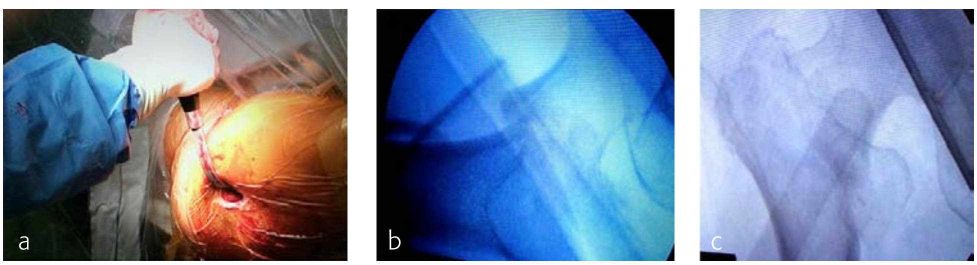
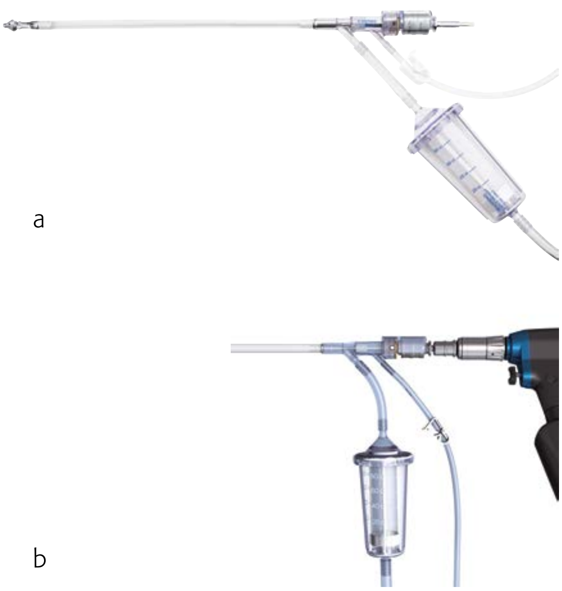


Fig 11a–c
Pushing down the anterior cortex of the proximal fragment can correct the anteversion. It is necessary to hold the elevator until blade or lag screw insertion.

Hans-Christophe Pape

NEWS FROM THE RIA TASK FORCE



a

b

Fig 1a–b
The Reamer Irrigator Aspirator system (a) with attached power tool (b).

Focus and update from the Reamer Irrigator Aspirator Task Force

The Reamer Irrigator Aspirator Task Force (RIATF) is a dynamic group of ten internationally-renowned orthopedic surgeons, tasked with overseeing technical improvements to the next generation Reamer Irrigator Aspirator (RIA) system (Fig 1).

Since its inaugural meeting in December 2013, the Task Force has been very active in testing new generation RIA prototypes and guiding technical improvements from a global clinical standpoint. The RIATF is at the forefront of evidence creation relating to indications for RIA usage, complications associated with RIA usage, and biomechanical considerations during reaming. Additionally, the RIATF seeks to educate orthopedic surgeons throughout the world in conjunction with AO Trauma, to facilitate successful use of the device.

What is the RIA system?

Reamers have been in clinical use for many years and were originally designed for the purpose of intramedullary widening in long bones, to allow the insertion of intramedullary nails. Reaming is also used to remove infected bone tissue. Inherent to the practice of reaming is the increased risk of pulmonary embolization of medullary fat under conditions of increased intramedullary pressure, leading to pulmonary dysfunction. Irrigation and aspiration capabilities were added to the device to circumvent these problems [1]. Serendipitously, this has led to increasing usage of the device as a means to harvest bone graft from long bones, with fewer complications than traditional methods (eg, iliac crest bone graft harvesting). The harvested bone graft can be used in the treatment of nonunions and large segmental bone defects.

Engineers are currently working to develop a new generation device, the RIA II, which will accommodate smaller reamer cutting heads in order to minimize wastage of bone graft material, and to expand the potential use of RIA in the tibia and in patients with smaller anatomy.

Current Task Force activities

Prototype testing

Medical members of the RIATF have tested prototypes of the next generation RIA system in anatomical specimen labs in Davos (December 2015), Solothurn (May 2016), and West Chester (October 2016) (Fig 2). These usability labs are a critical part of the development process.

Research

Medical members of the RIATF are heading up a number of research studies focusing on the RIA System, including:

- A retrospective clinical study regarding RIA indications and complications (Christoph Müller)
- Biomechanical investigation of the influence of the reaming diameter (RIA) on failure loads of human femora (Michael Raschke)
- Biological properties of harvest material (Ingo Marzi)
- Special applications of RIA (eg, acute polytrauma, oncology, infection)
- An animal study to establish local and systemic safety of the new generation device (RIA II) (Gerhard Schmidmaier)
- A clinical study to compare fracture healing outcomes in tibial defects treated with bone graft harvested by RIA to those treated by bone graft held in situ by a bioactive graft cage (Brent Norris).

Education

The RIATF members have recently produced educational material (Frequently Asked Questions about the Reamer Irrigator Aspirator system and Annotated Reamer Irrigator Aspirator Abstracts, Fig 3), which will feature in the curricula of AO Courses on IM nailing, Infection, and Orthogeriatrics.

A webinar entitled "Using the RIA without complications" was delivered from Switzerland in September 2016, by Prof Peter Giannoudis.

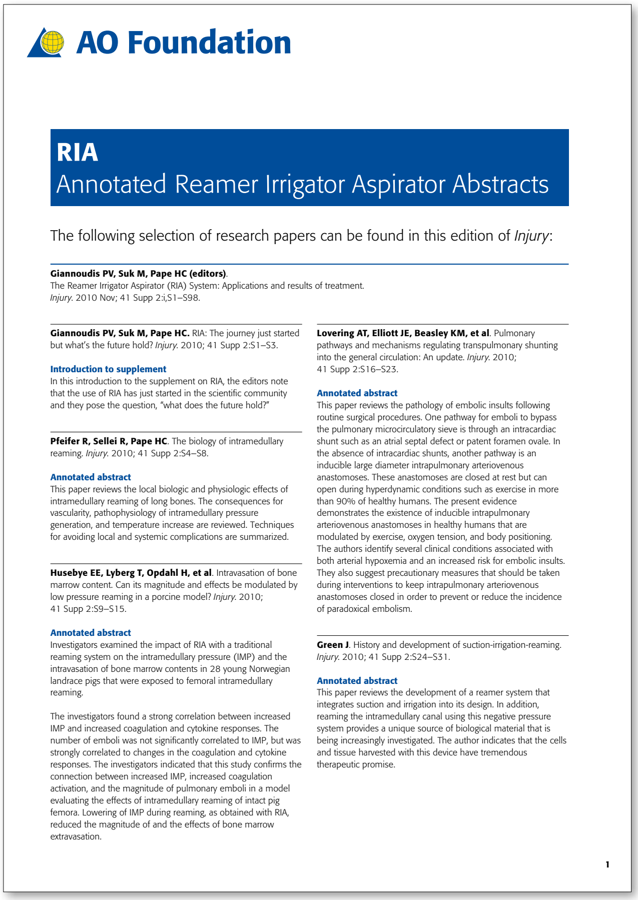
A teaching video relating to complication-free use of the RIA device is also under development. Initial filming in collaboration with the AO Education Institute took place in Solothurn in May 2016.

Fig 2a–d
Prototype testing of the new Reamer Irrigator Aspirator system.

The RIA Task Force Chair, Chris Pape says: “Advances in the surgical treatment of trauma have generated the need for more sophisticated RIA instrumentation. The new generation RIA device will allow surgeons to continue to improve outcomes in complex cases where patients require reaming and bone grafting”.

References

1 **Green J.** History and development of suction-irrigation-reaming. *Injury, Int J Care Injured*. 2010; 41:S2, S24–S31.



AO Foundation

RIA

Annotated Reamer Irrigator Aspirator Abstracts

The following selection of research papers can be found in this edition of *Injury*:

Giannoudis PV, Suk M, Pape HC (editors).
The Reamer Irrigator Aspirator (RIA) System: Applications and results of treatment.
Injury. 2010 Nov; 41 Supp 2:i,S1–S98.

Giannoudis PV, Suk M, Pape HC. RIA: The journey just started but what’s the future hold? *Injury*. 2010; 41 Supp 2:S1–S3.

Introduction to supplement
In this introduction to the supplement on RIA, the editors note that the use of RIA has just started in the scientific community and they pose the question, “what does the future hold?”

Pfeifer R, Sellei R, Pape HC. The biology of intramedullary reaming. *Injury*. 2010; 41 Supp 2:S4–S8.

Annotated abstract
This paper reviews the local biologic and physiologic effects of intramedullary reaming of long bones. The consequences for vascularity, pathophysiology of intramedullary pressure generation, and temperature increase are reviewed. Techniques for avoiding local and systemic complications are summarized.

Husebye EE, Lyberg T, Opdahl H, et al. Intravasation of bone marrow content. Can its magnitude and effects be modulated by low pressure reaming in a porcine model? *Injury*. 2010; 41 Supp 2:S9–S15.

Annotated abstract
Investigators examined the impact of RIA with a traditional reaming system on the intramedullary pressure (IMP) and the intravasation of bone marrow contents in 28 young Norwegian landrace pigs that were exposed to femoral intramedullary reaming.

The investigators found a strong correlation between increased IMP and increased coagulation and cytokine responses. The number of emboli was not significantly correlated to IMP, but was strongly correlated to changes in the coagulation and cytokine responses. The investigators indicated that this study confirms the connection between increased IMP, increased coagulation activation, and the magnitude of pulmonary emboli in a model evaluating the effects of intramedullary reaming of intact pig femora. Lowering of IMP during reaming, as obtained with RIA, reduced the magnitude of and the effects of bone marrow extravasation.

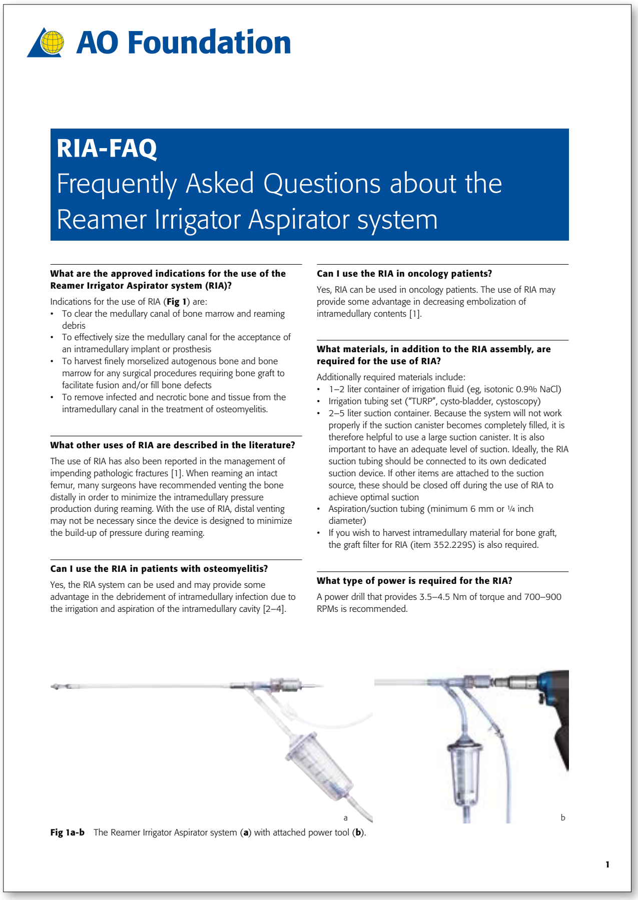
Lovering AT, Elliott JE, Beasley KM, et al. Pulmonary pathways and mechanisms regulating transpulmonary shunting into the general circulation: An update. *Injury*. 2010; 41 Supp 2:S16–S23.

Annotated abstract
This paper reviews the pathology of embolic insults following routine surgical procedures. One pathway for emboli to bypass the pulmonary microcirculatory sieve is through an intracardiac shunt such as an atrial septal defect or patent foramen ovale. In the absence of intracardiac shunts, another pathway is an inducible large diameter intrapulmonary arteriovenous anastomoses. These anastomoses are closed at rest but can open during hyperdynamic conditions such as exercise in more than 90% of healthy humans. The present evidence demonstrates the existence of inducible intrapulmonary arteriovenous anastomoses in healthy humans that are modulated by exercise, oxygen tension, and body positioning. The authors identify several clinical conditions associated with both arterial hypoxemia and an increased risk for embolic insults. They also suggest precautionary measures that should be taken during interventions to keep intrapulmonary arteriovenous anastomoses closed in order to prevent or reduce the incidence of paradoxical embolism.

Green J. History and development of suction-irrigation-reaming. *Injury*. 2010; 41 Supp 2:S24–S31.

Annotated abstract
This paper reviews the development of a reamer system that integrates suction and irrigation into its design. In addition, reaming the intramedullary canal using this negative pressure system provides a unique source of biological material that is being increasingly investigated. The author indicates that the cells and tissue harvested with this device have tremendous therapeutic promise.

1



AO Foundation

RIA-FAQ

Frequently Asked Questions about the Reamer Irrigator Aspirator system

What are the approved indications for the use of the Reamer Irrigator Aspirator system (RIA)?

Indications for the use of RIA (**Fig 1**) are:
- To clear the medullary canal of bone marrow and reaming debris
- To effectively size the medullary canal for the acceptance of an intramedullary implant or prosthesis
- To harvest finely morselized autogenous bone and bone marrow for any surgical procedures requiring bone graft to facilitate fusion and/or fill bone defects
- To remove infected and necrotic bone and tissue from the intramedullary canal in the treatment of osteomyelitis.

What other uses of RIA are described in the literature?

The use of RIA has also been reported in the management of impending pathologic fractures [1]. When reaming an intact femur, many surgeons have recommended venting the bone distally in order to minimize the intramedullary pressure production during reaming. With the use of RIA, distal venting may not be necessary since the device is designed to minimize the build-up of pressure during reaming.

Can I use the RIA in patients with osteomyelitis?

Yes, the RIA system can be used and may provide some advantage in the debridement of intramedullary infection due to the irrigation and aspiration of the intramedullary cavity [2–4].

Can I use the RIA in oncology patients?

Yes, RIA can be used in oncology patients. The use of RIA may provide some advantage in decreasing embolization of intramedullary contents [1].

What materials, in addition to the RIA assembly, are required for the use of RIA?

Additionally required materials include:
- 1–2 liter container of irrigation fluid (eg, isotonic 0.9% NaCl)
- Irrigation tubing set (“TURP”, cysto-bladder, cystoscopy)
- 2–5 liter suction container. Because the system will not work properly if the suction canister becomes completely filled, it is therefore helpful to use a large suction canister. It is also important to have an adequate level of suction. Ideally, the RIA suction tubing should be connected to its own dedicated suction device. If other items are attached to the suction source, these should be closed off during the use of RIA to achieve optimal suction
- Aspiration/suction tubing (minimum 6 mm or ¼ inch diameter)
- If you wish to harvest intramedullary material for bone graft, the graft filter for RIA (item 352.229S) is also required.

What type of power is required for the RIA?

A power drill that provides 3.5–4.5 Nm of torque and 700–900 RPMs is recommended.

a b

Fig 1a-b The Reamer Irrigator Aspirator system (**a**) with attached power tool (**b**).

1

Fig 3
New educational material developed by medical members of the RIA Task Force.

Philip Horsting, Jean Ouellet

SPINE

Expedium Verse System

Speed and versatility

The Expedium Verse pedicle screw system (Fig 1) combines the attributes of multiple screw types (side-loading, monoaxial, polyaxial, uniplanar, and reduction screws) while offering intraoperative flexibility allowing surgical staff to address unplanned circumstances with one versatile implant. This ultimately results in the delivery of a more predictable intraoperative experience for the treatment of both adult and paediatric spine deformity.

The Expedium Verse implant incorporates technology that allows for converting the polyaxial screw into a monoaxial screw while allowing for translation along the rod. The correction key is used as a locking mechanism that provides independent locking of polyaxial head and rod.

Easier rod capture with powerful and controlled correction

The "hypermobility" or increased angulation (Table 1) of the polyaxial head in combination with the reduction tabs simplify rod capture while providing a powerful threaded reduction mechanism that accommodates controlled approximation of the spine to the rod.

The pedicle screws serve as a powerful instrument in the facilitation of correction maneuvers. The result is a great reduction in the number of instruments required for fusion procedures, potentially simplifying the surgical instrument table and reducing the costs associated with the sterilization process.

The Expedium Verse pedicle screw can be converted into a monoaxial implant while allowing the screw to articulate around the rod. Tighten the poly lock of the correction key with the torque limiting handle while applying counter torque to lock the polyaxial head (Fig 2).

Implant (diam.)	4.35 mm	5 mm	6 mm	7 mm	8 mm
Expedium Favoured Angle System (°)	-25 > 55	-25 > 45	-20 > 50	-17 > 46	N/A
Expedium Verse (°)	-29 > 55	-30 > 52	-28 > 50	-24 > 46	-20 > 42

Table 1
Screw angular range of motion.

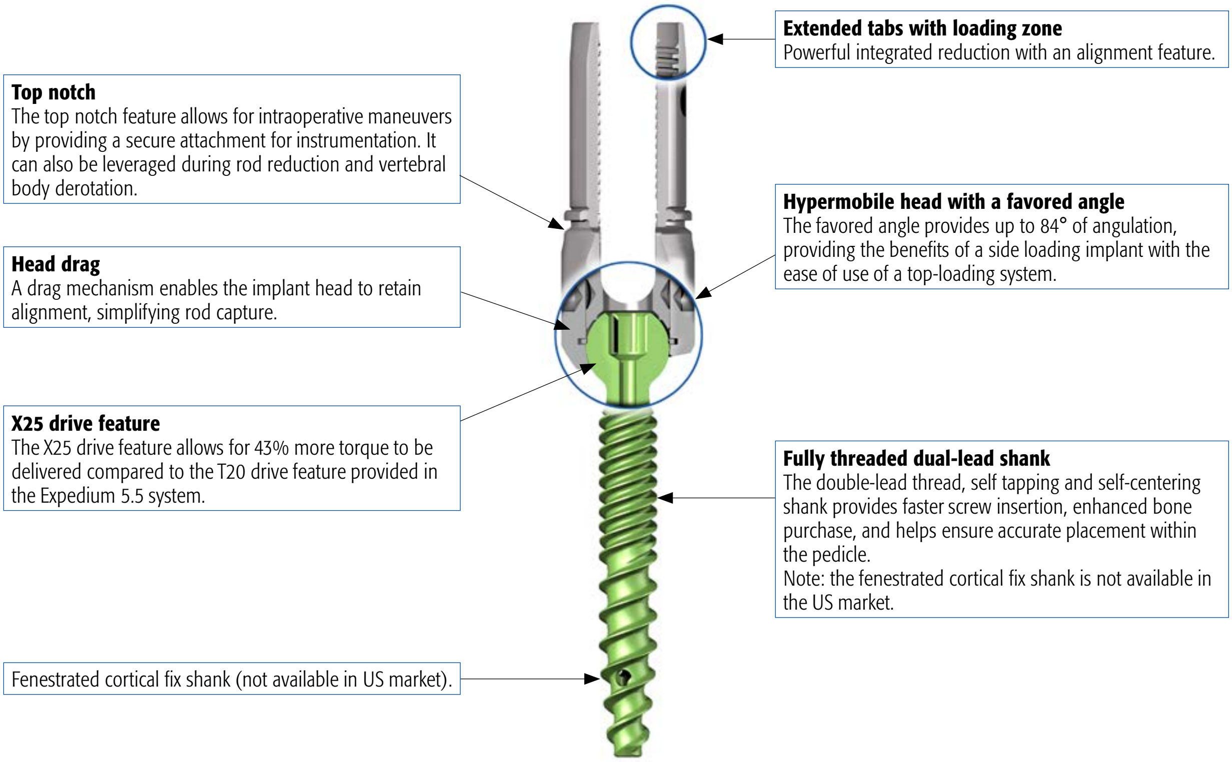


Fig 1
Expedium Verse polyaxial pedicle screw with system features.

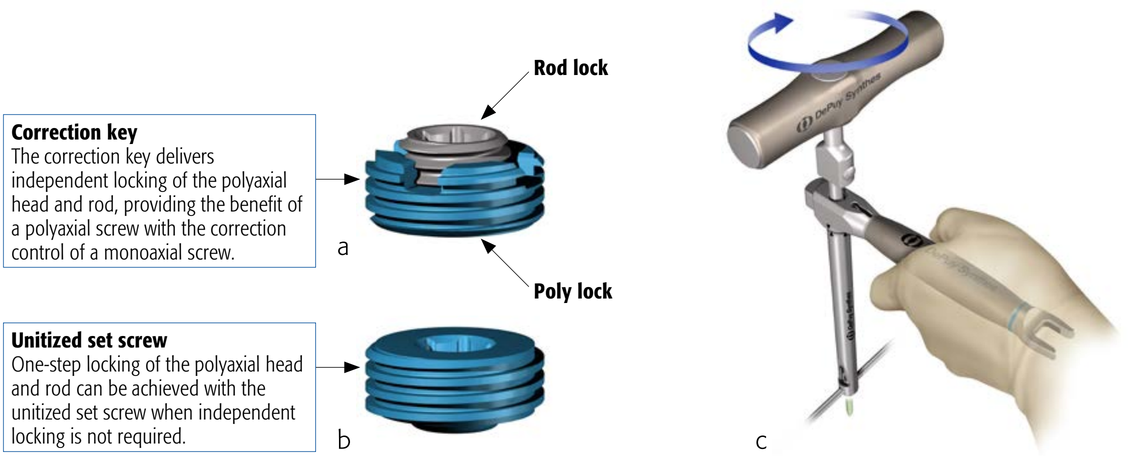


Fig 2a–c
Instruments. Correction key (a), unitized set screw (b), torque limiting handle (c).

Fig 3
Polyaxial screw driver.

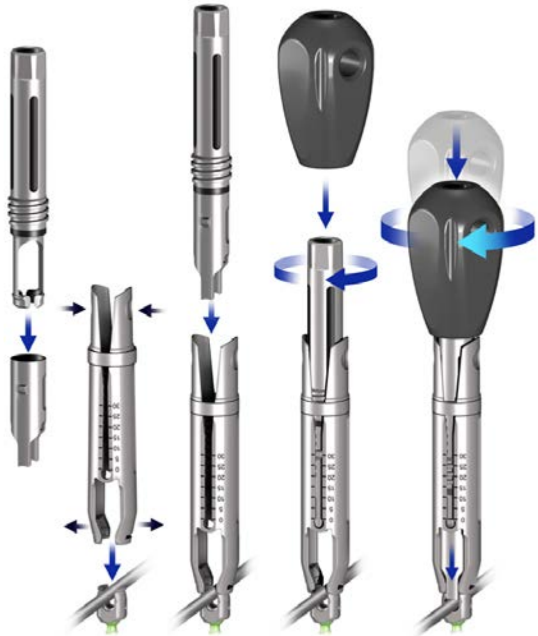


Fig 4
Flex clip reducer.

Instrument design and set configuration

Through the redesign and feature enhancement on both the instruments and implants, it was possible to significantly reduce the number of instruments when compared to a traditional system such as the Expedium 5.5, enabling a shift away from instrument based correction methods to a more implant based procedure.

The polyaxial screwdriver modular design also allows for intraoperative assembly and includes tissue protection sleeves (Fig 3).

The Expedium Verse system provides a flex clip reducer (Fig 4) known from the Expedium 5.5 system for surgeons in case a reduction tab is accidentally or intentionally removed prior to reducing the rod into the screw head.

A tab remover has been provided for removal of the Expedium Verse screw reduction tabs at the completion of the procedure (Fig 5).

Please refer to Expedium Verse IFU for complete listing of warnings, contraindications and precautions.

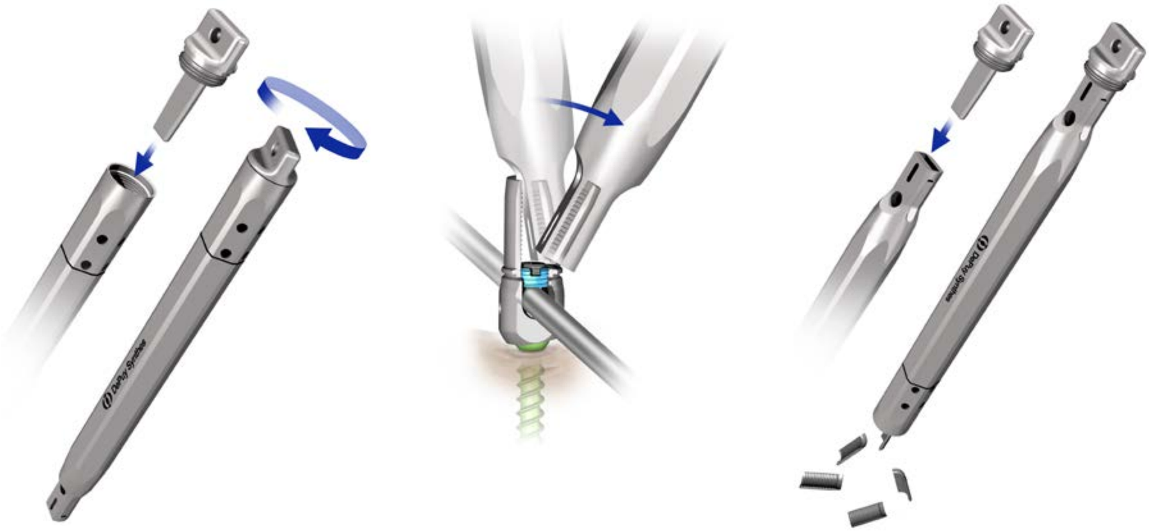


Fig 5a–c
Tab breaker.

Cases provided by Philip Horsting, Nijmegen, Netherlands

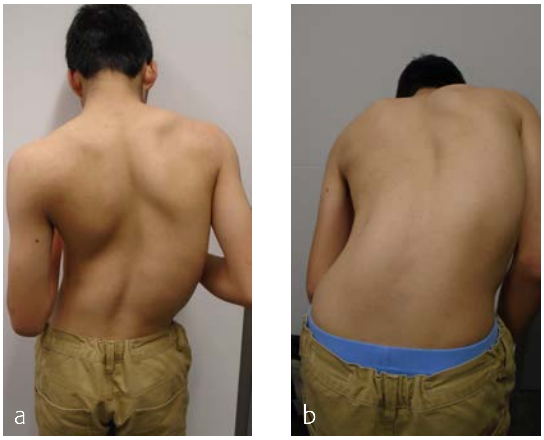


Fig 6a–b
Preoperative clinical pictures, posterior upright (a) and forward bending (b).

Case 1: Teenage boy with intellectual disability

Twelve months prior to his first visit to our clinic, the father of this 17-year-old intellectually disabled boy found a scoliosis, later confirmed by his therapist. The patient was physically grown comparable to his age but mentally functioned at a 2-year-old level. No syndromic diagnosis was made after visits to a pediatrician. He had been diagnosed with severe autism. Bahavioural changes might be suggestive of pain. The patient was unable to specifically indicate pain or (progressive) limitations.

On physical examination a cooperative boy was seen, normal build and height, normal to high paraspinal muscle tone. Standing upright he was off balance to the right. Neurological examination showed absent abdominal skin reflexes bilaterally. The curve was classified as neuromuscular type scoliosis (Fig 6). Due to the curve magnitude, being off balance, and with (severely) limited nonoperative options (Fig 7), surgical treatment was discussed with the family.

He was scheduled for a posterior deformity correction from T4–L3. Under general anesthesia, with IONM (TC-MEP) the deformity was corrected. Intraoperatively, an epidural catheter was placed with the tip at T7 for postoperative analgesia.

Mobilisation started the day after surgery. He was discharged the fourth day after surgery. He returned for scheduled follow-up after 7 weeks (Fig 8). He seemed less agitated compared to the period before surgery. He did not seem to have specific limitations.

Fig 7a–c
Preoperative x-rays: AP, lateral, and sidebending (noncompliant due to his mental abilities).

Fig 8a–b
Postoperative x-rays: AP, lateral (sitting).

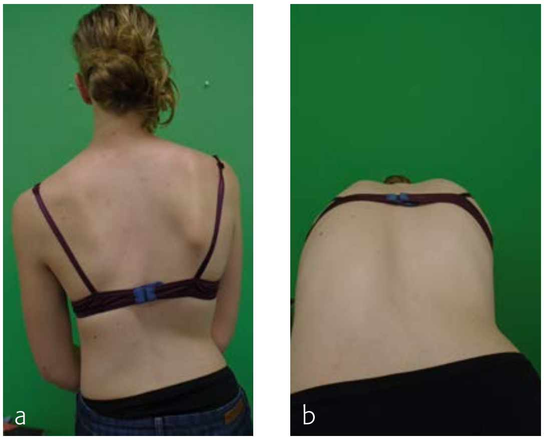


Fig 9a–b
Preoperative conventional imaging: posterior view upright and forward bending.

Case 2: 17-year-old female patient

The patient was known and under orthopedic control for a Lenke 5C-type AIS since 2009. Initial treatment with a Boston Brace failed to halt progressive growth, and curve progression became apparent beyond surgical treatment threshold (Fig 9). Bending showed TL correction 58 -> 30 (plm 50%). MT correction 43 -> 16 (plm 35%) (Fig 10). The patient was referred to our hospital for logistics regarding surgical planning.

After her visit to our clinic, she was planned for surgical correction of the deformity from T5–L4 (Fig 11). Surgical procedure with IONM (TC-MEP) postoperative epidural analgesia with the catheter tip at T8. She was mobilised the first postoperative day (Fig 12) and discharged the fourth day after surgery. The patient returned for her 6-month follow-up without any complaints. Limitations are in line with our advice (no sports for 6 months postoperatively). She has no pain and uses no medication.

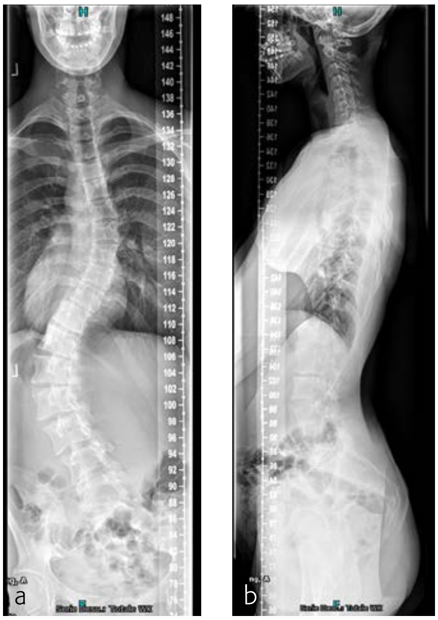


Fig 10a–b
Preoperative imaging: AP and lateral.

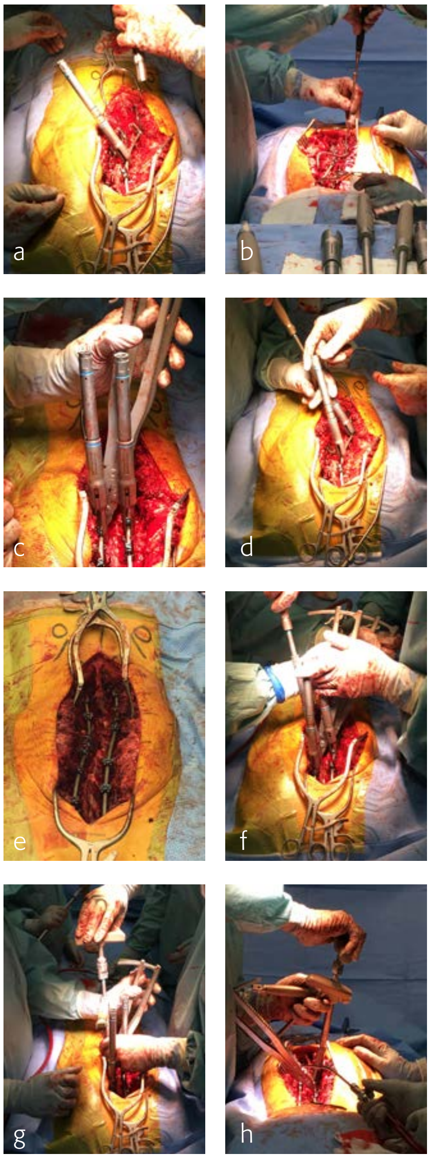


Fig 11a–h
Intraoperative imaging. Modular screw driver with ratchet. Multifunctional screw head extension tube with locking mechanism and anti-torque T-handle (one instrument for innie insertion, vertebral body derotation, and final tightening innie torque tightening).

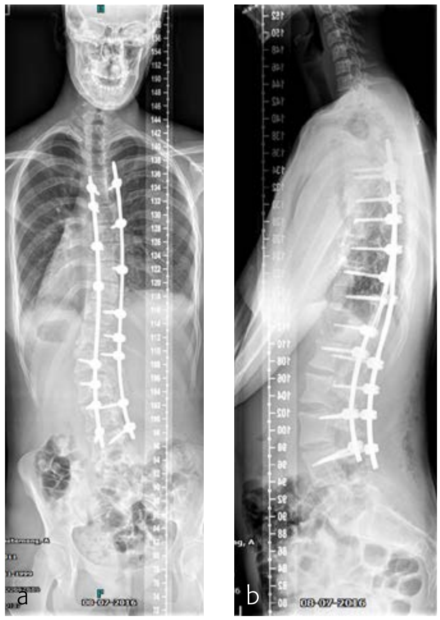


Fig 12a–b
Postoperative images: AP and lateral.

Most Common Sources of Pain

Pain Location	Prevalence in Respondents, No. (%)
Neck	333 (59.4)
With radiculopathy	155 (27.6)
Shoulder	272 (48.5)
Elbow	159 (28.3)
Wrist	139 (24.8)
Finger	175 (31.2)
Low back	349 (62.2)
With radiculopathy	172 (30.7)

Table 1
Operating clinicians at the Scoliosis Research Society were surveyed to assess the prevalence of musculoskeletal disorders (MSDs) among spine surgeons. The most common self-reported diagnoses included: neck pain/strain/spasm (38%, 215/561), lumbar disc herniation/radiculopathy (31%, 172/561), cervical disc herniation/radiculopathy (28%, 155/561), rotator cuff disease (24%, 134/561), varicose veins or peripheral edema (20%, 112/561), and lateral epicondylitis (18%, 99/561). Among active spine surgeons, multiple linear regression analysis revealed that total caseload correlated with neck pain ($P = 0.01$) and lower extremity edema ($P = 0.03$), while the number of deformity cases correlated with wrist pain ($P = 0.003$) and hand pain ($P = 0.03$). Age was correlated with shoulder ($P = 0.03$), elbow ($P = 0.04$), and hand pain ($P = 0.02$).

Power For Spine—the benefits of power tools in surgery

The Expedium 5.5 Power Instrument Set is designed to augment the current instrument set for the Expedium 5.5 implant family of products in three main areas:

- Enhanced surgeon ergonomics and health
- Speed and efficiency
- Safety and accuracy.

Enhanced surgeon ergonomics and health

It is a well-known fact that spinal deformity surgeries are long procedures with repetitive forceful maneuvers often in a less than ideal ergonomic position. Such repetitive tasks lead to chronic overuse injury. Auerbach [1] quantified the type of work-related injuries that spine surgeons experienced over their careers (Table 1).

The conclusion that can be derived from research such as in Table 1 is that compared with disease estimates in the general population, spine surgeons have a higher prevalence of MSDs.

The instrument length in the Expedium 5.5 Power Instrument Set is designed to improve surgeon ergonomics and provides a more comfortable shoulder and torso positioning during surgical procedures. Additionally, the powered hand piece reduces the number of repetitive motions that can lead to surgeon fatigue or overuse injuries.

Improving ergonomics as well as decreasing the repetitive motions of the upper extremity would indeed improve the health of operating clinicians. There is a growing need for surgeons to adapt their practice to incorporate better ergonomics. This can be achieved with good training programs and attaining a good understanding of the risks and benefits of using power in spine surgery.

Speed and efficiency

The application of powered instruments also offers potential timesaving for each screw implant. The greatest cumulative benefit is expected during deformity procedures.

Safety and accuracy

The power hand piece is designed to facilitate steadier hand positioning during pedicle preparation and screw delivery, potentially reducing the off-axis motion associated with manual pedicle preparation and screw delivery.

Seehausen [2] showed that "the use of power tools to create pedicle tracts and place pedicle screws was associated with shorter fluoroscopy times and a lower revision rate compared with using manual tools". He showed that both techniques posed similar low risks of injury to the patient.

Power drilling also guarantees high accuracy of the navigation system as low downward forces are applied to the spine.

Expedium 5.5 spine system

The Expedium 5.5 Power Instrument Set will address the key ergonomic and repetitive use injuries for surgeons performing high volumes of deformity or degenerative surgery as well as potentially reducing OR time and improving accuracy. This is accomplished through the ability to utilize the Expedium 5.5 product portfolio (ie, polyaxial, monoaxial, uniplanar screws) with powered pedicle preparation and screw delivery.

The instruments were developed in close collaboration with deformity surgeons. Through optimization of instrument length and geometry, shoulder, elbow, and trunk positioning is improved when compared to manual instrumentation.

Comparison of surgeon posture using manual and powered instruments

During pedicle preparation and screw delivery, powered instrumentation allows the surgeon to maintain a low shoulder position, an elbow position close to the torso, and decreases the amount of lateral bending often seen when using manual instrumentation (Figs 1 and 2). Maintaining alignment to the torso while minimizing the extension of the upper extremities provides an opportunity to reduce muscle recruitment and surgeon fatigue.

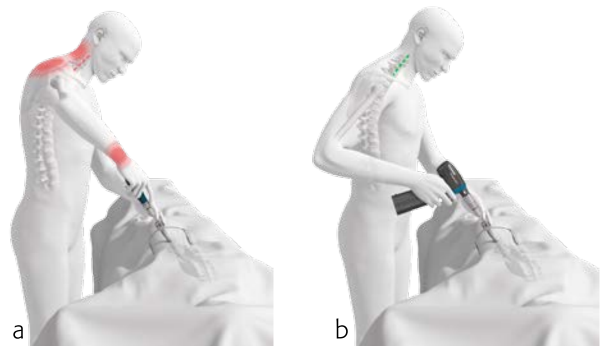


Fig 1a–b Comparison of shoulder height and elbow position.
a Manual.
b Powered instruments.

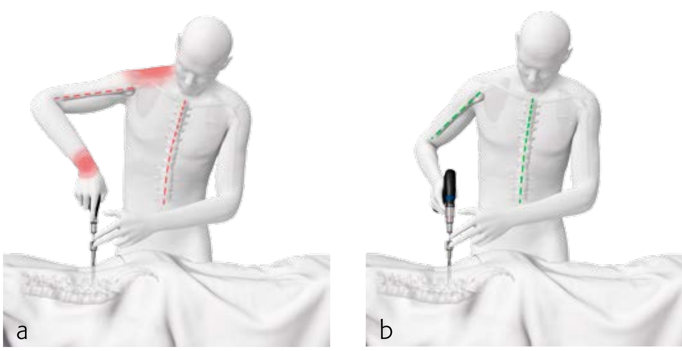


Fig 2a–b Comparison of spine lateral bend and elbow lift.
a Manual.
b Powered instruments.

Similarly, using powered instruments reduces the number of repetitive motions required during spine surgery, reducing energy expenditure and decreasing the potential for musculoskeletal disorders associated with overuse [1].

Product overview

The Expedium 5.5 power system uses the Colibri II power device (Fig 3), (which is known as the Small Battery Drive II (SBDII) in the USA). The features and benefits of using the system are shown.

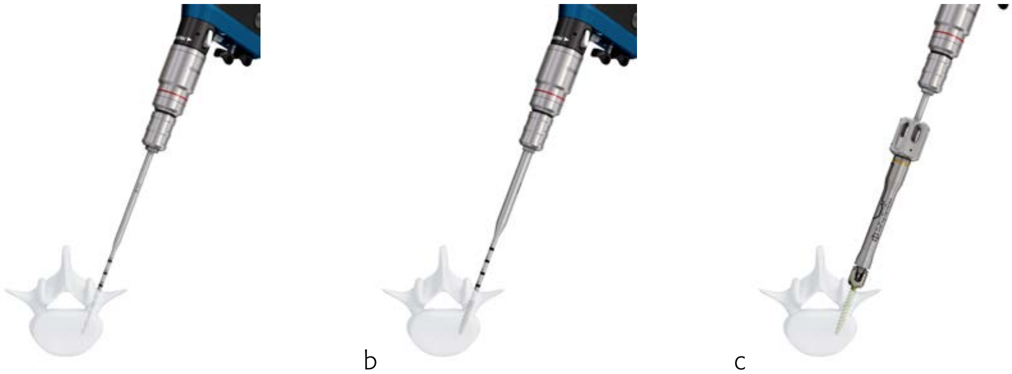
Fig 3
The Colibri II power device (known as the Small Battery Drive II (SBDII) in the USA).

The powered instruments for the Expedium 5.5 system enable powered drilling, tapping, and screw delivery with a cordless hand piece, quick coupling attachment, and optimized instrumentation (Fig 4).

References

1 **Auerbach JD , Weidner ZD, Milby AH, et al.** Musculoskeletal disorders among spine surgeons-results of a survey of the Scoliosis Research Society Membership. *Spine.* 2011 Dec; 36(26):e1715–1721.

2 **Seehausen DA, Skaggs DL, Andras LM, et al.** Safety and efficacy of power-assisted pedicle tract preparation and screw placement. *Spine Deformity.* 2015 March; 3(2):159–165.



a b c

Fig 4a-c
The powered instruments for the Expedium 5.5 system.

Case provided by Jean Ouellet, Montreal, Canada

Case: A two-level VCR

A T2 to pelvis, two-level vertebral column resection (VCR) was completed at the McGill University Health Center in 7 hours (Figs 5–7).

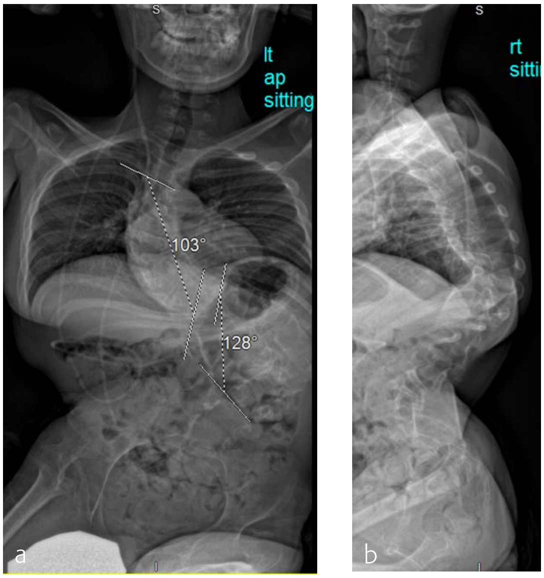


Fig 5a–b
Preoperative x-rays.

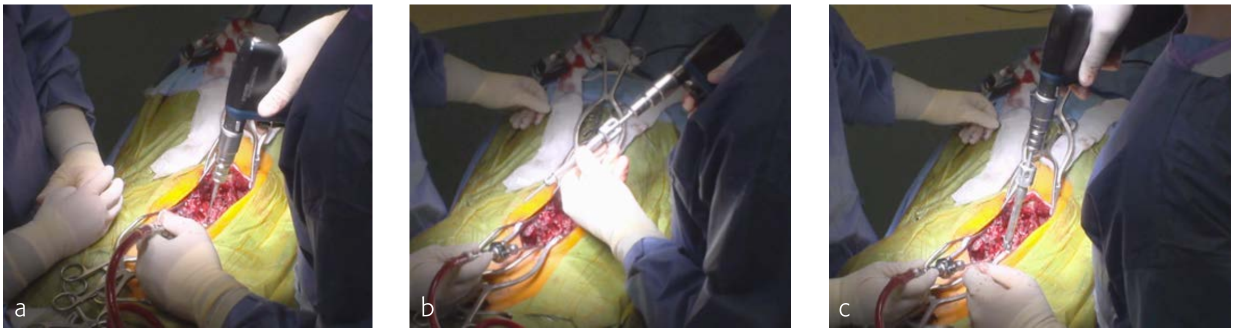


Fig 6a–c
Intraoperative images showing the use of the power tool.

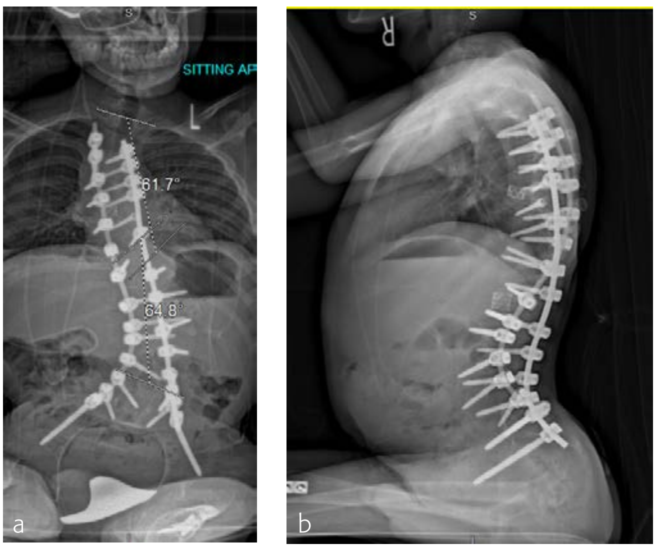


Fig 7a–b
Postoperative x-rays.

Stephen Lewis, Paul Manson

NEURO

Fig 1
Members of the Neurosurgery Working Group (NEWG) enjoy a warm drink during a meeting in Vienna in 2008.

Fig 2
AO Foundation office in Dübendorf, Switzerland. An early stakeholder group in 2015 holds discussions regarding the formation of a new Technical Commission for Neurosurgery.

A new AO Technical Commission for Neurosurgery

The AOTK Executive Board and the AO Foundation Board approved the formation of a new AO Technical Commission (TK) for Neurosurgery in December 2015. This significant milestone recognizes the increasing importance of neurosurgery as a clinical discipline within the AO Foundation.

Historically, neurosurgeons have been associated with AO educational courses since the mid-1980s, when they assisted in teaching complex multispecialty operations such as craniofacial fracture repair, skull base surgery, tumor resection, and neuro-cranial reconstruction. In 2005, the requirements for better instruments and materials generated the need for a neurosurgical technical advisory group. Initially, a Neurosurgery Working Group was formed to support the AOTK System with the development of craniomaxillofacial (CMF) products for cranial neurosurgery. Chaired by Geoffrey Manley, this group immediately took charge and began to work with dedication towards its goal to improve patient care (Fig 1).

In 2012, the Neurosurgery Working Group was made an expert group within the AOTK System, and renamed as the AO Neuro Trauma and Reconstruction Expert Group (NTREG). Prof Christian Matula, from the Medical University of Vienna (Austria) was elected as its first Chairman. Some of the important work undertaken by this group included the re-classification of neurological pathologies in order to adequately differentiate between the many clinical situations requiring treatment. To this end, Christian Matula actively engaged with his AOCMF colleagues, including Stefano Fusetti, Beat Hammer, Robert Kellman, and Edward Bradley Strong to deliver the AO Neuro Skull Base and Cranial Vault classification system. The group continued its mission to advance patient care through R&D, using AO's expertise and experience in classification, analysis, and treatment outcomes. Subsequently, discussions began regarding the formation of a new TK for Neurosurgery (Fig 2).

Today, the newly established AOTK Neuro comprises an international group of neurosurgeons (Prof Randy Chesnut, Prof Shoichiro Ishihara, Dr Fernando Gonzales, and Prof Christian Matula), and is Chaired by Prof Stephen Lewis from Perth, Australia (Fig 3). Dr Richard Hopper, a plastic surgeon, will offer CMF expertise to the group as needed. The new TK will allow the AO Foundation to effectively extend its activities into the development of products for the treatment of neurological and neurovascular disorders. The AOTK Neuro will oversee project teams focusing on development projects in specialty areas such as neurotrauma, cerebrovascular surgery and skull base surgery, and will review products for eventual approval.

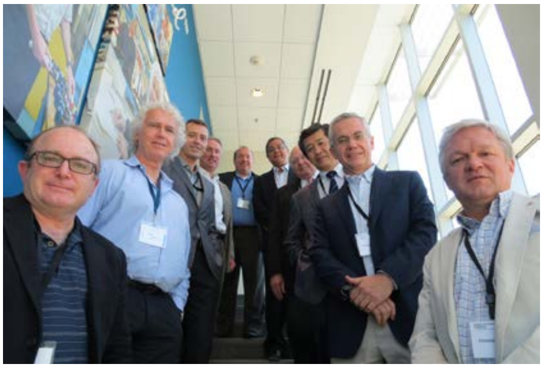


Fig 3
Inaugural meeting of the TK (Neuro) in Raynham, USA in July 2016. From left: Stephen Lewis (Chair – Perth); Randall Chesnut (Seattle); Richard Hopper (Seattle); Paul Gordon (Codman); Mike Barthold (DPS); Laxmin Laxminarain (Codman); Paul Manson (Baltimore); Shoichiro Ishihara (Tokyo); Fernando Gonzales (Durham USA); Christian Matula (Vienna).

Paul Gordon, Director of Market Development at Codman Neuro, said he was very pleased to be adding this new dimension to the on-going collaboration with AONeuro. "Neurological trauma and pathologies are a profound global health care problem. The development teams from Codman Neuro and DePuy Synthes CMF look forward to working with the AO neurosurgical experts to develop devices that will provide doctors the tools to improve their patients' lives."

The neurosurgeons that work within the AOTK System have always had a keen interest in education as well as the development of innovative neurosurgical products and devices.

Paul Manson, AO Foundation Past President, said he warmly embraced the development of the new Technical Commission. "In 2005, the formation of the Neuro Working Group brought cranial neurosurgeons more closely into the AO. These neurosurgeons then realized the need to improve the teaching of traumatic brain injury, skull base surgery, and neurocranial reconstruction, developments and protocols stimulated by recent experience in trauma units, including those in military settings and combat zones. AO courses addressing these topics were implemented in 2008 through the visionary actions and financing of the European CMF Group to cover the requirements for teaching new information relevant to the practice of complex multispecialty operations. It is no surprise that cranial neurosurgeons, after experiencing the exciting work of the AO Foundation, wished to embark upon the AO Neuro initiative in 2011. Further progress in surgical treatment has again generated the need for more sophisticated instrumentation. The recent merger of Synthes and Johnson & Johnson answered this need with broader technology support, and hence the requirement for a more neurosurgically sophisticated Neuro Trauma Expert Group, and now a dedicated Technical Commission for Neurosurgery. The process has been similar to the development of other specialty divisions in the Foundation, where rapid increases in progress generated the need for physicians with focused skills and expertise."

The new AOTK Neuro will follow in a rich tradition of medical device development. Since 2005, the Neuro Working Group and subsequently the AO Neuro Trauma and Reconstruction Expert Group have been instrumental in the development of many surgical devices, several of which have been adopted by other AO clinical specialties.

Neurosurgical solutions developed since 2005

Following hard work performed by the various working group/expert groups, a range of neuro solutions have already been developed. The Matrix Neuro Ultra Low Profile cranial plating system (Fig 4), launched in 2012, offers a significantly reduced plate-screw profile (0.28 mm compared to a previous thickness of 0.40) while providing comparable construct stiffness and strength. Chamfered plates mean almost no palpability under the skin and an improved experience for patients.

Also launched in 2012 was the Matrix Neuro Rigid Mesh and Bender (Fig 5), a contourable low profile titanium mesh that provides reliable rigidity in the reconstruction of large cranial defects. This mesh is used in reconstruction, fracture repair, craniotomies, and osteotomies.


a


b


c

Fig 4a–c
Components of the Matrix Neuro Ultra Low Profile cranial plating system, including plates with champfered edges.

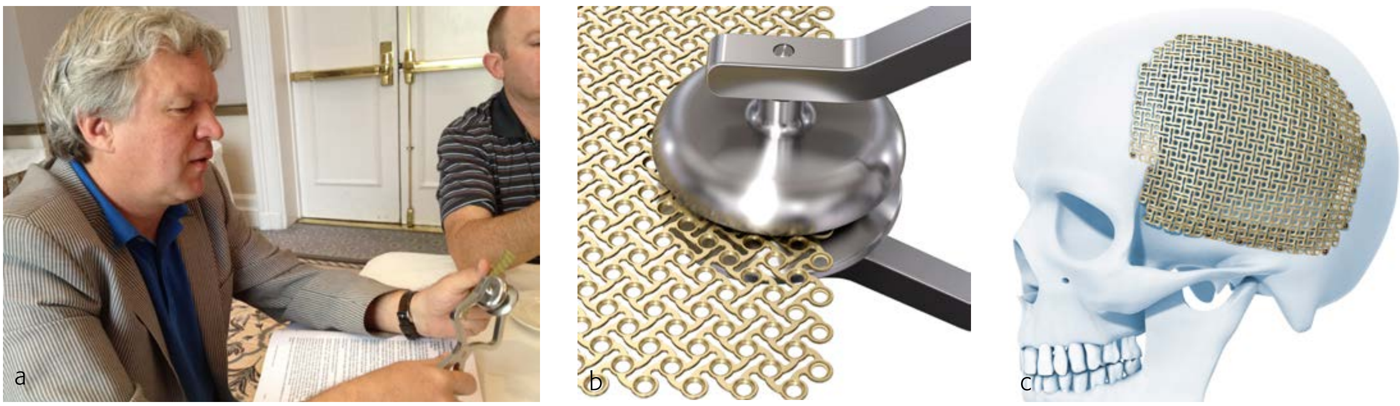

a b c

Fig 5a–c
Christian Matula (then Chair of the NTREG) tests a prototype of the rigid mesh bender in San Francisco.

Fig 6a–b
Members of the NTREG test the Electric High Speed Drill system in a validation lab in Palm Beach Gardens, USA.

The iPlan CMF 3.0, launched in 2013, is a preoperative CMF planning and intraoperative navigation system that offers improved accuracy and OR time savings. It allows virtual simulation of the surgical treatment, automatic segmentation, transfer of the complete virtual plan into the OR, the import of preformed orbital reconstruction plates via STL, and the generation of models for customized implants.

The Electric High Speed Drill system (Fig 6), launched in 2014, is a high precision system designed to cut and shape spinal and cranial bone and has applications within neurosurgery, neurotology, skull base, otolaryngology, and spinal surgery.

The Matrix Neuro Preformed Mesh implants (Fig 7), launched in 2014, are anatomically contoured rigid mesh implants designed to fit temporal, fronto-tempo-parietal, and frontal areas. The preformed nature of these implants has reduced bending time and overall OR time. The specific contouring is based on data from a clinical CT study of 80 patients.

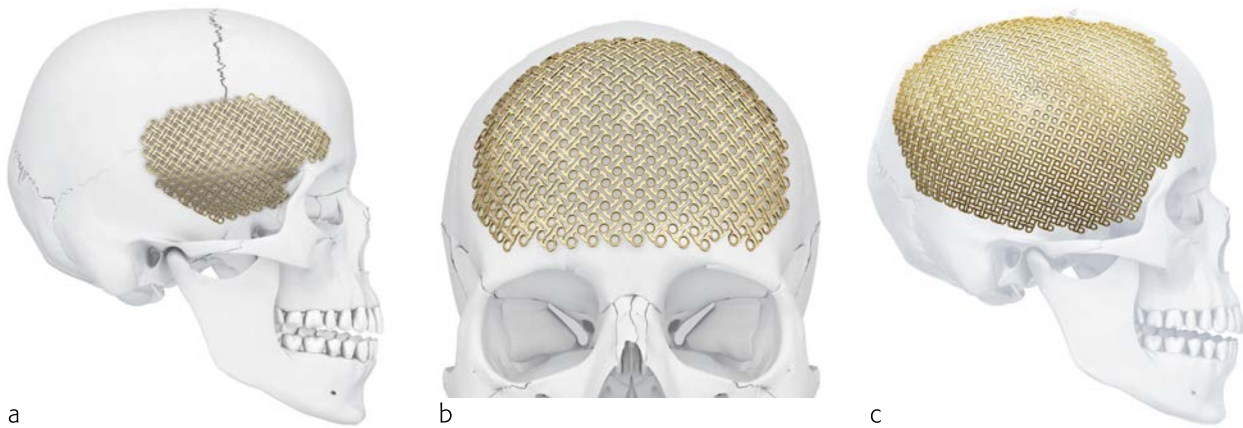


Fig 7a–c
Matrix Neuro Preformed Mesh implants for temporal (a), frontal (b), and fronto-tempo-parietal (c) areas.

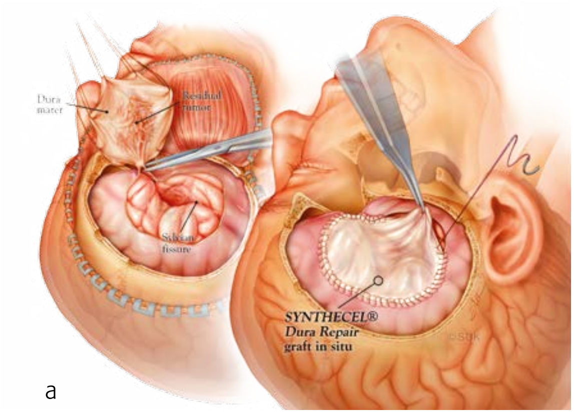
Synthecel Dura Repair (Fig 8), also launched in 2014, is a dural substitute based on biosynthesized cellulose technology. It is designed for the repair of dura mater during cranial or spinal surgery, following traumatic, neoplastic, or inflammatory damage.

Ongoing development of new solutions

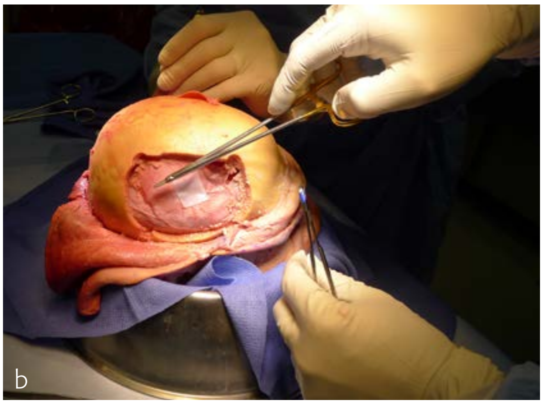
The TK (Neuro) had its inaugural meeting in Raynham, USA in July 2016 and is starting to work on new technical solutions for multimodal monitoring and CSF flow management. Future developments are likely to focus on virtual reality, robotics, and biologics.

NeuroTouch is a haptic virtual training simulator and offers state of the art neurosurgical education for the 21st century. Additionally, SuperNav is an intraoperative navigation tool being developed via an interdisciplinary research project between the AO Foundation and the University of Vienna. It is a novel software system leveraging computational power to provide a virtual surgical tool and has four application domains: a virtual craniotomy and approach planning tool; a patient communication tool; educational software; and elective single-stage cranioplasty.

The innovative surgical solutions delivered by the Neuro Working Group and Neuro Trauma and Reconstruction Expert Group have greatly enhanced the AOTK product inventory and have been successfully adapted to other AO specialties. As the new Technical Commission for Neurosurgery starts its new venture in 2016, there is great potential for progress through collaboration with industrial partners and the other surgical disciplines within the AO Foundation. As the new AOTK (Neuro) Chairman, Stephen Lewis has said: “The new TK for Neurosurgery desires to be a significant contributor to the AOTK cause. We look forward to cross collaboration with the other TK groups in the pursuit of excellence in patient care”.



a


b


c

Fig 8a–c
Synthecel Dura Repair (a) being tested by the NTREG in a validation lab in West Chester in 2014 (b). Members of the NTREG gather with clinical staff for a quick photo before testing (c).

Carl-Peter Cornelius, Goetz Giessler, Gerson Mast, Frank Wilde

CRANIOMAXILLOFACIAL

Biplanar plug-on tandem cutting guide for raising and contouring bone flaps from the lateral scapular border and tip

Surgical techniques in craniofacial reconstruction using fibula and anterior iliac crest (DCIA) flaps are now well established. Such approaches using free flaps, computer-assisted planning, and customized templates allow savings in operation time, improved accuracy of osteotomies, and easy in-setting. However, the use of flaps from the lateral scapular border and tip is less well defined in the literature.

The subscapular vascular system permits the retrieval of a wide array of different flaps in almost every conceivable combination of skin, fat, fascia, muscle, and bone. Although the volume of vascularized bone from the lateral scapular border and inferior angle or tip is limited, the availability of extended soft-tissue components at the same vascular pedicle offers valuable options in composite head and neck defects. In contrast to virtual surgical planning (VSP) and computer-assisted production of cutting templates for fibula and anterior iliac crest DCIA flaps, similar planning methods and supporting tools to raise and contour the scapular border and tip were until recently considered impossible because of its anatomical features.

The cutting guide design for the scapular border is complicated by the fact that a muscle cuff (infraspinatus, teres minor/major, and portions of subscapularis) must be preserved around the lateral border to maintain the blood supply provided by branches of the circumflex scapular artery. This need for an intact muscle cuff precludes the unimpaired application of cutting guides, which in fibula or DCIA flaps can be conveniently placed on bare bony surfaces at the outer iliac wing or lateral aspect of the fibular shaft, respectively.

The fundamental need for uninterrupted muscular cover layers means that the lateral scapula must be accessed from two perpendicular planes (posterior and medial), a factor that has driven the development of a biplanar cutting guide design. Another feature in the specification catalogue is angulated slots or flanges to accurately define the resection of intermediate bone wedges and obtain closing osteotomies. Reports of high rates of pseudoarthrosis between the scapular bone flap segments are the reason behind the demand to achieve maximum contact bony interfaces.

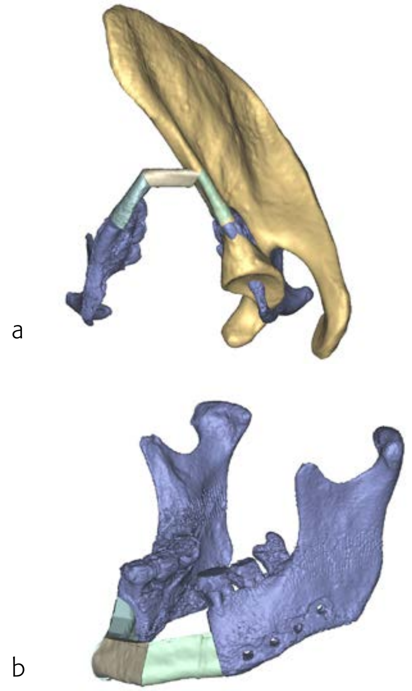


Fig 1a–b
Virtual planning (ProPlan CMF software).
a 3-D superimposition of entire scapula providing a subsegment of its lateral border to restore the anterior mandibular body on the left.
b Three bony subsegments from the right lateral scapular border and tip filling the anterolateral mandibular defect.

Biplanar plug-on tandem cutting guide design

Computer-assisted planning (ProPlan CMF/TRUMATCH CMF Solutions) provides a virtual 3-dimensional model for a detailed osseous reconstruction of the maxilla or mandible with subsegments of the lateral scapular border and/or tip (Fig 1) based on high-resolution CT scans of the craniofacial skeleton and scapular region. To transfer such graphical representation accurately into real surgery requires an assorted toolkit of stereolithography (STL) models, selective laser sintered (SLS) templates for bone contouring and subsegmentation osteotomies, and patient specific implants (PSI).

The specific anatomic conditions along the lateral scapular border led to the development of biplanar cutting guides consisting of a frame component and a vertical rod rider used in a plug-on mode (Fig 2). The framework makes up a template, which marks the outer margins of the in toto bone segment to be delivered in a first step. It rests on two footplates at the cranial and caudal ends. Each of these footplates holds a connector socket to accommodate a removable vertical rod rider spanning the entire vertical length of the bone flap. The framework component is applied to the posterior bone surface after a rectangular channel has been opened through the infraspinatus muscle.

The bone flap segment is not cut out along its final borderlines initially. It remains affixed to the footplates until the wedge ostectomies have been performed, allowing its division into further subsegments (Figs 2c and 3). For this purpose, the rod rider component of the cutting guide equipped with two hovering pairs of slots and flanges is plugged on. It

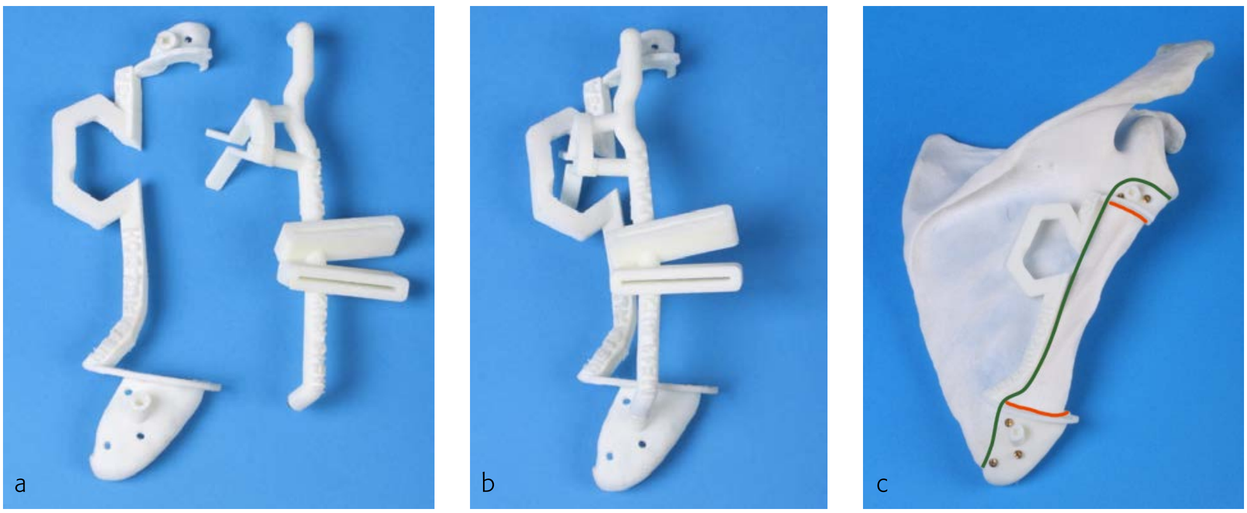
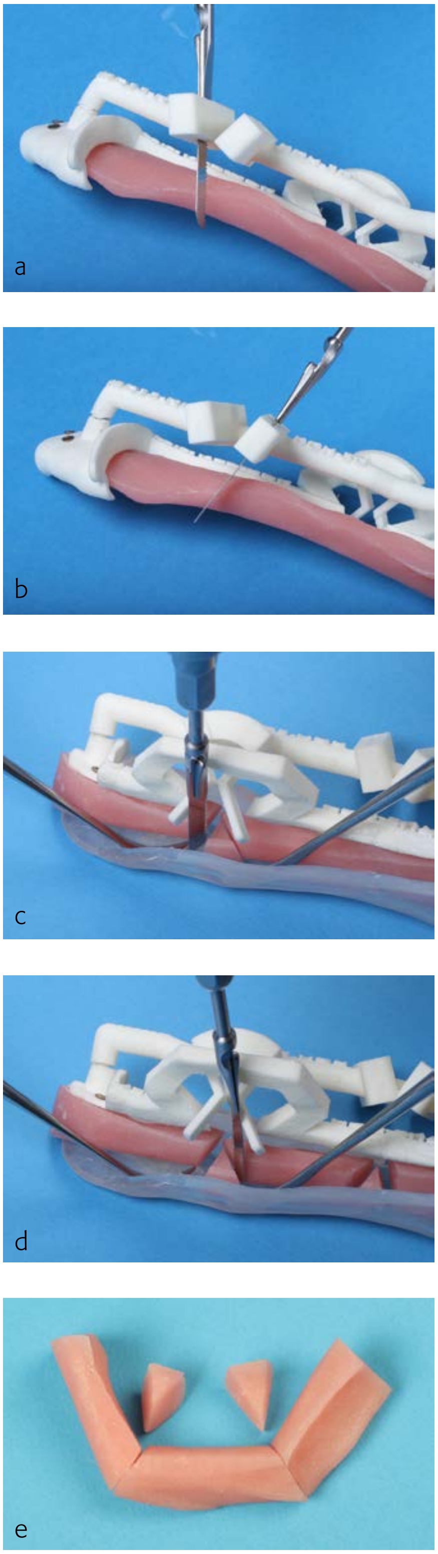


Fig 2a–c
Biplanar plug-on cutting guide for segmentation of the lateral scapular border and tip.
a Outer framework of SLS cutting guide (left) and vertical rod with slots and flanges (right).
b Vertical rod plugged on the footplates with slots and flanges located just above bone level when in situ.
c Outer SLS framework held to anatomic scapula specimen by screw fixation of the footplates. Initial cut out encompasses the footplates (green line). Final cut out subsequent to subsegmentation proceeds inside caudal and cranial footplates (red lines).



is convenient to continue the subsegmentation on a side table, after ligation of the entire flap (see Fig 6).

The transition zone between the lower lateral border and the tip of the scapula can be approached from the posterior aspect by means of the slots (Fig 3a, b). Since the adjacent bone regions receive a separate blood supply either via the circumflex scapular artery or the angular branch exiting from the thoracodorsal artery, they can be divided into bipedicled subsegments (Fig 3a, b) following the transsection of the muscle cuff (see Fig 6). By contrast, the continuity of the muscular layers sandwiching the infraglenoid scapular bone portion must be preserved. Therefore, the only access to this region is via the medial aspect, which corresponds to the longitudinal bone edge of the in toto scapular segment. A gateway arch, hooked to the connecting bridge of the outer framework component, opens a pass-through for the pair of flanges put forward by the rod component at 90° to top over the bone edge.

The tandem ensemble of the bone flap mounted with both cutting guide components is turned onto its lateral side (see Fig 6b, c). The muscle sheaths over the intended infraglenoid osteotomy location on either side are subperiosteally undermined. The wedge osteotomies within the muscle tunnel are then attained under the guidance of the flanges crossing the medial osteotomy line of the segment. Finally, the vertical rod component is lifted off the framework component and the subsegmentation is completed with the transverse cuts along the inside of the upper and lower foot plates. The scapula subsegment assembly is now ready to be folded (Fig 3e) and to be double checked inside the defect of the STL mandible model (see Fig 6d).

Fig 3a–e
Mockup review of subsegmentation procedure.
a–b Posterior plane, outline of wedge osteotomy. Pink acrylic resin = replica of in toto scapular bone segment.
c–d Medial plane, wedge osteotomy inside infraglenoid. Translucent silicon sleeve represents muscle tunnel (lateral periscapular infraspinatus, teres minor and major, subscapularis).
e Neomandibular subsegments with closed gaps (replica) arranged to fit into the mandibular defect, with removed wedges.

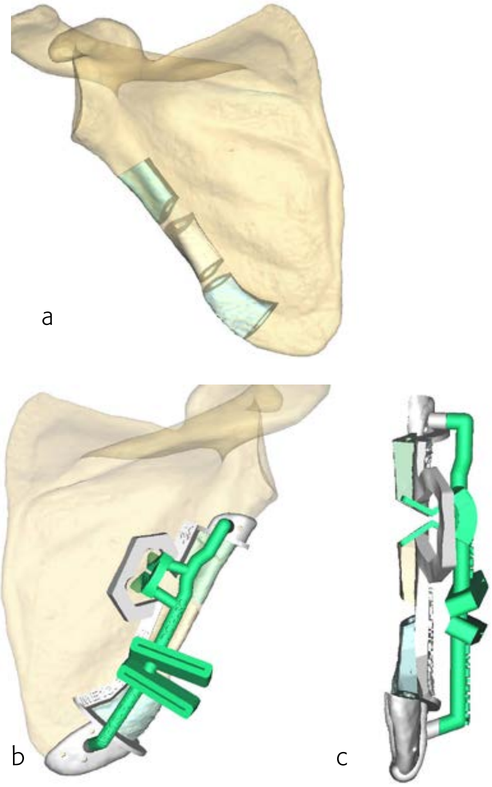


Fig 4a–c
Cutting guide design.
a Anterior transview of right scapular bone, colour coded subsegments projected along lateral border and tip. Removed bone wedges reveal beveled intersegmental bone ends.
b Two-part cutting guide design, posterior view, outer framework (pale grey) and plug-on rod rider with slot and flange extensions (light green).
c Cutting guide design, view from medial margin (1⁄4 longitudinal bone cut).

Case: Oncology patient requiring mandibular reconstruction

A 58-year-old male oncology patient required secondary mandibular reconstruction following composite resection of the floor of the mouth, mandibular symphysis, anterior body regions of the mandible, and bilateral limited neck dissection. The existing reconstruction plate bridging the anterolateral mandibular defect was widely exposed through the intraoral mucosa. The chin and lower lip were sagging due to submandibular soft-tissue shrinkage and lack of bone suspension. For secondary reconstruction, a two-in-one free flap from the subscapular vascular system containing the lateral scapular border and tip in combination with a latissimus dorsi flap was selected, since severe peripheral arterial occlusive disease prohibited the use of an osteofasciocutaneous fibula free flap. Virtual surgical planning was used to design the bony reconstruction with three subsegments (total length 8.1 cm) from the right (nondominant arm) lateral scapular border and tip (Fig 4).

Scapular SLS templates or cutting guides were manufactured for secondary resection of the mandibular bone stumps, along with a set of STL models and a patient specific mandibular reconstruction plate (PSMP) (Fig 5).

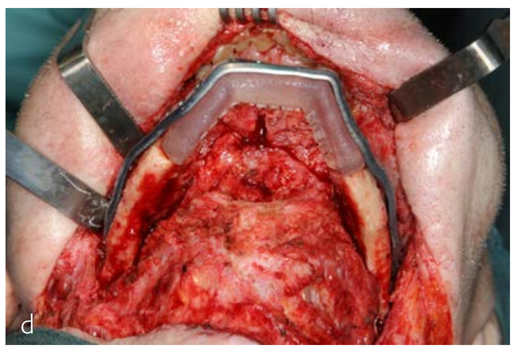


Fig 5a–d
Stereolithographic models.
a Selective laser sintering resection guides attached to both bodies of the STL mandible model delineating the anterior defect borders with their flanges. Resection guide rigged with targeting cylinder trocars to drill congruent burr holes for the PSMP.
b The STL mandible model and assorted STL neomandibular scapular subsegments.
c Milled PSMP spanning the anterolateral defect of the STL mandibular model including the STL neomandible.
d Intraoperative size check with PSMP and STL neomandible.

Intraoperatively, the circumflex scapular and thoracodorsal vascular pedicles were dissected to their common subscapular trunk and the angular branch supplying the scapular tip preserved (Fig 6). An elliptical 18 cm x 7 cm myocutaneous latissimus dorsi flap was raised to provide coverage for the extensive submandibular soft-tissue deficit. The in toto scapular bone flap was retrieved using the outer frame of the cutting guide (Fig 6a). In tandem with the vertical rod and its extensions, the wedge osteotomies for segmentation were carried out on a side table (Fig 6b, c). Prior to the flap transfer into the recipient site, the fit of the neomandibular segments was double checked within the defect of the STL model (Fig 6d).

Microanastomosis was performed end-to-end to the left maxillary artery and end-to-side to the internal jugular vein. Postoperative imaging confirmed minimal intersegmental gaps to the mandibular remnants with undisturbed healing but limited overall bone volume (Fig 7). Therefore removal of the PSPMP and a preimplantological augmentation with corticocancellous iliac bone grafts followed 16 months later. Finally, dental implants were inserted (Fig 8).

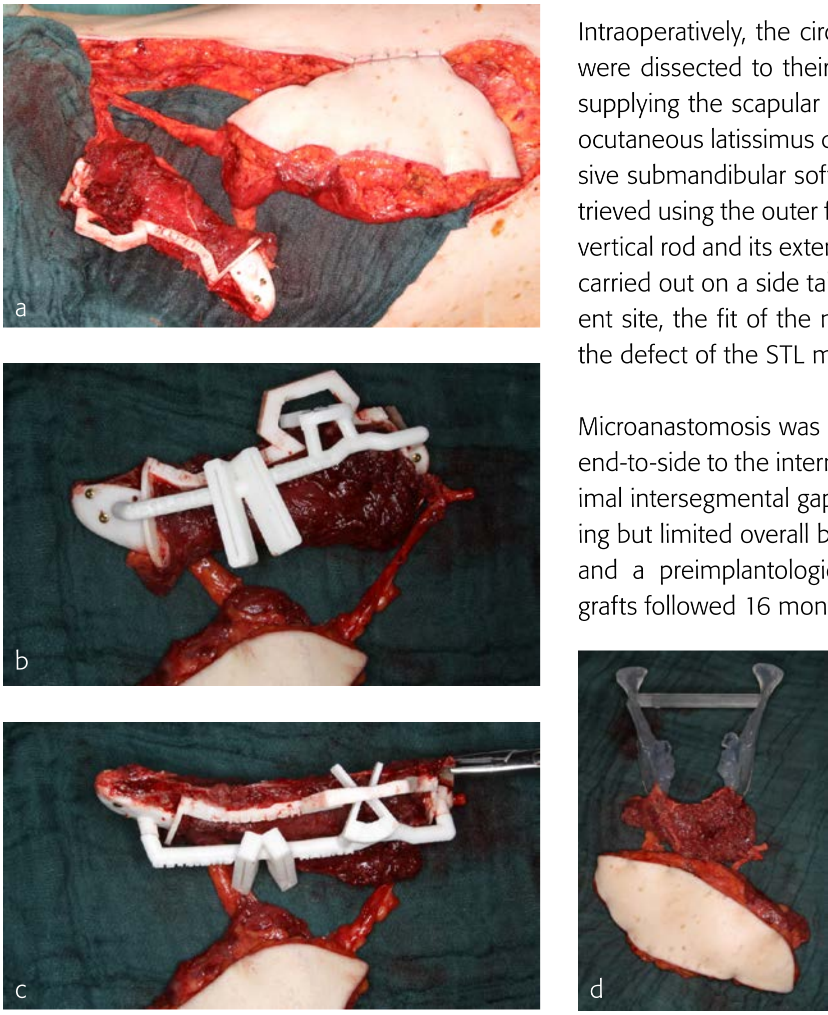


Fig 6a–d Flap raising and bone contouring.

a Subscapular vascular network in situ. Bifurcation into circumflex scapular and thoracodorsal pedicles supplying lateral scapular border/tip and latissimus dorsi flaps (two-in-one). Angular vessel branch emerging from beneath latissimus island to scapular tip. Outer frame of SLS cutting guide component secures to in toto bone flap.

b Posterior view of scapula bone flap and in tandem assembly of cutting guide components, on side table.

c Medial view highlighting the biplanar accessibility through the slot pair posteriorly, and via the gateway and flanges medially.

d Scapular subsegments positioned into defect of the STL mandible model.

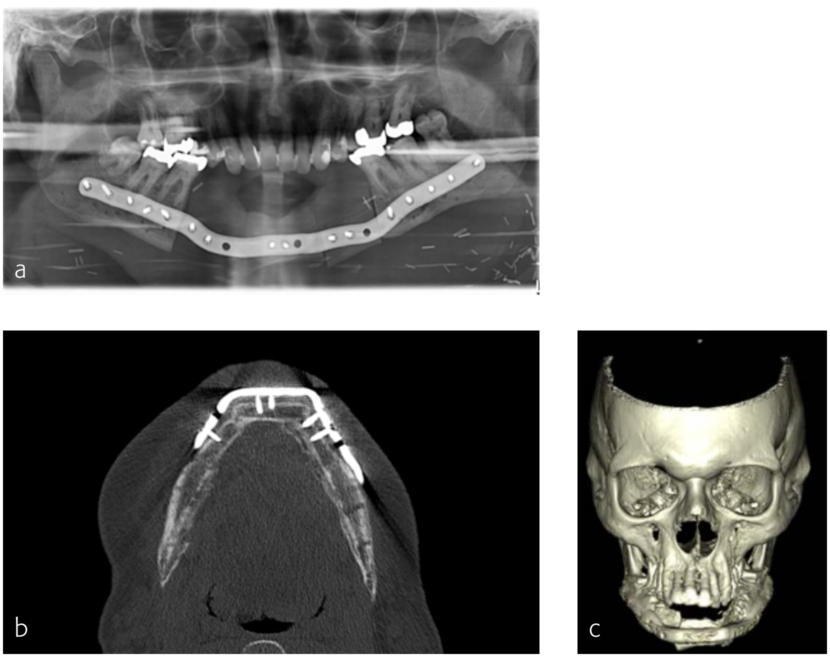


Fig 7a–c Postoperative imaging results.

a Panoramic 1-week postoperative x-ray.

b Axial 14-month postoperative CT scan confirms good matching and consolidation at the bony interfaces between native mandible and scapular subsegments.

c 3-D reformatted 14-month postoperative CT scan.

Fig 8a–b Implants.
a Panoramic x-ray following insertion of enosseous dental implants.
b Attachment of implant-supported lower denture.

Conclusion

The biplanar cutting guide for the lateral scapular border and tip may be regarded as a further proof of concept that challenging anatomic conditions in free flap raising, contouring, and insetting can be resolved by the application of innovative CAD/CAM techniques. However, it should be noted that the soft-tissue components on the subscapular vessel system are commonly not captured in computer-assisted planning at this time. Sound clinical judgment and decision making is still a prerequisite for proper planning and successful results at the current stage of technical evolution.

The use of virtual surgical planning in conjunction with STL models and the biplanar cutting guide offers many advantages in reconstructive mandibular and maxillary surgery, including negation of the guesswork inherent to freehand osseous contouring, unprecedented accuracy of wedge osteotomies, the optimization of bone healing by enabling maximum contact of the angulated bone ends, and acceleration of the surgical procedure. The reduction of operating time and theatre costs largely compensates for the additional cost of VSP procedures, a factor that is particularly significant in fixed budget health care reimbursement.

One attractive surgical possibility is the immediate placement of dental implants allowing single stage reconstruction of the jaw and dentition. However, the bony cross section is not uniform across the length of the lateral scapular border and tip, and the shape is partially twisted. The varying bone stock is not ideal for primary implant insertion in an even distribution, and may require a subsequent local bone augmentation. The most recent recommendation therefore is that the insertion of dental implants should be postponed until the preconditions have been amended.

Erik Asimus, Brian Beale, Randy Boudrieau, Loïc Déjardin, Michael Kowaleski

VETERINARY

Fig 1
A tibial tuberosity advancement procedure using the VET TTA system on a canine stifle.

Fig 2
The TTA plate showing the proximal locking holes.

Fig 3
Wedge with offset spacers (for treating MPL) both made of radiolucent PEEK.

Fig 4
A tibial tuberosity transposition and advancement (TTTA) procedure using an offset spacer.

Tibial Tuberosity Advancement (TTA) System

Cranial cruciate ligament (CrCL) failure in dogs is a pervasive injury that results in abnormal joint motion, progressive osteoarthritis, meniscal lesions, and loss of function. Several high tibial osteotomies, among which the forerunner is the tibial plateau leveling osteotomy (TPLO), have been devised over the past 20 years to neutralize the cranial tibial thrust (CrTT) force. This tibiofemoral shear force is responsible for joint instability following CrCL failure. The Tibial Tuberosity Advancement (TTA) system has been used as an alternative to the TPLO to restore joint stability during weight-bearing.

Unlike the TPLO, which relies on a reduction of the tibial plateau slope via a radial osteotomy, neutralization of the CrTT with the TTA is achieved by advancing the tibial tuberosity until the angle between the straight patellar ligament and the tibial plateau remains 90° or less, regardless of the stifle joint flexion/extension angle. The advancement of the tibial tuberosity is allowed by creating an osteotomy of the tibial crest in the frontal plane followed by plate stabilization after placement of a wedge within the osteotomy to maintain the gap width. A bone graft is placed within the osteotomy gap to enhance healing. Furthermore, the TTA can be used to treat CrCL rupture cases with concomitant medial patellar luxation (MPL) via the use of offset spacers that induce a lateral transposition of the tibial crest.

System design

The TTA system (Fig 1) is indicated for the treatment of CrCL disease in canines. It is compatible with small and mini fragment systems and the plate is available in right and left versions as well as in the following sizes:

- 2.4 mm/2.7 mm TTA plate: 53 mm (size 4) and 65 mm (size 5)
- 2.4 mm/3.5 mm TTA plate: 78 mm (size 6), 90 mm (size 7), and 104 mm (size 8).

The locking screw trajectories in the proximal plate section are designed to optimize screw purchase within the tibial crest. Furthermore, the incorporation of locking technology (Fig 2) permits a fixed-angle device to increase construct stability.

Wedges and spacers are made of radiolucent PEEK (Fig 3). The Wedges are available in 8 widths (4.5, 6, 7.5, 9, 10.5, 12, 13.5 and 15 mm) and can easily be cut to the desired length to accommodate the tibial width using the graduated length markings. Additionally, 3 or 5 mm PEEK offset spacers can be snapped to the wedge allowing for simultaneous treatment of MPL (Fig 4).

Cases provided by Karen Perry and Loïc Déjardin, East Lansing, USA

Fig 5a–b
Preoperative x-rays of the left stifle joint.

Fig 6a–b
Preoperative x-rays of the right stifle joint.

Case 1: 2-year-old labrador retriever

A 2-year-old labrador retriever presented for assessment of a moderate intermittent weight-bearing left pelvic limb lameness of four months duration. Orthopedic examination revealed moderate stifle joint effusion, medial buttress formation of the proximal tibia, crepitus, and a moderate pain response upon manipulation and extension of the stifle joint. Joint laxity was evident with both cranial drawer and CrTT. There was also mild effusion palpable in the right stifle joint, but this was otherwise unremarkable upon examination.

The x-rays of both stifle joints (Figs 5 and 6) revealed bilateral moderate joint effusion and minimal bony proliferation along the distal aspect of the patella. Considering the clinical findings, these radiographic signs were interpreted as minimal bilateral osteoarthritis secondary to CrCL disease.

The left stifle joint was evaluated for a Tibial Tuberosity Advancement and the owner was advised that stabilization of the right stifle joint would likely be required in the future. Preoperative TTA planning was conducted using anatomic tibial plateau and patellar tendon angle landmarks. A 13.5 mm wedge and a size 6 plate were selected.

Under anesthesia, exploration of the left stifle joint revealed a partial rupture of the CrCL, the remnants of which were debrided. A caudal pole tear of the medial meniscus was identified and medial caudal pole hemimeniscectomy performed.

A frontal plane bicortical osteotomy of the distal half of the tibial tuberosity was created. The size 6 plate was anatomically contoured to fit the medial surface of the tibia. The cranial edge of the plate was placed parallel to the cranial aspect of the tibial tuberosity at the level of the insertion of the straight patellar tendon. The proximal screw hole in the distal plate section was positioned over the cranial cortex of the tibia. The most proximal screw hole in the plate was appropriately positioned. The plate was then secured to the medial surface of the tibial tuberosity using three 2.4 mm locking screws in the proximal portion of the plate. The osteotomy was completed proximally and the spreader was used to distract the osteotomy. A depth gauge was used to measure the width of the tibial tuberosity proximally and the 13.5 mm wedge length was trimmed accordingly. The cranial and caudal tabs of the wedge were contoured to fit the medial tibial cortex. Pointed reduction forceps were used to compress the distal end of the tibial tuberosity to the tibial shaft ensuring adequate bony contact at this level. A 2.4 mm cortical screw was inserted into the caudal tab of the wedge, angling caudally and distally. A 3.5 mm cortical screw was inserted into the proximal screw hole in the distal plate now overlying the center of the tibial diaphysis. A 2.4 mm cortical screw was then inserted into the cranial tab of the wedge, angling cranially and proximally. Finally, a 3.5 mm cortical screw was inserted into the distal screw hole in the distal plate. Stability in CrTT was ensured. The surgical site was flushed and a bone graft inserted into the osteotomy gap (Osteoallograft Orthomix Fine). Closure was routine.

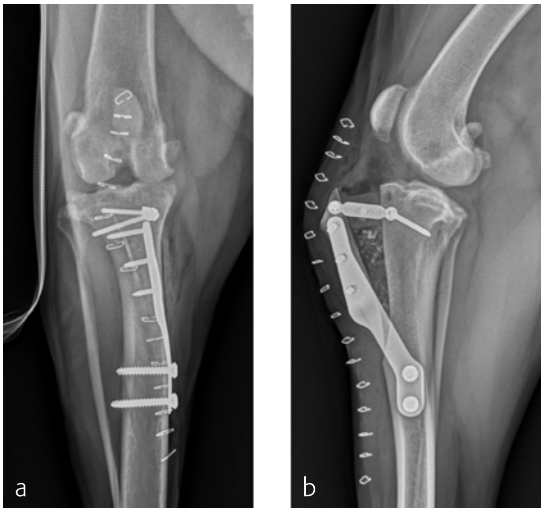


Fig 7a–b
The immediate postoperative x-rays of the left stifle joint.

Immediate postoperative x-rays (Fig 7) revealed satisfactory implant and osteotomy positioning. The x-rays obtained 10 weeks postoperatively (Fig 8) showed no evidence of implant-associated complications and partial bone healing within the osteotomy gap. Osteoarthritic changes within the joint were static. Clinically at this stage, mild bilateral pelvic limb lameness was apparent with bilateral stifle joint effusion. The left stifle joint was stable in CrTT with no pain response upon stifle joint manipulation.

The patient presented again 11 months postoperatively for assessment of right pelvic limb lameness associated with CrCL rupture. At this stage, severe right pelvic limb lameness was evident but no lameness of the left pelvic limb was observed. While the right stifle joint was unstable in cranial drawer and CrTT, the left stifle remained stable with no pain response upon palpation over the implants and a normal range of motion of the joint. X-rays of the previously operated left stifle (Fig 9) revealed no implant-associated complications and healing of the osteotomy. The osteoarthritic changes were static radiographically. A TTA was performed on the right tibia at this time using a 13.5 mm wedge and a size 6 plate as had been used on the left previously.

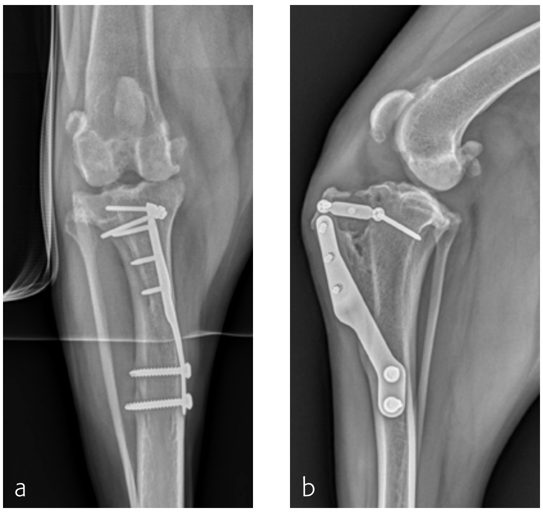


Fig 8a–b
The 10-week postoperative x-rays of the left stifle joint.

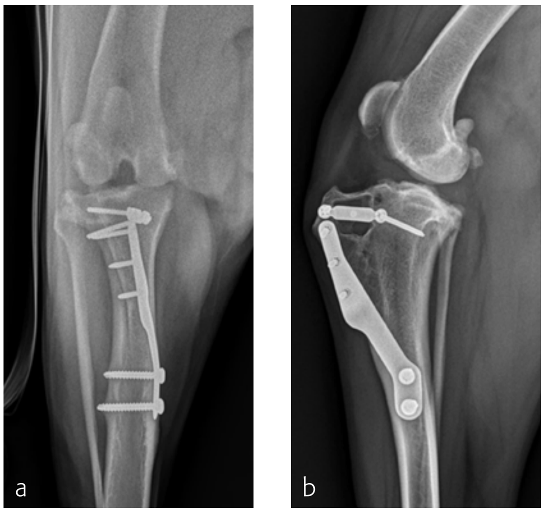


Fig 9a–b
The x-rays of the left stifle joint 11 months postoperatively. Note the presence of mineralized bone within the osteotomy gap. Osteoarthritic changes were similar to those seen preoperatively.

Fig 10a–b
Preoperative x-rays of the right stifle joint demonstrating moderate joint effusion and periarticular osteophytosis.

Case 2: 18-month-old labrador retriever

An 18-month-old labrador retriever presented for assessment of right pelvic limb lameness of ten days duration. A left TTA had been performed 6 months previously for treatment of CrCL disease. Gait assessment revealed severe weight-bearing right pelvic limb lameness. Orthopedic examination revealed moderate right stifle joint effusion, medial buttress formation of the proximal tibia, and a palpable click upon manipulation of the stifle joint. Grade one MPL was also evident. There was a severe pain response upon manipulation of the right stifle joint and laxity was evident in both cranial drawer and CrTT. The left stifle joint was stable in CrTT with no pain response on palpation over the previously placed implants. There were no other salient findings on the orthopedic exam.

The x-rays of the right stifle joint (Fig 10) revealed moderate joint effusion and periarticular osteophytosis likely secondary to CrCL disease with concomitant MPL.

The right stifle joint was considered a suitable candidate for a tibial tuberosity transposition and advancement (TTTA) to stabilize the CrCL deficient stifle and realign the quadriceps mechanism with a single surgical procedure. Preoperative TTTA planning was conducted as previously described and a 12 mm wedge and a size 7 plate were selected.

Under anesthesia, exploration of the right stifle joint revealed complete rupture of the CrCL, the remnants of which were debrided. Compression injury to the caudal horn of the medial meniscus was identified and medial hemimeniscectomy of the caudal pole was performed.

Following a frontal plane osteotomy of the tibial tuberosity, it was estimated that to re-align the quadriceps mechanism appropriately, 5 mm of lateralization of the tibial tuberosity would be required. The size 7 plate was contoured to fit the medial surface of the tibia, while at the same time placing an additional slight bend to the plate at the midportion so as to allow this lateralization to occur. Plate application, tibial tuberosity advancement, and trimming of the wedge were performed as described in the previous case; a 5 mm spacer was additionally attached to the cranial tab of the wedge in order to also transpose the tibial tuberosity laterally. The medial cortex of the tibia was recessed slightly using a high-speed drill immediately caudal to the distal extent of the osteotomy to allow unrestrained positioning of the additional curve in the contoured plate. Plate fixation was achieved using 2.4 mm locking and 3.5 mm standard cortical screws identical to the previous case. The wedge was secured in place using two 2.4 mm standard cortical screws with the cranial screw applied through the spacer. Stability in CrTT was ensured as was mediolateral stability of the patella. The surgical site was flushed and a bone graft inserted into the osteotomy gap (Osteoallograft Orthomix Fine). Closure was routine.

Immediate postoperative x-rays (Fig 11) revealed satisfactory implant and osteotomy positioning with the patella appropriately positioned within the femoral sulcus. There was no laxity in CrTT and the patella could not be luxated. X-rays obtained 10 weeks postoperatively (Fig 12) revealed no evidence of implant-associated complications and smooth osseous proliferation bridging the osteotomy gap. Osteoarthritic changes within the joint were mildly progressive. Clinically at this stage, no pelvic limb lameness was evident. The range of motion of the right stifle joint was within normal limits. The stifle was stable in CrTT and the patella could not be luxated. No pain response was noted with the physical examination.

Fig 11a–b
The immediate postoperative x-rays.

Fig 12a–b
The 10-week postoperative x-rays. The images demonstrate proper implant position and partial bone healing of the osteotomy site. Mild progression of osteoarthritis was present at 10 weeks. Notice the lateralization of the tibial tuberosity on the craniocaudal views as compared to the previous case.

AOTK MEET THE EXPERTS

The AOTK Meet the Experts sessions held during Davos Courses in December remain one of the most important activities organized by AOTK each year. Please join us again in 2016 during the lunch breaks in Café Chamonix.

Meet the Experts Sessions 2015

Doug Campbell and Thomas Fischer, members of the Hand Expert Group, delivered a comprehensive and insightful overview of the features and benefits of the Variable Angle Locking Hand system launched in 2015 (Fig 1). The system has been described as a revolution in small bone fracture care by the innovative thinkers involved in the development of this concept. More information on the VA Locking Hand system can be found in the lead article of this edition of AOTK System Innovations.

Andrew Sands and Leslie Grujic, members of the Foot and Ankle Expert Group, presented cases indicated for midfoot fusion, and demonstrated how to use the Medial Column Fusion Plates with midfoot fusion bolts to correct and stabilize feet with severe deformation, such as Charcot foot (Fig 2). The Compression/Distraction Device was used to manipulate the bones and temporarily hold them in an appropriate position during the reconstruction of the foot. This very versatile instrument can be adjusted in several planes. The combination of instruments in a multiplanar construct can attain multiple corrections simultaneously. The Medial Column Fusion Plate and the Compression/Distraction Device were both launched in 2014 and presented in last year's edition of AOTK System Innovations.

Fig 1
Thomas Fischer and Doug Campbell present the new VA Locking Hand system.

Fig 2
Andrew Sands and Leslie Grujic demonstrate the new plates and devices for midfoot fusion.

Christopher Finkemeier, member of the Intramedullary Nailing Expert Group, presented the TFN-Advanced Proximal Femoral Nailing System (TFNA) (Fig 3). The new nail has a radius of curvature of 1000 mm to improve anatomical fit and to help avoid impinging the anterior cortex. The small proximal nail diameter of the TFNA and some new design features of the proximal nail end reduce the potential impingement of the nail with the lateral femoral wall and the head-neck-fragment, which could otherwise result in loss of reduction and varus malalignment, both indicators for an increased cut-out risk. Multiple instrumentation features, including a multihole drill sleeve for establishing the precise nail entry path and aiming aids for placing the guide wire of the head element in the correct position have been added to the TFNA system to ease accurate implant placement. The TFNA was launched at the end of 2014 and presented in last year's edition of AOTK System Innovations.

Roger Härtl from New York and Avelino Parajon from Madrid gave an overview of leading edge navigation technology applied to spine surgery using the Kick 2D system and Viper navigated instruments. According to the presenters, one of the main drivers to adopt navigation is the dramatic reduction of radiation exposure. Although practice is required in order to adapt to the learning curve, navigation assisted surgery has been shown to be very accurate, with some studies already demonstrating that this approach allows for pedicle screw displacement reduction.

Fig 3
Expert nailing expert, Christopher Finkemeier, presents the TFN-Advanced Proximal Femoral Nailing system.

Fig 4
Avelino Parajon and Roger Härtl explain techniques, technology, and instrumentation for navigated spine surgery.

Dr Parajon showed how the Kick 2D open software allows an interface with any imaging system through a very easy calibration workflow and specific tools, such as the X-Spot instrument (Fig 4). Dr Härtl then highlighted the importance of good stabilization of the patient in order to rely on the images taken before starting the navigated surgery. The Kick 2D system is mobile and can be easily transported. For more information on Computer Assisted Surgery, please see the articles in the AOTK System Innovations No 2-2010 and 2015.

Jean Ouellet, Chairman of the Deformity Expert Group, introduced the Expedium Verse, a new pedicle screw-based spinal deformity system, and provided an overview of the core principles of spinal deformity correction (Fig 5). He reviewed multiple techniques developed for addressing such deformity and explained how the implant selected influenced the type of forces applied to the spine. He stated that a system should be versatile to allow for a combination of correction techniques, then performed a lumbar segment coronal deformity correction and later answered questions from the audience while providing additional tips on how to utilize the system to its full potential.

Michael Kowaleski and Randy Boudrieau from the Veterinary Expert Group led a highly informative session about the recently approved Vet Tibial Tuberosity Advancement (TTA) system (Fig 6). The TTA system was developed for the treatment of cranial cruciate ligament disease in canines and combines locking screw technology with conventional plating techniques. The system also features a cut to length PEEK spacer. The detailed design features and benefits of the new TTA system were demonstrated in a hands-on session using a dry bone model. More information on the TTA system is found in the veterinary section of this edition of AOTK System Innovations.

Fig 5
Jean Ouellet from Canada demonstrates the new Expedium Verse spine deformity system.

Fig 6
Randy Boudrieau and Michael Kowaleski demonstrate the TTA system.

Spinal surgeons Michael Dittmar and Osmar de Moraes delivered a highly engaging webcast describing recent advances in spinal fusion, including the use of biomaterials (Fig 7). Topics discussed included the basic biology of fusion and bone healing using autogenous graft and bone morphogenetic protein (BMP), and fusion in surgically challenging cases such as osteoporosis. The surgeons discussed innovations in spinal fusion that could greatly improve outcomes in the future, including the use of mesenchymal stem cells and gene therapy. New biomaterials could offer significant advantages such as a reduction in fusion time, a reduction in fusion failure rate, and less invasive implantation procedures.

The webcast also featured a demonstration of surgical techniques used in spinal fusion, including the use of cervical cages with hydroxyapatite inserts, the insertion of hydroxyapatite putty into the spinal column, and the application of flexible hydroxyapatite strips enriched with bone marrow aspirate. The surgeons also demonstrated how the injection of PMMA cement into the vertebral body via fenestrated pedicle screws can assist with spinal fusion in osteoporotic patients. The session was broadcast live to AO members around the world and following their presentation, the surgeons addressed questions directly from the internet audience.

Fig 7
Michael Dittmar and Osmar de Moraes present their spinal fusion webcast.

Martin Altmann, Dominic Gehweiler, Boyko Gueorguiev, Ladina Hofmann–Fliri, Lukas Kamer, Frank Kandziora, Hansrudi Noser, Michael Raschke, Simon Scherrer, Maartin Spruit, Andre Weber, Markus Windolf, Ivan Zderic.

NEWS FROM ARI

Impact of bone cement augmentation on the fixation strength of TFNA blades and screws

Hip fractures constitute the most debilitating complication of osteoporosis with a steadily increasing incidence in an aging population. Intramedullary nailing of osteoporotic proximal femoral fractures can be challenging because of poor implant anchorage in the femoral head. Recently, cement augmentation of PFNA blades with polymethylmethycrylate (PMMA) has shown promising results by enhancing the cutout resistance in proximal femoral fractures. The aim of this biomechanical investigation was to assess the impact of cement augmentation on the fixation strength of TFNA blades and screws within the femoral head, and compare its effect with these head elements placed in a center or anteroposterior off-center positions.

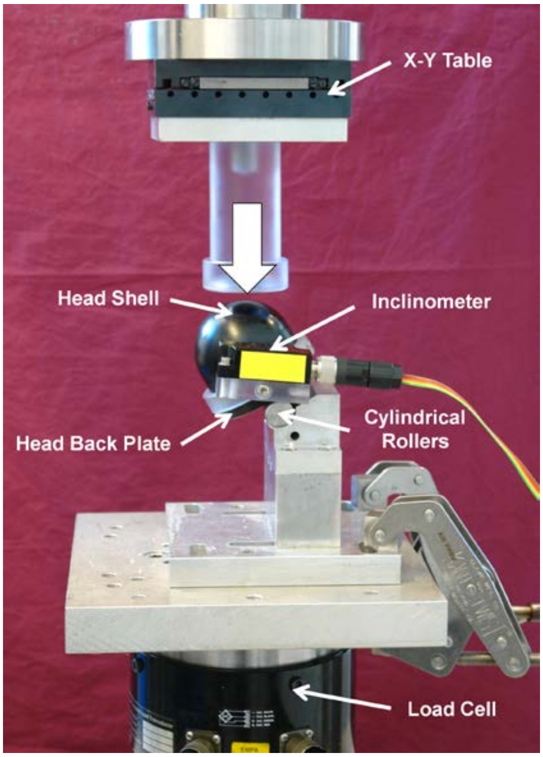


Fig 1
Setup with a specimen mounted for mechanical testing.

Materials and methods

Eight groups were formed out of 96 polyurethane foam specimens with low density, simulating isolated femoral heads with severe osteoporotic bone. The specimens in each group were implanted with either non-augmented or PMMA-augmented TFNA blades or screws in a center or anteroposterior off-center position, 7 mm anterior or 7 mm posterior. They were mechanically tested in a setup simulating an unstable pertrochanteric fracture with lack of posteromedial support and load sharing at the fracture gap (Fig 1). All specimens underwent progressively increasing cyclic loading until catastrophic construct failure. Varus/valgus and femoral head rotation angles were monitored by an inclinometer mounted on the head. A varus collapse of 5° or a 10° head rotation were defined as the clinically relevant failure criterion.

Results

Load at failure for specimens with augmented TFNA head elements (screw center: 3799 N ± 326 (mean ± SD); blade center: 3228 N ± 478; screw off-center: 2680 N ± 182; blade off-center: 2591 N ± 244) was significantly higher compared to the respective nonaugmented specimens (blade center: 1489 N ± 41; screw center: 1593 N ± 120; blade off-center: 1018 N ± 48; screw off-center: 515 N ± 73), $p<0.001$. Considering all specimens and groups together, the load at failure increased after cement augmentation by 117–420 % (Fig 2). In both nonaugmented and augmented specimens, the failure load in center position was significantly higher compared to the respective off-center position, regardless of head element, $p<0.001$. Nonaugmented TFNA blades in off-center position revealed significantly higher load at failure versus nonaugmented screws in off-center position, $p<0.001$ (Fig 3).

Conclusion

Cement augmentation clearly enhances fixation stability of TFNA blades and screws. Nonaugmented blades outperformed screws in anteroposterior off-center position. Positioning of TFNA blades in the femoral head is more forgiving than TFNA screws in terms of failure load.

Note

Augmentation with TFNA has not been approved by FDA.

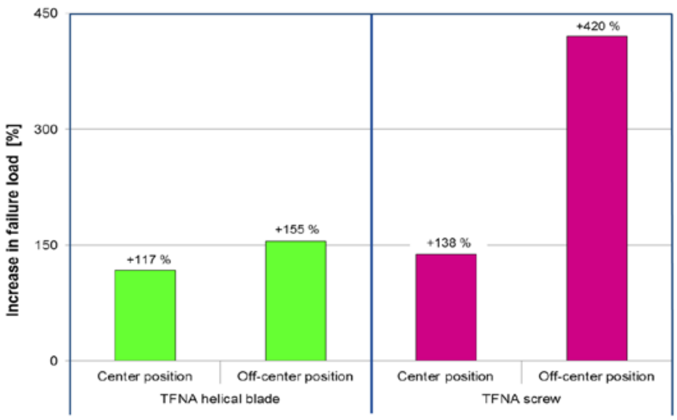


Fig 2
Increase in failure load after PMMA cement augmentation of TFNA helical blades and screws in center and anteroposterior off-center position.

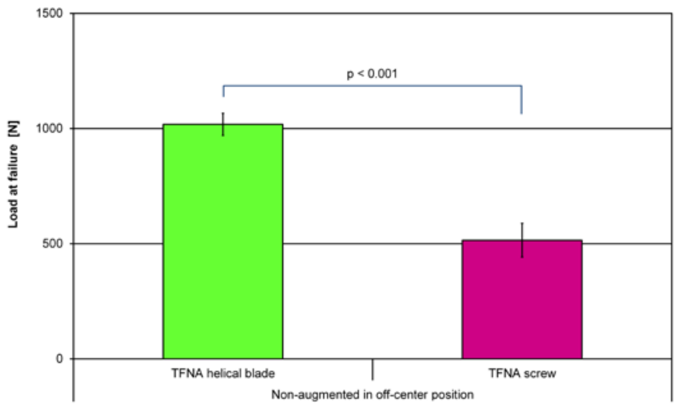


Fig 3
Significantly higher load at failure of nonaugmented TFNA helical blades in off-center position in comparison to nonaugmented screws in off-center position.

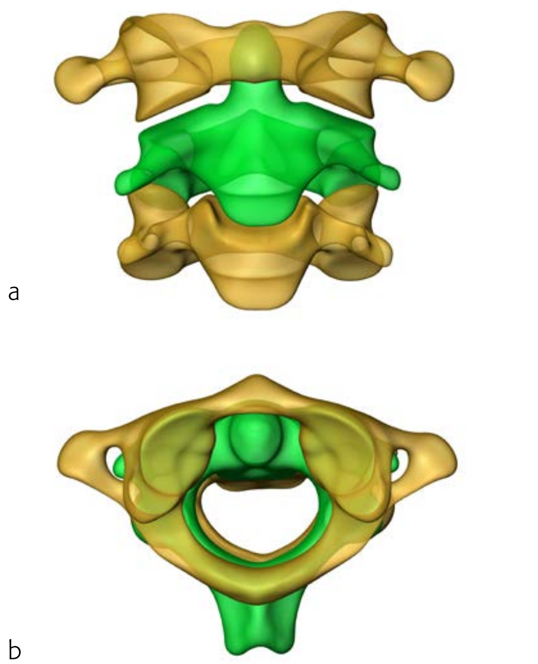


Fig 1a–b
Semitransparent anterior (a) and cranial (b) views of the 3-D mean model of C1–C3, illustrating average antomical information with regard to bony surfaces and screw corridors.

Three-dimensional statistical modelling of the upper cervical spine based on quantitative computed tomography to evaluate bony corridors and screw position

Surgical fixation of the upper cervical spine includes screw positioning through bony corridors close to vital structures. The procedure is known to be challenging, especially in elderly patients with decreased bone mineral density. The anatomical variation among different individuals has to be taken into account as it represents important a priori knowledge, and is relevant for surgical decision making and safe screw placement. It is therefore advantageous to study the anatomy of the upper cervical spine highlighting the anatomical variation, bone mass distribution, and bone loss pattern.

Three-dimensional (3-D) statistical modelling is a scientific state-of-the-art approach to analyzing anatomical variations. The method has been adopted to assess image data of C1–C3 with regard to size, shape, and bone mass distribution. Safe screw corridors in C1 and C2 can also be determined.

Materials and methods

A total of 120 standard clinical quantitative computed tomography (QCT) scans of the intact cervical spine from adult European male and female patients aged 18–90 years were included in the project. The QCTs were processed to obtain a 3-D statistical model of C1–C3. It included a 3-D mean model of the bony surfaces and an averaged volumetric bone mineral density (vBMD) model (Figs 1 and 2). The model was analyzed via virtual vBMD biopsies (screw-like regions of interest) to investigate the 3-D bone mass distribution and principal component analysis (PCA, a standard statistical procedure for identification of the most important variations) to evaluate 3-D shape and size patterns.

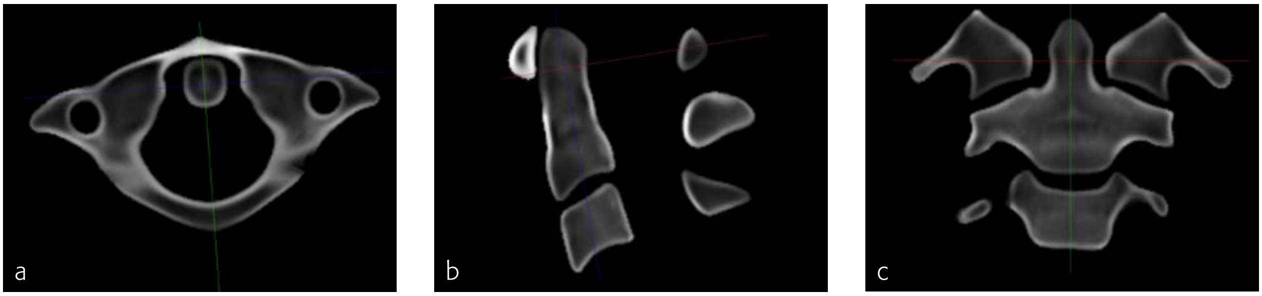


Fig 2a–c
Averaged bone mass model of C1–C3 in axial (a), sagittal (b), and coronal (c) grey values of the QCT given in volumetric bone mineral density.

Results

The PCA revealed a highly variable anatomy. Size was the predominant variation in the first principal component (PC) and shape changes were primarily described by the remaining PCs. For example, PC 2 exhibited a variation of the angulation and curvature of the odontoid process in the anterior/posterior orientation whereas PC 3 mainly demonstrated a variation of the curvature of the odontoid and the orientation of the transverse process (Fig 3a).

Virtual screw positioning of two 3.5 mm odontoid screws with a 1 mm safety zone in parallel position was possible in 81.7% of cases. In 86.4% of those cases, where two parallel odontoid screws could not be virtually positioned, it was possible to virtually implant two odontoid screws alternatively in a twisted position. Consequently, it was possible to place two odontoid screws in a total of 97.5% of cases (Fig 3c).

When grouping all cases according to the vBMD values in three groups (low, medium and high vBMD), the averaged values of the virtual vBMD biopsies of 3.5 mm odontoid screws exhibited a similar line curve pattern for all groups with a low peak for the caudal cortex and a high peak for the cranial cortex. The vBMD values of the trabecular bone of the vertebral body were comparatively low compared to those of the odontoid (Fig 3b).

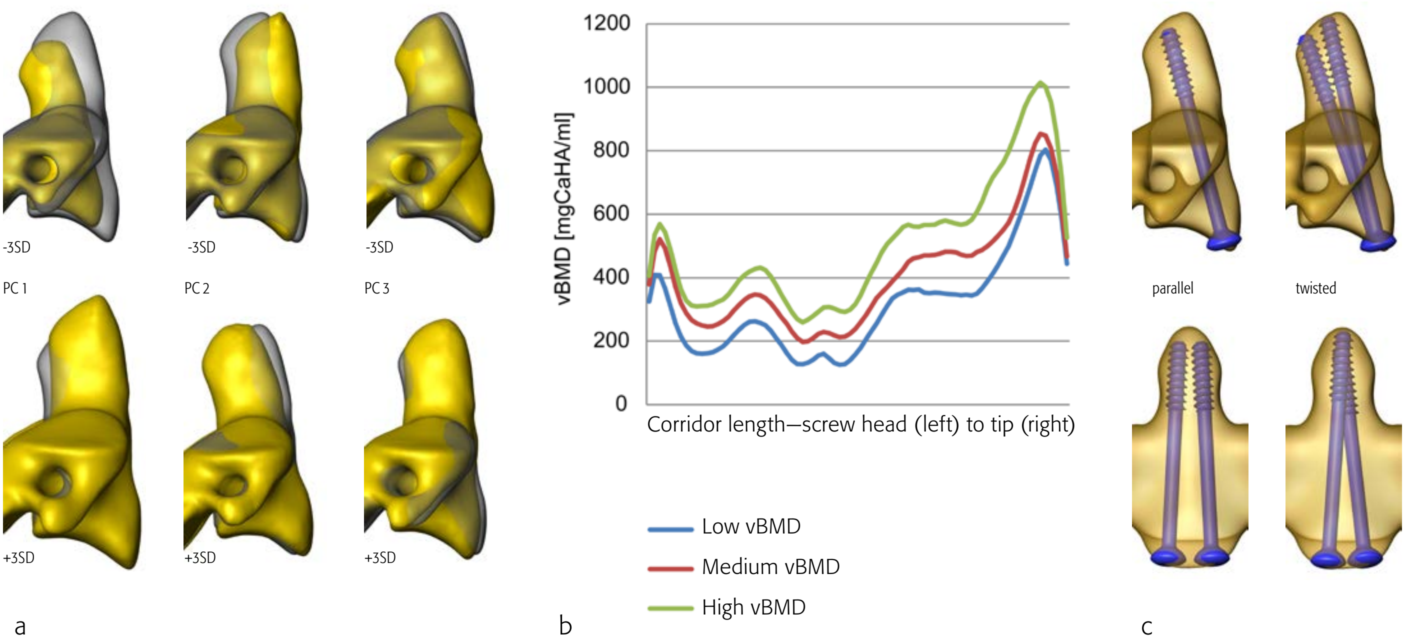


Figure 3a–c
a The 3-D mean model of C2 (grey transparent) and 3-D variations (± 3 SD, yellow) according to PCs 1, 2 and 3.
b Line curves of the averaged virtual vBMD biopsies of 3.5 mm C2 odontoid screws according to the three vBMD groups.
c Parallel and twisted positioned odontoid screw templates in the mean model.

The C1 virtual implantation of 3.5 mm lateral mass screw templates with 1 mm safety zone was possible in 93.8% of cases. The average corridor length was 19.4 mm, the average convergence towards the median plane was 8.4°, and the average ascent was 14.9° (Fig 4a).

According to the three vBMD groups mentioned above, the averaged values of virtual vBMD biopsies of 3.5 mm lateral mass screws exhibited a similar line curve pattern with a high peak for the posterior cortex and approximately a half sized peak for the anterior cortex. The vBMD values of the trabecular bone were comparatively low (Fig 4b).

Conclusions

The 3-D statistical model of the upper cervical spine established in the current SpineTK-supported study permitted the anatomical assessment of C1–C3 and the evaluation of parameters relevant for C1 and C2 screw positioning. The model allows for additional parameters to be evaluated (corridor dimensions, screw lengths and orientations, entry/exit points, and vBMD distribution). Further research questions using this powerful computer tool towards upper cervical spine fracture analysis and treatment are explored.

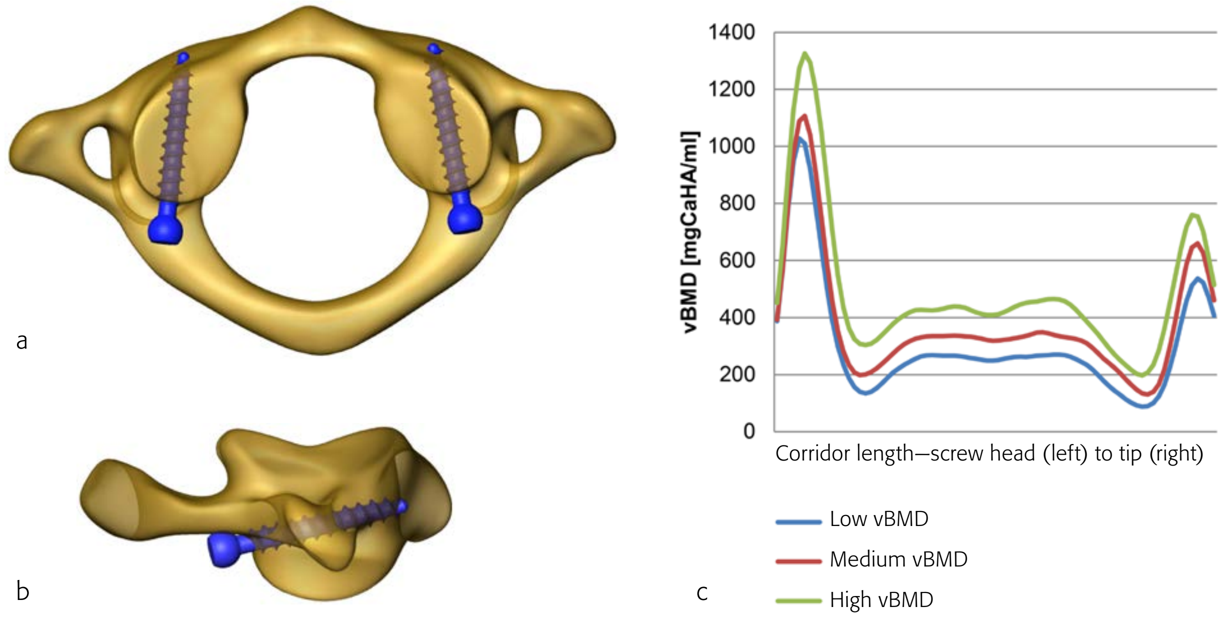


Fig 4a–c
a–b Lateral mass screw templates in the mean model.
c Line curves of the averaged virtual vBMD biopsies of 3.5 mm C1 lateral mass screws according to vBMD groups.

A FOCUS ON INFECTION

Infection in bone and joints is a potentially very serious condition. Prompt recognition, appropriate referral, and immediate treatment are essential in order to avoid serious long term consequences. Infection prevention and management is currently a hot topic across the AO Foundation. Not only have we recognized the need for a new Anti-Infection Task Force in the AOTK in order to guide the development of products and techniques for the diagnosis, prevention, and treatment of surgical infection, this common challenge has also featured as a focus of study and discussion within the education, research, and clinical investigation arms of the AO Foundation.

As a result of the importance of raising awareness in this area we have decided to dedicate a specific chapter to infection. Here at the forefront of innovation, AOTK hopes to utilize the successful work of AO Foundation colleagues to achieve a better understanding of bone infection.

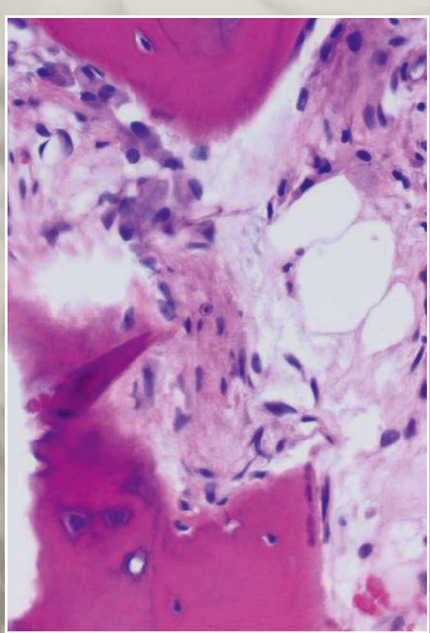


Fig 1
Medical members and AOTK System staff at the Biomaterials Retreat in Solothurn, August 2015.

Fig 2
Medical members, guests, and AOTK System staff at the inaugural meeting of the Anti-Infection Task Force in Münster, August 2016.

New TK Focus on Anti-Infection Strategies

Biomaterials were a strategic focus area for the AOTK System in 2015–16, with the reorganization of the existing Biomaterials Task Force and new direction setting. A Biomaterials Retreat (Fig 1) was held in Solothurn, Switzerland on 28-29 August 2015, with the aim of defining unmet clinical needs in the strategic focus areas of infection, osteoporosis, and tissue regeneration. There were 49 international attendees including surgeons from the clinical specialties of trauma, spine, CMF, cardiothoracic, and veterinary. Representatives from DPS Biomaterials and External Innovations, scientists from the AO Research Institute, and staff from the AOTK System were also in attendance.

Following extensive brainstorming and discussion, clinical needs were divided into long and short term needs, and projects were prioritized by surgeons with clinical and research interests in the areas of infection, osteoporosis, and tissue regeneration.

The Biomaterials Retreat revealed the pressing need for the following solutions:

- Smart implants to detect infection, detect fracture healing, measure tissue viability and detect contamination.
- Noninvasive methods to determine bone viability/healing.
- New bone void fillers that optimize stability. These fillers need to be osteoinductive, angiogenic, anti-infective, and incorporated into bone at a speed that matches healing.

A new interdisciplinary Anti-Infection Task Force dedicated to developing relevant solutions was established under the guidance of Chairman Michael Raschke, and held its inaugural meeting in August 2016 in Münster, Germany (Fig 2). The medical members are global key opinion leaders in the field of infection and include Michael Verhofstad (Netherlands), Georg Peters (Germany), Carlos Federico Sancineto (Argentina), Zhao Xie (China), and Willem-Jan Metsemakers (Belgium). Stephen Kates (US) and Fintan Moriarty (ARI) will be regular guests at task force meetings, and will help to align the group´s activities with the ongoing work of the AO Clinical Priority Program for Infection. The aim of the new Task Force is to guide the development of products and techniques for the diagnosis, prevention, and treatment of surgical infection. Members also seek to improve education globally regarding effective anti-infection protocols.

Surgical site infection following internal fixation of open or closed tibial fractures in India: a multicenter observational cohort study

Surgical site infections (SSI) after musculoskeletal trauma remain a challenge for both patients and surgeons and can have considerable socioeconomic implications for health care systems. This is particularly evident in low and middle income countries (LMICs) such as India due to accelerated urbanization and industrialization with a disproportionately large number of trauma incidents such as motor vehicle accidents. Poor hygienic conditions accompanied by difficulties in getting immediate access to adequate health care facilities and a subsequent delay in treatment certainly add to the rate of infection among trauma patients in these countries although clinical evidence is lacking. Tibial fractures that require surgical intervention are particularly at risk of infection, often with sometimes serious and debilitating consequences.

As a result of the need for increased clinical evidence, the AOTK Asia Pacific (Trauma) Expert Group initiated a multicenter prospective cohort study in India via the AO TK Trauma network. The most important findings of the study are presented in this article and represent a summary of the developed manuscript.

The investigators of the study aimed to gather more clinical evidence about the incidence and characteristics of SSI one year after open or closed tibial fractures treated surgically with internal fixation. Factors influencing the occurrence of SSIs, its management, and patients' health-related quality of life (EQ-5D) after fracture treatment were also assessed. Patients enrolled in the study were followed up at 3, 6, and 12 months postsurgery. The study was conducted by AOCID. Initially, 11 centers agreed to participate in the study, although one center was later withdrawn. A total of 787 patients were included. Among these 10 centers an exceptionally good follow-up rate could be achieved. A total of 768 (98%) patients included in the study attended the 12 month follow-up visit for the primary endpoint. In order to guarantee the accuracy of the eligibility criteria of each patient enrolled as well as the accuracy of each infection case detected in the study, an adjudication committee was established.

The majority of patients included in the study were male (80%), nonsmokers (96%), and had no comorbidities (89%) (Table1). Table 2 shows the distribution among the different locations in the tibia as well as the method of fixation for the different fracture locations. The initial finding was the unexpected low infection rate. Overall, only 23 patients (2.9%) suffered from an infection. The incidence of infection was 1.6% (10 infections in 625 patients) in closed, and 8.0% (13 infections in 162 patients) in open fractures, which represented a statistically significant difference ($P < 0.0001$). No difference between the incidence of superficial and deep infections for open and closed fractures could be observed ($P = 0.2362$). Tables 3 and 4 show the distribution of infections depending on the soft-tissue involvement for open and closed tibial fractures.

The study also showed that of the 23 patients with infection, 11 were treated with a plate and 10 with a nail (Table 5). Additionally, the occurrence of infection did not seem to be influenced by the facility in which the patient was treated (private hospital, public hospital, or a combination of both). A delay in surgery (> 6 hours) did not seem to have an influence on the occurrence of infection, but it is worth referring to the fact that 88% of patients had a delay of more than 6 hours between injury and surgery (on average 64.0 hours for open fractures and 76.0 hours for closed fractures). The presence of an infection had an obvious effect on fracture healing, with only 13 out of 23 (57%) fractures healing radiographically in patients with an infection and 674 out of 764 (88%) in patients without an infection ($P < 0.0001$). This was underlined by a significant longer healing time for patients with an infection (223 days ± 102.6 vs 149.2 ± 72.0, $P = 0.0234$). At 12 months follow-up, only 4 infections were treated successfully, leaving 19 infections unresolved. Health related quality of life was significantly impaired for patients with infection and open fracture at 12 months. Patients without infection and patients with an infection of a closed fracture returned to their preinjury health related quality of life ($P < 0.0001$) (Fig 1). Four out of five microorganisms isolated in patients with infection were Staph. aureus. A rather long prophylactic postoperative antibiotic administration was observed in patients with closed tibial fractures in mean for 8 days (± 5.0), which was only one day shorter than in patients with open tibial fractures (9 ± 5.0). Once an infection occurred, it was treated primarily with antibiotics (57%) with only 35% of patients receiving a combination of antibiotics and surgery.

The study provides a significant insight into the incidence of infection for internally fixed open and closed tibial fractures in India. It presents unique data on the characteristics of infection, prognostic factors, infection management, and patient reported outcomes. The incidence of infection within the study is similar to that reported in developed countries perhaps as a result of the prolonged use of prophylactic antibiotic administration, which raises concern for the potential development of antibiotic resistance. The study also highlights the difficulty experienced in the management of an infection once present. Future research should aim to identify the best practice for management of SSIs in India and the best practice for prophylactic antibiotic use to ensure that SSI infections are reduced while avoiding unnecessary administration of antibiotics. This study represents a successful example for clinical research conducted by the AOTK Trauma network.

Characteristic	N (%) N=787
Age (mean ± SD)	40.1 ± 14.0
Sex	
Female	159 (20.2%)
Male	628 (79.8%)
Ethnicity	
Indian	787 (100.0%)
Smoker	
No	752 (95.6%)
Yes	22 (2.8%)
Former	13 (1.7%)
Co-morbidity	
None	700 (88.9%)
Yes	87 (11.1%)
Diabetic	
No	734 (93.3%)
Yes – Insulin-dependent	24 (3.0%)
Yes – Insulin-independent	29 (3.7%)

Table 1
Demographics of study participants.

Method of fixation	Fracture location				Total N=787 N (%)
	Proximal (N=254)	Diaphyseal (N=337)	Distal (N=95)	Malleolar (N=100)	
Plate	223 (87.8%)	36 (10.7%)	39 (41.0%)	42 (42.0%)	340 (43.2%)
Reamed intramedullary nail	2 (0.8%)	274 (81.3%)	47 (49.5%)	2 (2.0%)	325 (41.3%)
Screw	27 (10.6%)	1 (0.3%)	2 (2.1%)	39 (39.0%)	69 (8.8%)
Unreamed intramedullary nail	1 (0.4%)	22 (6.5%)	3 (3.2%)	3 (3.0%)	29 (3.7%)
Screw and wire	0 (0.0%)	0 (0.0%)	0 (0.0%)	9 (9.0%)	9 (1.1%)
Wire	0 (0.0%)	0 (0.0%)	2 (2.1%)	3 (3.0%)	5 (0.6%)
Intramedullary nail (unspecified)	0 (0.0%)	3 (0.9%)	1 (1.1%)	0 (0.0%)	4 (0.5%)
Plate and wire	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (2.0%)	2 (0.3%)
Plate and reamed nail	0 (0.0%)	1 (0.3%)	0 (0.0%)	0 (0.0%)	1 (0.1%)
External fixator	1 (0.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.1%)

Table 2
Local distribution of fractures of the tibia included in the study and method of fixation depending on fracture location.

Gustilo Classification	Number with Infection N (%) N=13
I	1 (7.7%)
II	3 (23.1%)
IIIA	2 (15.4%)
IIIB	7 (53.8%)
IIIC	0 (0.0%)

Table 3
Rate of infection according to open fracture classification by Gustilo.

Tscherne Classification	Number with Infection N (%) N=10
0	1 (10.0%)
1	5 (50.0%)
2	3 (30.0%)
3	1 (10.0%)

Table 4
Rate of infection according to closed fracture classification by Tscherne.

Method of fixation	Infections
Plate	11 (47.8%)
Reamed intramedullary nail	7 (30.4%)
Screw	1 (4.3%)
Unreamed intramedullary nail	3 (13.0%)
Screw and wire	0 (0.0%)
Wire	0 (0.0%)
Intramedullary nail (unspecified)	1 (4.3%)
Plate and wire	0 (0.0%)
Plate and reamed nail	0 (0.0%)
External fixator	0 (0.0%)

Table 5
Infection rate depending on treatment modality.

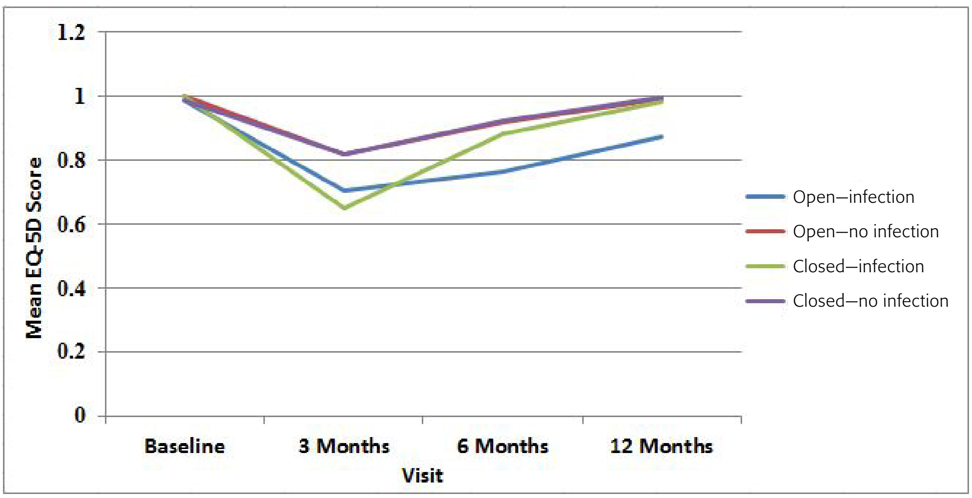


Fig 1
Quality of Life (EQ-5D) score over the course of treatment for open and closed fractures with and without infection. Please note that the line for "open—no infection" coincides with the line for "closed—no infection".

Clinical Priority Program on Bone Infection

International consortium tackles highly relevant clinical problem

Trauma surgeons have long recognized infection as one of the most serious and distressing complications of operative fracture care. While the incidence of deep implant-related bone infection is relatively low in closed fractures, the risk of infection increases dramatically for open fractures, with an estimated 27% incidence in civilians and 40% incidence in war injuries. Despite best current practice, including antibiotic prophylaxis, we have failed to eliminate costly bone infection. The increasing prevalence of drug-resistant pathogens signals a new obstacle. Surgical treatment options are also often complicated by the need for fracture stability and implant removal. Furthermore, despite elaborate revision protocols, treatment failure rates can be as high as 50% leading to loss of function, arthrodesis, amputation, and death. Infection has therefore made a serious resurgence as a major complication of orthopedic trauma and reconstruction surgery. As we approach the limit of the effectiveness of current techniques, novel approaches to infection management must be developed.

Bone Infection as an AOTrauma Clinical Priority Program (CPP)

AOTrauma has acknowledged the challenge posed by bone infection and defined it as the focus of a Clinical Priority Program (CPP). The aims of this new CPP are as follows:

- Achieve a better understanding of bone infection
- Provide solutions for this very pressing clinical problem
- Have a positive impact on patient care.

The CPP on Bone Infection is led by Prof Stephen Kates, Virginia Commonwealth University, Virginia, USA and Prof Edward Schwarz, University of Rochester, New York, USA. The projects within the CPP have been expansive and ambitious from the outset. Clinical Priority Program principal investigator Prof Kates explains that AOTrauma's latest CPP has the potential to change the way clinicians think about bone infection, with projects aimed specifically at prevention, diagnosis, treatment, and education.

Fig 1
(L–R) Jack Daiss, Edward Schwarz, Stephen Kates, and Kohei Nishitani receive the 2015 CORR/ORS Richard A Brand Award for Outstanding Orthopedic Research.

Highlight 1: CPP Bone Infection team receives Clinical Orthopedics and Related Research/Orthopedic Research Society Award

Prompt and reliable diagnosis of bone infection is a critical first step in the successful treatment of infection. In 2015, a team of researchers within the CPP on Bone Infection received the Clinical Orthopedics and Related Research (CORR)/Orthopedic Research Society (ORS) Richard A Brand Award for Outstanding Orthopedic Research for their paper entitled "A multiplex assay of host immunity against Staphylococcus aureus for osteomyelitis patients" (Fig 1). The award serves to promote, support, develop, and encourage research, educational activities, and knowledge dissemination in surgery, musculoskeletal disease, and related disciplines. The work involved serological assay that enables detection of S. aureus–specific antibody responses in the blood of patients, which promises the improved diagnosis of infection in patients.

Highlight 2: International bone infection registry established

The lack of a dedicated registry for bone infection patients has hampered efforts to estimate the magnitude of this important clinical problem on an international scale. The CPP on Bone Infection has established the first dedicated registry on bone infection and has been actively recruiting patients for the past few years. Despite the complexity of establishing such a registry on an international scale, the CPP bone infection registry is currently recruiting patients from numerous centers across the globe. The addition of a dedicated Chinese laboratory facility at Zunyi Medical University as well as recruitment centers across China, (Fig 2) has offered the potential to significantly enhance patient recruitment. The additional collection of biological specimens will ensure that the demographic and patient related outcome data that will be generated can be expected to be followed thereafter by scientific studies investigating the patient-related responses governing outcomes. International collaborations such as this registry are invaluable to the AOTrauma CPP Bone Infection network and will greatly enhance the network's efforts to improve the care of S. aureus and MRSA implant-related bone infections in the future.

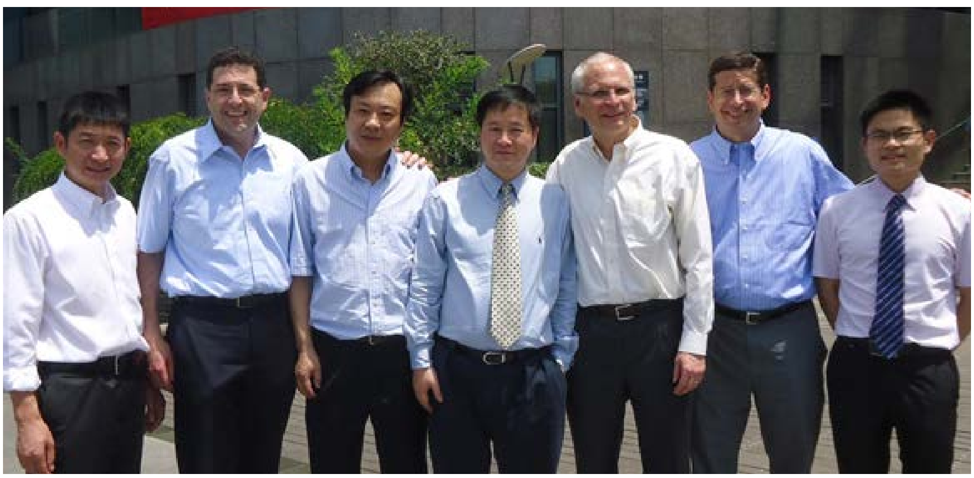


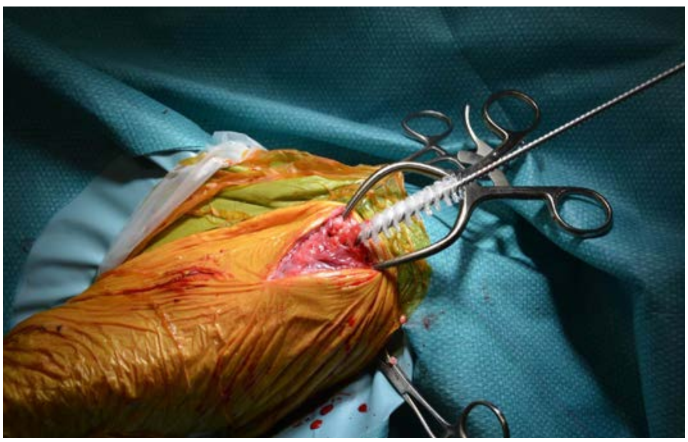
Fig 2
AOTrauma CPP on Bone Infection team while visiting hospitals in China.

Highlight 3: Development of animal models

The relatively high rate of failure when treating implant-related bone infection indicates that current treatment protocols are less than optimal. Preclinical in vivo models offer the possibility of reproducible controlled conditions in which to study treatment failure. In the AO Research Institute, the CPP has worked together to develop animal models in mice, rats, rabbits, and sheep.

The CPP group has developed a large animal model that recapitulates the treatment of a chronic infection with a staged re-nailing involving an antibiotic cement nail (Fig 3). The chronic infection receives debridement, device exchange, and both local and systemic antibiotic administration in the first ever description of such a model. The international collaboration, and preclinical and veterinary surgery capabilities within ARI, have allowed such a model to be first established within the CPP and is now available for future interventional studies that will surely follow.

Fig 3a–c
Intraoperative images of a staged re-nailing with implant removal (a), debridement (b), and placement of an intrastage antibiotic-loaded cement nail (c) in the sheep model.



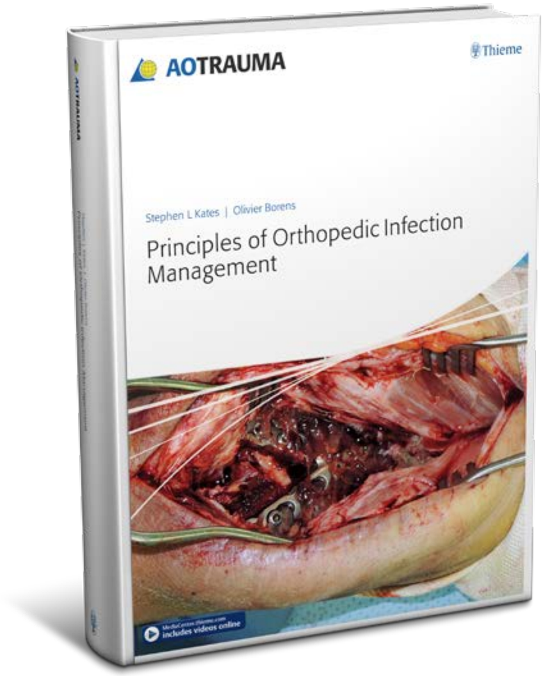


Fig 1
Principles of Orthopedic Infection Management by Stephen Kates and Olivier Borens.

AOTrauma to launch first orthopedic infection publication

AOTrauma will launch its latest book publication called *Principles of Orthopedic Infection Management* (Fig 1) during Davos Courses 2016.

This highly informative book provides the core principles, treatment options, and the latest information and research specifically on orthopedic infection and related issues, and includes contributions from more than 60 renowned specialists, as well as 25 detailed patient cases, and more than 500 illustrations and images.

The book's editors, Stephen Kates from USA and Olivier Borens from Switzerland, said that few books adequately dealt with the sorts of issues experienced by surgeons in their daily practice and that a highly practical publication on infection was urgently needed.

"At the time of planning for the book there was very little literature and indeed no orthopedic text that covered the sorts of things we felt were important. Many books were written specifically for and by infectiologists but nothing combined the daily practical needs of both the surgeon and the infection specialist."

"It was our great pleasure then to be able to liaise with medical colleagues and education experts to develop this text at a time when infection had come to light as a critical and overlooked factor within orthopedic treatment."

"We are extremely pleased to have been able to work with opinion leaders from a wide range of fields and specialties as well as staff from AOTrauma and the AO Education Institute to bring this book to publication."

Principles of Orthopedic Infection Management will be launched during the AOTrauma Masters Course on Infection on Tuesday 6 December 2016, and will then be made available for purchase at www.thieme.com.

NEWS FROM AOTK

3rd AOTrauma Asia Pacific Scientific Congress and AOTK Experts' Symposium

This was the third occasion in which the AOTrauma Scientific Congress and the TK Experts' Symposium took place as a combined event presenting an opportunity for researchers, surgeons, and members of the AOTK System to share their regional expertise, insights, and experiences (Fig 1). The event took place in Chengdu, China and followed a comprehensive schedule of parallel lectures and presentations over one and a half days. Nearly eighty scientific posters rounded up the overwhelming knowledge presented on interactive screens at several places throughout the venue. A number of prizes were awarded for the best case presentations and papers as well as for young investigators and fellows with the aim of motivating young surgeons to progress their research and contribute to better healthcare.

Fig 1a–b
Scientific congresses and symposiums have a long standing tradition within the AO community and establish a platform for the exchange of knowledge and experience in the creation of a network of surgeons around the world. Chair of the AOTK System, Tim Pohlemann is joined at this event by AO Foundation Past Presidents Jaime Quintero and Suthorn Bavonratanavech, and incoming President Nikolaus Renner.

Fig 1
Bob McGuire takes center stage during an AOSpine TK Meeting..

Fig 2
Medical members of the Hand Expert Group discuss prototype designs for the Variable Angle Hand system during an anatomical specimen lab in 2015.

Fig 3
Medical members of the Upper Extremity Expert Group engage with engineers during a prototype lab.

AOTK System: What is it, what does it do, and who is it comprised of?

The AOTK System is a critical institute within the AO Foundation working in close collaboration with its industrial partners. The AOTK System is responsible for the development of new operation techniques, implants, and instruments under the medical guidance of independent orthopedic surgeons (Figs 1–3). AOTK comprises of four technical commissions: Trauma, Spine, CMF, and most recently, Neuro. Within each of these commissions are a variety of Expert Groups focusing on anatomical regions or surgical techniques. Each Expert Group comprises between five to seven surgeons (medical members) from all corners of the globe. It is important that the differences in patient care and treatment across EMEA (Europe, Middle East, Africa), Latin America, North America, and Asia Pacific are acknowledged and accurately represented during discussions about global clinical needs and product innovation.

Expert Group members meet 2–3 times per year under the guidance of their project manager. There are six project managers in the AOTK System, based at the AO Center in Davos, Switzerland, and each manager is supported by an administrative assistant in the organization of meetings and anatomical specimen labs all over the world. Face-to-face meetings present an ideal opportunity for medical members to liaise with industry representatives to discuss new concepts and technology as well as test new prototypes and devices.

Meet the Team

The AOTK Management Team (Fig 4) administers the AOTK System. Group managers and assistants prepare and conduct meetings, ensure thorough documentation, and implement effective project management. Here now is a chance to meet the people behind the AOTK System.

Claas Albers–Director of the AOTK System

A fully qualified lawyer, Claas gained experience in marketing and business management across several companies and industry segments before attending his first Davos Courses in 2004. He joined the AOTK System shortly after and feels privileged to be able to work with the world's top surgeons as they continuously strive to improve patient care by creating surgical solutions to clinical needs.

Karsten Schwieger–Trauma TK Manager

Karsten has a mechanical engineering background and joined the AO Foundation in 2003. For six years he managed the Biomedical Services Program in the AO Research Institute (ARI) before moving to the AOTK System as a Project and Expert Group Manager. Karsten has experience in biomechanical study design and statistic collation.

Christoph Noetzli–Trauma TK Manager

Christoph started in the AOTK System in 1997 developing the TK database. He has a background in mechanical engineering, database development, and intellectual property management. While he has always had an input in the AOTK System, Christoph works predominantly as a Senior Consultant for the AO Foundation, providing a technical insight into many of the products and concepts developed both by the AOTK System and across the other AO Institutes.

Fig 4
The AOTK Management Team pictured in December 2015 during the annual AO Foundation Davos Courses.
Absent: Nevena Petrovic.

Melissa Forster–Trauma TK Manager
Following four years as a Trauma Sales Representative with Synthes in the UK, Mel joined the AO Foundation in September 2014 as an AOTK Project Manager. It was evident that her experience with Synthes would prepare her well for the trauma groups that she now manages. Speaking shortly after her arrival in the mountains, Mel commented on her role within the TK: "I learnt about AO in 2010 through my role with Synthes. I feel extremely honored to be able to work with experienced and reputable surgeons in the pursuit of product innovation."

Lois Wallach–Trauma, Neuro, and CMF TK Manager
Lois has a long standing interest in life sciences. She gained her BSc (Hons) degree in Physiology and Pharmacology and her PhD in Neurophysiology in the UK. Before joining the AOTK System in September 2014, she worked in medical education for 14 years as a lecturer at the University of Southampton, delivering anatomy and physiology teaching to students in medicine and the allied health professions. Since joining AOTK, Lois has greatly enjoyed the interdisciplinary nature of the daily work with clinicians, industrial partners, and researchers and in particular the privilege of working with world-renowned surgeons to improve patient care.

Andrea Chierici–Spine TK Manager
Andrea has been AOSpine TK Manager since June 2012. He has an Industrial Engineer Diploma from Bologna University and an MBA from SDA Bocconi Business School, Milan. In 2003 he initiated a career in international sales and marketing, working with cardiovascular products including autotransfusion, thoracic and orthopedic drainages, and extracorporeal circulation. In 2009 he worked at Orthofix as an International Product Manager. In this role, he was deeply involved in new product and technique development with both R&D and product advisors.

Ursi Eberli–Veterinary TK Manager
Ursi studied Human Movement Sciences at the ETH in Zurich, specializing in biomechanics. Following the completion of her Master Thesis on implant augmentation at ARI in 2011, she joined the CT Imaging Team of Biomedical Services where she works as a project leader involved mainly in preclinical studies. In April 2014 she acquired additional responsibility working with the AOTK System and is privileged to manage the Veterinary Expert Group.

Géraldine Pozzan–AOTK Coordinator
Géraldine has a sport and event management background and joined the AO Foundation in 2011. Working with great colleagues, Geraldine coordinates and supports AOTK meetings between TK managers, surgeons, and industry representatives. She is proud to be a part of the AOTK. When not at work, she likes to spend time with her horses and ensures that she enjoys all the good things in life.

Regina Brun—Executive Assistant
Regina started with the AO Foundation in 2001 as a patent administration assistant. After a few years she acquired a new role as Assistant to the Head of the AO Development Institute (ADI). Regina joined the AOTK System in 2009 and is responsible for the logistical organization of a variety of Trauma Expert Groups.

Vanessa Schenk—Assistant
Vanessa studied movement sciences at the Federal Institute of Technology (ETH) in Zürich. She initiated her career with the AO Foundation in 2005 as a Project Leader at the AO Development Institute, working for five years in the field of bone cement augmentation. Following a short break, Vanessa returned to the AO in 2010 and currently manages the logistical organization for all Spine Expert Groups in the AOTK System.

Evelyn Florin—Assistant
Evelyn qualified as an anesthetic nurse in 1992. Following 17 years in this role working throughout Switzerland, she joined the AO Foundation in 2013 as an Assistant in the AOTK System. While she has held a variety of positions within the AOTK, Evelyn has been predominantly responsible for the logistical organization of CMF and Neuro surgeon meetings. She enjoys life in the mountains and as a certified diving instructor Evelyn enjoys indulging in this pastime with family and friends.

A word from the Medical Members ...

David Helfet MD, New York, USA (Fig 5)

"I have been privileged to be a member of the AOTK for 18 years. This has provided a unique opportunity to interact with all members of the AO family, from the early pioneers to the current global network of surgeons, scientists, educators, engineers, nurses, and all those that have made the AO Foundation a success."

"I have been fortunate enough to attain a significant insight into the life cycle of product development from innovation to launch through collaboration with the AO Foundation's industrial partner. Such involvement, along with the opportunity to be affiliated with the testing and evaluation processes employed by the ARI and CID institutes, has been truly remarkable and represents what makes the AOTK so unique. The AOTK Medical Members possess a genuine appreciation of the degree of work involved in the product development process. It is extremely rewarding to witness a concept become an innovative clinical solution and this is particularly evident when we get to use the product in a clinical situation!"

"An added bonus of my AOTK membership has been the relationships that have evolved over the years. I have formed many lasting friendships with all AOTK affiliates and for that I remain thankful."

Dankward Höntzsch Dr med, Tübingen, Germany (Fig 6)

"My first contact with the AOTK System was in October 1985. I was a 37-year-old orthopedic surgeon working at BG Trauma Centre in Tübingen, Germany and was honored to be invited to join the AOTK Trauma Group under the leadership of Stephan Perren, a pioneer of internal fixation techniques with the AO Foundation. Early in my career with the AOTK, I was extremely fortunate to be working with the world's leading medical and scientific authorities on the surgical fixation of bone fractures. I recall attending meetings at the Müller Foundation in Bern as well as in the old tower of the airport at Zürich Flughafen where we were blessed with 360° panoramic views. I initiated two AOTK surgeon groups for External Fixation and Minimally Invasive Osteosynthesis in 2000 and 2001 respectively and have witnessed three group chairmanships as a member of the AOTK Trauma Group. The innovative highlights of my time in the AOTK System include the release of the Universal Tibial and Femoral Nails, EXFIX clamps, ASLS, and numerous instruments to enable minimally invasive osteosynthesis."

"As we approach the 200th gathering of the AOTK Medical Members exactly 31 years to the month that I joined this exciting Foundation, I am proud to be able to say that I have enjoyed participation in more than 100 such meetings. The AO will always be an important part of my life."

Fig 5
David Helfet participating at another AOTK Trauma meeting.

Fig 6
Dankward Höntzsch.

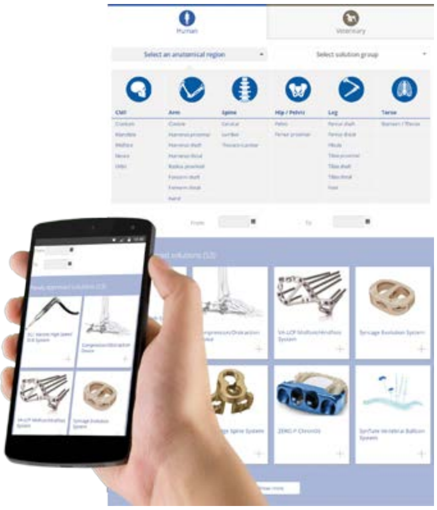


Fig 1
New AOTK Approved Solutions website for use with a range of devices.

New AOTK Approved Solutions Website

March 2016 saw the launch of the AOTK System´s brand new AOTK Approved Solutions website (Fig 1). It can be found under the "Innovations" tab in the AO Foundation website.

Showcasing surgical products that have been approved by the AOTK System, the new website has a clean, modern, and intuitive user interface. It has been constructed using state of the art responsive design, meaning it can be viewed in high quality on all popular browsers and devices. Filters allow the user to search the site according to areas of interest including anatomical region, product type, and approval date (Fig 2).

Users are able to access comprehensive product information, including relevant clinical cases, surgical image galleries, and descriptions of associated instruments. Users can also stream videos from the "Meet the Experts" sessions held during the annual Davos Courses and at other international congresses, showing expert surgeons demonstrating the features and advantages of newly approved technologies (Fig 3).

We invite you to visit the AOTK Approved Solutions website today.

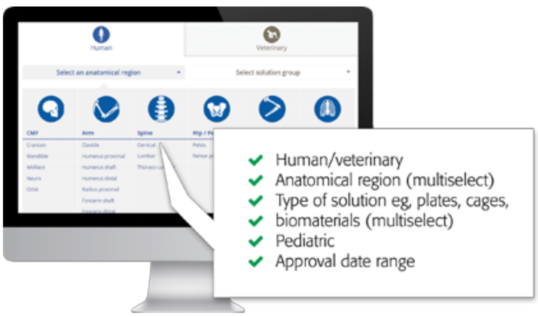


Fig 2
Filters allow content to be browsed according to specific areas of interest.

Fig 3
Users of the website can browse product details including clinical cases and videos showing product demonstrations by expert surgeons.

Craig Cooper

STRATEGY FUND

An Introduction to the AO Strategy Fund

Following a successful launch in December 2013, the AO Strategy Fund (Fig 1) continues to support a range of projects aimed at the development of new services and the advancement of technologies designed to address unmet clinical and educational needs. After receipt of 196 applications from innovative minds around the globe, funding has been allocated to 25 strategically important new initiatives. In this article, you can read about three of the exciting projects currently being supported by the AO Strategy Fund.

AO Socks for Customized Weight Bearing

The primary driver for this two year project led by Prof Peter Brink, Chairman of Traumatology at Maastricht University Medical Centre in the Netherlands, is the identification of a correlation between weight bearing and fracture healing in patients with pelvic and lower limb injuries (Fig 2). Speaking about the innovative nature of this project, Prof Brink believes it has the potential to transform clinical thinking around postsurgical weight bearing, patient rehabilitation, and education. "These socks could provide essential data on the recovery process. With the knowledge attained over the next ten years, I predict that postsurgery treatment protocols could be completely rewritten."

Multipurpose Surgical Simulation

The AO Foundation in collaboration with the Imperial College London and AO North America aims to develop a cross-platform multifunctional simulator as a new training tool for young surgeons across the

Fig 1
AO Strategy Fund.

Fig 2
The AO Socks for Customized Weight Bearing showing their various sensors.

AO's Clinical Divisions (Fig 3). Tobias Hüttl, Executive Director for AOCMF and AOVET spoke positively about the potential move away from classical training to the acquisition of surgical skills via simulation. "Prohibitive cost and limited availability of donors make it more and more difficult today to complete specimen-based education. If the correct metrics for simulation are identified, it can offer many advantages."

Limb Surgery in Disasters and Conflicts

The Limb Surgery in Disasters and Conflicts project (Fig 4) aims to improve patient outcomes and alleviate suffering by defining the minimum standards of care and by developing practice guidelines for the management of people with limb injuries in areas of natural disaster and conflict. The International Committee of the Red Cross (ICRC), the World Health Organization (WHO), and the AO Foundation have teamed up to make a difference. Dr Ian Norton, Technical Advisor with the World Health Organization, spoke of the importance of identifying clear guidelines around the treatment procedures that need to be adopted in disaster and conflict zones. "The world needs the consensus and guidance that we are trying to bring together. Education in the area we are addressing is a public good."

If you would like to read more about the many other exciting projects that the AO Strategy Fund is sponsoring, please visit the AO Strategy Fund page on the AO Foundation website.

Fig 3
Simulation being used for education.

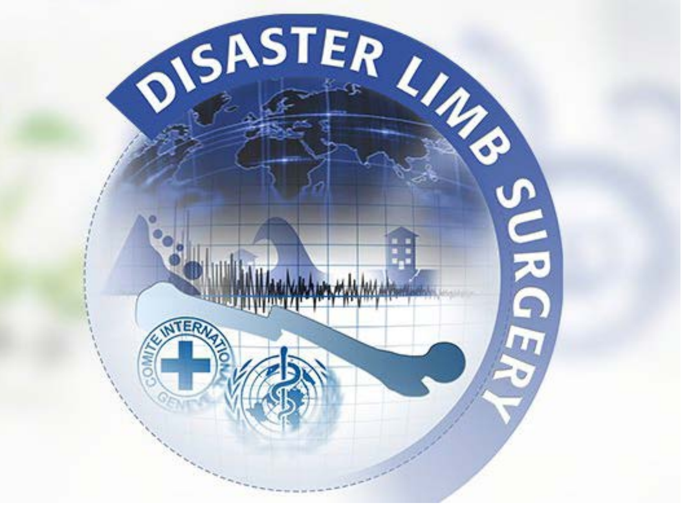


Fig 4
Limb Surgery in Disasters and Conflicts.

Mario Gasparri

PORTRAIT: FRED PIERACCI

The AOTK Thoracic Expert Group (THEG) of 2016 represents true transformation. In April 2007, four thoracic surgeons under the guise of the Sternal Surgery Working Group were brought together in a Dallas hotel to discuss advancements in sternal fixation. Following two years of successful innovation and a subtle change in membership, the "Sternal Surgery" members became part of the Thoracic Working Group and expanded their area of discussion to include rib fixation and cable systems.

In today's clinical culture, thoracic surgery involving bone fixation is gaining popularity. Within a trauma environment, there has been a move towards chest wall intervention as opposed to the tradition of conservative management. Not only is this good news for the thoracic trauma patient in terms of rehabilitation, but presents additional justification for the great work undertaken by the THEG. In January 2016, the group was elevated in status and as a result, authorization for a fifth member was granted. In October 2016, the THEG met in Berlin joined by Fred Pieracci, the group's latest addition and focus of this year's surgeon portrait.

Dr Fred Pieracci (Figs 1–3) was raised in the suburbs of Chicago as the son of an Italian immigrant family. Many of his ancestors worked with their hands either as stone masons, carpenters, or farmers. He believes that this was an important influence in his decision to pursue a career as a surgeon. Following the completion of medical studies in Pennsylvania and surgical residencies in New York city, Fred moved to Denver, Colorado to complete a Critical Care Fellowship.

Fig 1
Dr Pieracci taking a break at Denver Health Medical Center in Denver, Colorado.

Fig 2
Hard at work in the OR with fellow surgeon Dr Amy Reppert.

"I am a trauma surgeon and the Trauma Medical Director at Denver Health Medical Center. I enjoy caring for acutely and severely injured patients because it presents multiple and simultaneous problems that need to be quickly prioritized and fixed. I enjoy helping patients through some of the worst unexpected days of their lives, and working with a predominantly younger and underserved patient population. I enjoy the opportunity to operate across all areas of the body."

"Within trauma, I am further specialized in the surgical management of rib fractures. Rib fractures are one of the most common injuries following trauma but have received relatively little attention over the last few decades. Before surgical rib repair started to gain momentum, I strongly believed in the rationale for fixation and I am now extremely excited to be at the forefront of it, defining indications and helping to direct the future of technologic developments."

"As a member of the AOTK Thoracic Expert Group, I look forward to participating in a multidisciplinary approach to advancing the field of rib repair while collaborating across the disciplines of orthopedics and cardiothoracic surgery. Membership in the THEG presents a great opportunity for me to work with innovators that possess a fresh and different perspective. I am excited to bring my own observations regarding the limitations of current technology before a group of people with the ability to design and implement the next wave of instruments."

Fred is happily married to Antonia, a clinical psychologist, and has three children, Emma (9), Luca (7) and Gia (4), as well as new puppy Zora. He enjoys taking advantage of the spectacular Colorado landscapes, playing and coaching soccer, and practicing Tae Kwon Do and the acoustic guitar. Fred joins the THEG as a medical member and we look forward to working with him at the AOTK System.

Fig 3
Enjoying some fun with colleagues at the Denver Health Medical Center.

For further information please contact:

AO Foundation
TK System
Clavadelerstrasse 8
7270 Davos
Switzerland
Phone: +41 81 414 24 71
Fax: +41 81 414 22 90
aotk@aofoundation.org
www.aofoundation.org/tk

Issued: December 2016
Photos and illustrations courtesy of Synthes partners and authors