AO Foundation

AOTK System

Innovations 2015

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Production by AO Education Institute.
Typeset by Nougat.

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EDITORIAL

Dear reader,

The AOTK System is pleased to announce the long awaited return of the AOTK System Innovations magazine. The re-birth of this AO institution marks a new beginning and a fresh outlook on product innovation across our clinical divisions of Trauma, Spine, CMF, and Veterinary. Since our last publication in 2013, AOTK has witnessed two new additions to the team in Trauma and CMF, a new Chairman of AOSpine TK, and a renewed agreement for continued collaboration with our industrial partner. The focus of the AOTK, however, remains the same; the adoption of an innovative approach to the development of surgical products and techniques. This issue contains contributions from the AO Research Institute and AO Clinical Investigation and Documentation, as well as a special introduction from the AO Education Institute to AOSTaRT, an award-winning online learning hub for orthopedic trauma residents.

In our lead article we introduce the Trochanteric Fixation Nail Advanced or TFNA. This new solution from the Intramedullary Nailing Expert Group incorporates all of the benefits of the existing TFN with additional improvements to specific aspects of the nail design. The outcome is an innovative implant with promising results.

The Foot and Ankle Expert Group introduce the Variable Angle LCP Midfoot/Hindfoot system. This system demonstrates an extension of the significant innovation achieved by this group in 2013 when the VA LCP Forefoot/Midfoot system was awarded the TK Innovation Prize and became highly successful following its introduction to the market.

We report on the same high level innovation from our Spine and CMF divisions with the introduction of Facet Wedge and MatrixWAVE. Both of these innovations demonstrate a continued advancement in surgical thought and practice through the development and improvement of existing systems and techniques.

Following their first product demonstration at the Meet the Experts sessions at AO Davos Courses 2014, the members of AOVET have provided a more in-depth analysis of the Double/Triple Pelvic Osteotomy Plate. This article details two exciting corrective procedures with great clinical results.

Our portrait piece in this year's issue features Dr Karl Stoffel from the Kantonsspital Baselland in Switzerland. With the help of Dr Christoph Sommer, Chairman of the Lower Extremity Expert Group and Chief Trauma Surgeon at Kantonsspital Gräubunden, we have been able to produce a candid and insightful article that certainly supports the AOTK System's decision to feature Dr Stoffel's outstanding contribution to orthopedic and trauma surgery.

Robert McGuire happily passes the reigns of the AOSpine TK Chairmanship to new Chairman Maarten Spruit.

As referenced at the start of this Editorial, AOTK is proud to introduce Dr Maarten Spruit as the newly appointed Chairman for AOSpine TK. Having joined in 2008 as a member of the Fusion Expert Group, Dr Spruit has demonstrated his value through membership and chairmanship of the Cervical Expert Group since 2010. We wish him the best of success in his new position and offer our thanks to his predecessor, Dr Robert McGuire, for his knowledge, expertise, and dedication to AOSpine TK and the entire AO community since 2003.

With all of this and more, the 2015 edition of AOTK System Innovations promises to be an exciting issue. We hope you enjoy it. Finally, 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 the 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

Michael Blauth, Christopher Finkemeier

TFN-ADVANCED PROXIMAL FEMORAL NAILING SYSTEM (TFNA)

Although PFNA and TFN nailing systems have been successfully used in the past, several clinical issues for improvement have been identified by surgeons and engineers. Many of these issues have now been addressed and solved by implant and instrument design changes incorporated into the new TFNA nailing system.

The complications of penetration or anterior cortical impingement while using long intramedullary nails for pertrochanteric femur fractures are due to a mismatch of the femoral antecurvation with the radius of curvature (ROC) of currently available cephalomedullary nails. Bazylewicz et al [1] reported that most of the intramedullary nails with a ROC of 1800 mm ended up in the anterior half of the space available for the nail with 16% within 3 mm of the anterior cortex. Patients that are shorter and/or have an increased femoral bow as measured on a lateral x-ray are more likely to have an anterior nail tip position or cortical impingement [2]. To thoroughly investigate this issue, a comprehensive 3D computer graphical anatomy study of the femur was conducted to serve as a basis for a new nail design [3]. Analyzing 27 Caucasian and 13 Japanese subjects, the ROC resulted in 962±157 mm (Caucasian subjects) and 790±151 mm (Japanese subjects). These results indicate significant differences between ethnicities and that the ROC should be closer to these values instead of 1500 mm, which is a frequently chosen radius in current nail systems on the market.

The new TFNA has a radius of curvature of 1000 mm to improve the anatomical fit and to help avoid impingement of the anterior cortex (Fig 1).

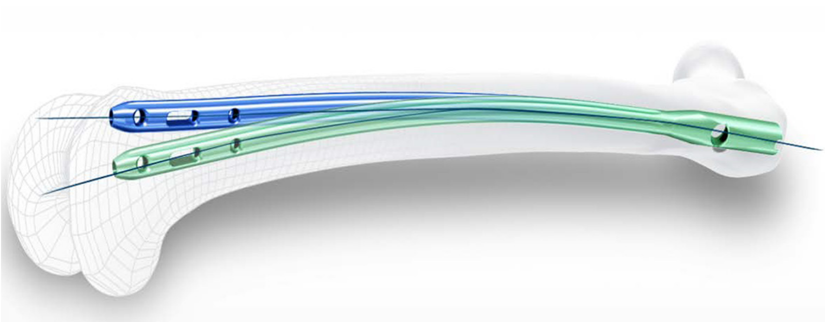

Fig 1
The TFNA nail, illustrated in green, has a 1000 mm ROC and perfectly follows the antecurvation of most femurs. The blue nail demonstrates a less favorable fit of a simulated nail with 1500 mm ROC.

Loss of closed reduction during nail insertion

Surgeons often report some loss of reduction during nail insertion, specifically in cases involving nail insertion through a fractured greater trochanter. This often leads to an unintended varisation of the head-neck fragment (HNF) and a medialisation of the HNF resulting in reduced bone contact in the calcar area (Fig 2 and 3).

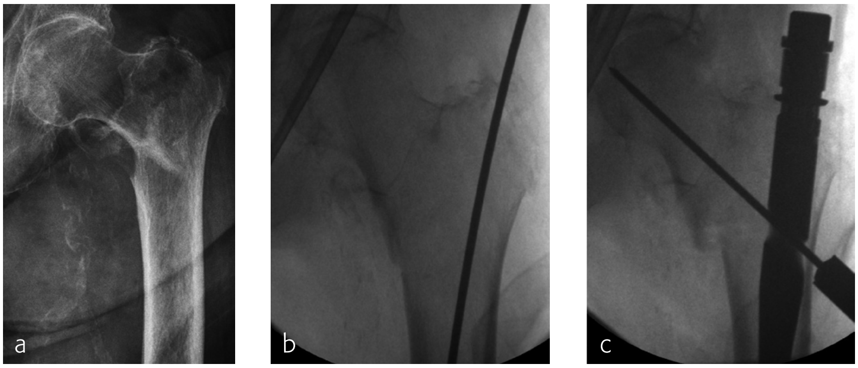

Fig 2a–c
A 60-year-old female patient with a 31-A2 fracture (a). Closed reduction on the traction table and insertion of the guide wire (b). With nail insertion, the HNF displaces to medial and varus (c).

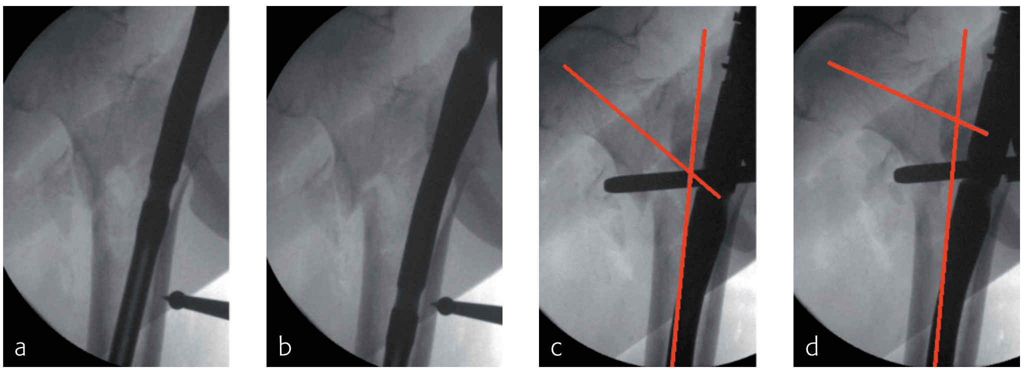

Fig 3a–d
An 81-year-old male patient. Closed reduction and insertion of a 10 mm diameter nail (a). With advancement of the most proximal part of the PFNA, the HNF displaces to medial. This cannot be prevented by pushing the shaft from lateral with a ball spike pusher (b). The attempt to reduce the calcar with a collinear clamp results in pronounced varus malalignment (c and d).

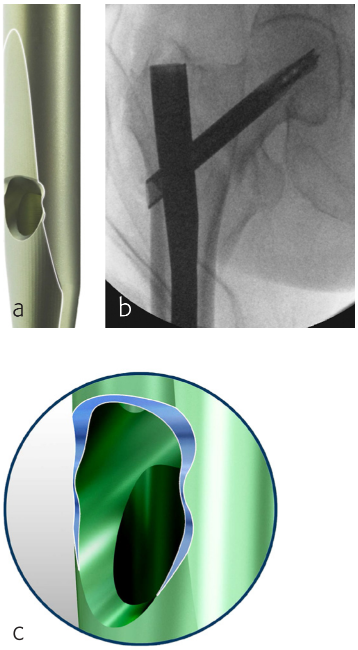

Fig 4a–c
The LATERAL RELIEF CUT design of the nail (a) avoids impingement of the lateral cortex (b). The BUMP CUT design of the proximal hole for the head element (c) provides improved fatigue strength compared to existing nails of similar size.

The combination of a large proximal nail diameter and a very lateral entry point has been identified as a potential reason for such a loss of reduction. As a result, a smaller diameter nail with a laterally flattened profile to more appropriately respect the anatomy of the proximal lateral femoral wall would be advantageous. Both design features have been realized with the new nail. The smaller 15.66 mm proximal nail diameter of the TFNA (compared to 16.5 mm and 17 mm for PFNA/PFNA-II and TFN) and the LATERAL RELIEF CUT design (Fig 4) of the proximal nail end serve to reduce the potential impingement of the nail with the lateral femoral wall and the HNF. Both of these issues could result in varus malalignment and a loss of reduction, which remain key indicators for an increased risk of cut-out. The small proximal nail diameter also helps to preserve bone in the insertion area, which is especially beneficial in the femora of small stature patients.

Evaluating nail fatigue is a key stage in the preclinical analysis of new implant designs. The median fatigue limit for the TFNA nail was 24% higher than that of the Gamma 3 nail and 47% higher than that of the InterTAN nail. This increase in fatigue strength is likely attributed to the use of a high-strength Ti-Mo (Ti-15Mo) alloy and the design features of the nail (Fig 4c).

Suboptimal placement of the head element

Apart from the newly introduced nail design features, which help to maintain a good reduction, it is also essential to place the head element in the correct position of the femoral head to avoid cut-out or cut-through. Numerous studies have demonstrated that a center/center position of the head element ensures the best clinical outcome. Multiple instrument features, including a multi hole drill sleeve for the facilitation of precise nail entry and aiming aids to accommodate the placement of the head element guide wire in the correct position have been added to the TFNA system to enable accurate implant placement. The insertion handle is radiolucent and has radiographic indicators to help the surgeon with exact guide wire placement for head element positioning in the lateral view (Fig 5). This feature, together with the guide wire aiming device, which checks guide wire position in the AP view, is influential in the placement of the guide wire in the center/center position of the femoral head. It also helps to reduce the number of imaging maneuvers and x-ray shots required.

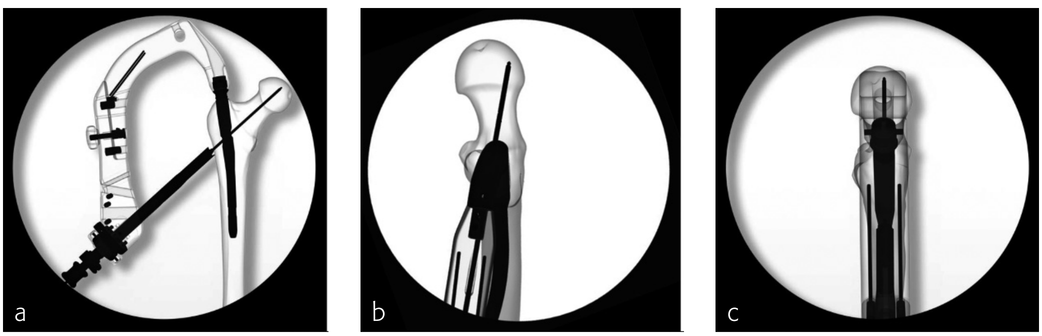

Fig 5a–c
Illustration of the radiolucent aiming arm (a). Nail rotation has to be adjusted until the two radiographic lines on the insertion handle are parallel to both the femoral shaft and nail. This ensures that the guide wire is in the correct position in the lateral view (b, c). As a prerequisite for this, a 'true lateral' projection of the proximal femur (ie, a 180° angle of the femoral neck and shaft) has to be established by rotating the C-arm from a neutral position to about 15° to compensate for the anteversion of the head and neck.

a

b

Fig 6a–b
The TFNA Helical Blade (a) and TFNA Screw (b) have an oblique lateral end that lies flush with the lateral cortex, therefore reducing head element protrusion into the soft tissues. Both the helical blade and screw are available in lengths of 70 to 130 mm with 5 mm increments.

Cut-out and cut-through

Multiple biomechanical and finite element (FE) studies have illustrated that the purchase of implants in osteoporotic bone is compromised. A blade-shaped head element and augmentation have been proven to enhance implant stability and this is especially significant in a society with a growing ageing population and increasing cases of osteoporosis. Having a modular nailing system, which comprises a screw, blade, and augmentation, offers a distinct advantage when addressing specific fracture situations, local bone quality, and issues like suboptimal reduction and implant placement. The surgeon has the option to choose between the TFNA Helical Blade and the TFNA Screw (Fig 6) for head element fixation, which accommodates differing surgical preferences and facilitates hospital standardization. It is recommended to use the helical blade in cases of poor bone quality because it allows for bone compaction around the head element and avoids the bone loss that occurs with the drilling and insertion of the standard hip screw. Optional holes in the blade or screw enable augmentation of the head element in cases where additional fixation is required (only in countries where augmentation is approved from a regulatory perspective). The benefit and efficacy of augmentation is of particular significance in an off-center position of the head element.

Leg shortening and lateral protrusion of the head element

For reasons of versatility, the new TFNA system offers two locking options (Fig 7). The first option locks rotation of the head-neck element. The second option inhibits lateral sliding of the head-neck element, thus preventing shortening of the femoral neck and lateral protrusion of the head element.

a

b

Fig 7a–b
A built-in locking mechanism (a) facilitates rotational locking (b), which allows sliding of the screw or blade head element while blocking rotation. Static locking can be achieved by tightening the locking mechanism with a torque limiter to create a fixed construct with no head element movement. The static locking mode maintains the femoral neck length.

Fig 8
The self-retaining technology is used between the connecting screw and ball hexagonal screwdriver as well as between the insertion handle and nail to reduce the risk of accidental detachment and subsequent de-sterilization.

Instrumentation and implant removal

The QUICK CLICK self-retaining technology is designed for easier and safer attachment of the nail to the insertion handle (Fig 8). An optional percutaneous set with larger instruments including protection sleeve and insertion handle are available for large stature patients.

Another important feature of the instrumentation is its ability to enable interfragmentary compression when used in conjunction with a compression nut after rotation has been locked. Matching internal threads in implant and removal instruments facilitate implant removal.

Nail lengths and distal locking

The new nail system comprises short nails (lengths 170 mm, 200 mm, 235 mm) with distal nail diameters of 9, 10, 11 and 12 mm as well as long nails (lengths 260 to 480 mm in 20 mm increments) with distal nail diameters of 9, 10, 11, 12 and 14 mm. Such choice should address a broad range of patient anatomy. All nails are available in Caput-Collum-Diaphyseal (CCD) angles of 125°, 130° and 135°. The long nail provides three distal locking options including a unique oblique distal hole that has an offset angle of 10° to more appropriately target stronger bone in the condyles. Multi-planar locking also offers increased stability.

The TFNA system is indicated for:

- Stable and unstable pertrochanteric fractures
- Intertrochanteric fractures
- Basal neck fractures
- Combination of pertrochanteric, intertrochanteric, and basal neck fractures.

The long nails are additionally indicated for:

- Subtrochanteric fractures
- Pertrochanteric fractures with shaft fractures
- Pathologic fractures (including prophylactic use) in both trochanteric and diaphyseal regions
- Long subtrochanteric fractures
- Proximal or distal nonunions, malunions, and revisions.

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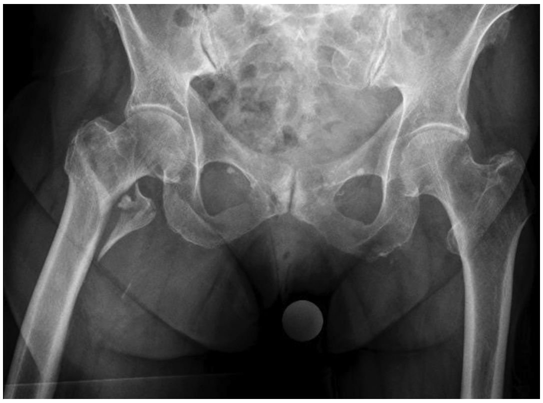
3 **Schmutz B, Kmiec S, Wullschleger M, et al.** 3D computer graphical anatomy study of the femur: a basis for a new nail design. 2nd AOTrauma Asia Pacific Scientific Congress & TK Experts' Symposium. May 2014; Seoul.

Case provided by Michael Blauth, Innsbruck, Austria



Case 1: Fall at home

An 83-year-old female patient sustained a 31-A.2.2 fracture of the right proximal femur after a fall at home (Figs 9–10). Intraoperative and postoperative images are shown (Figs 11–13).

Fig 9
AP x-ray.

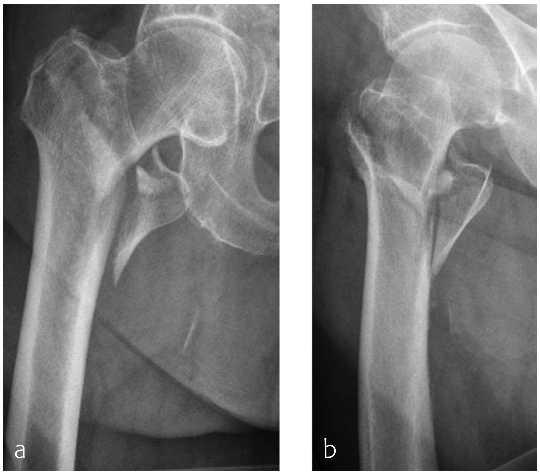


Fig 10a–b
Injury images.

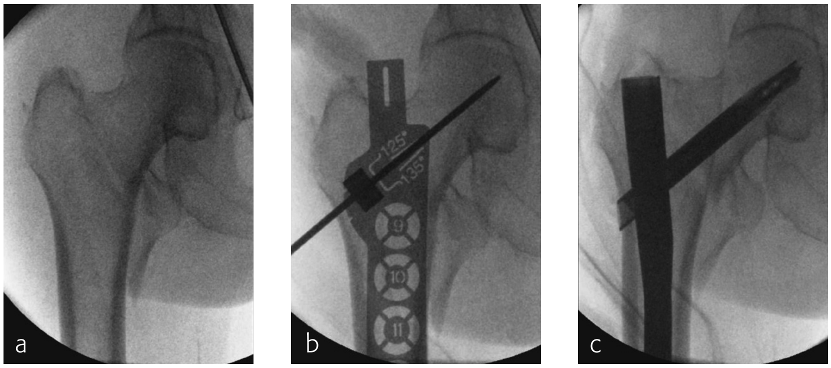


Fig 11a–c
AP views of the closed reduction (a), measurement of the CCD angle, in this case 130° (b), and the final result with the blade in center/center position and the blade tip approximately one cm from the joint line (c). The distal end of the blade is flush with the lateral femoral cortex.

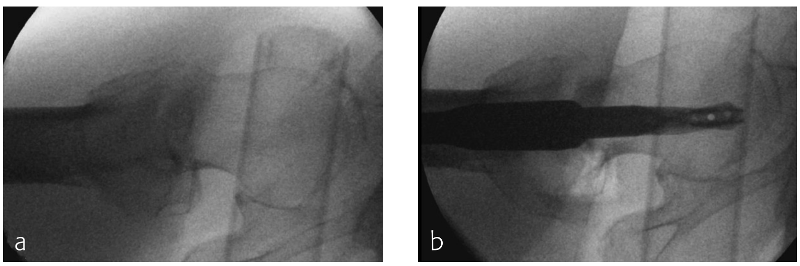


Fig 12a–b
Lateral views after closed reduction with a slight extension malalignment (a). The final result, with a slightly eccentric position of the blade (b).

Fig 13a–b
Postoperative images at day 3 after mobilization.

Case provided by Michael Blauth, Innsbruck, Austria

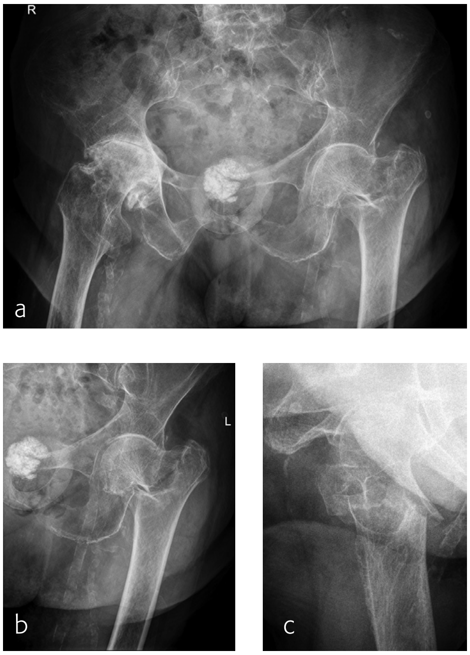


Fig 14a–c
Injury images.

Case 2: Pertrochanteric fracture

A 98-year-old female patient sustained a pertrochanteric fracture of the left proximal femur due to fall in her nursing home (Fig 14). There was significant pain and coxarthritis in the right hip, and hypertension.

Surgery was performed within 24 hours. There was an indication for augmentation due to the instability of the fracture. The patient additionally suffered from osteoporosis and dementia.

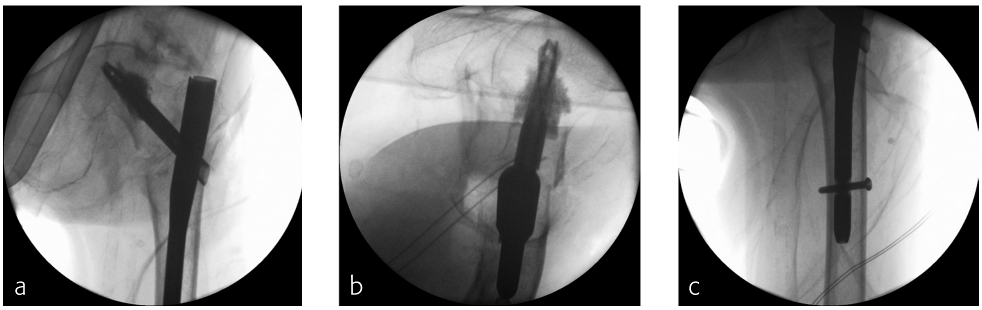


Fig 15a–c
Intraoperative images. Good reduction and implant placement. Peri-implant augmentation with PMMA V Plus cement to offer increased stability. Implants used: TFNA (170/10), 130° blade (85 mm), 4 ml of VERTECEM V+ cement.

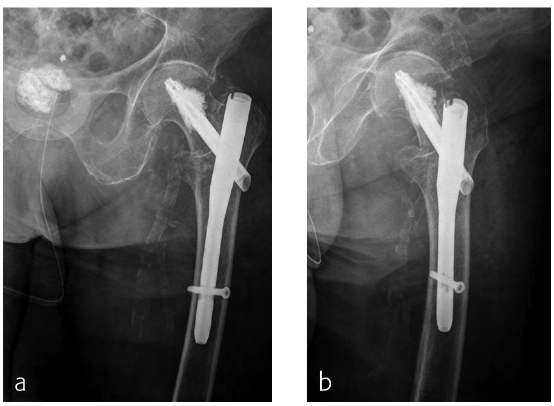


Fig 16a–b
Postoperative x-rays.

Fig 17a–b
Follow-up x-rays after a few days. There was subsidence of the fracture with controlled sliding of the blade.

Martin Jaeger, Norbert Südkamp

TRAUMA, UPPER EXTREMITY

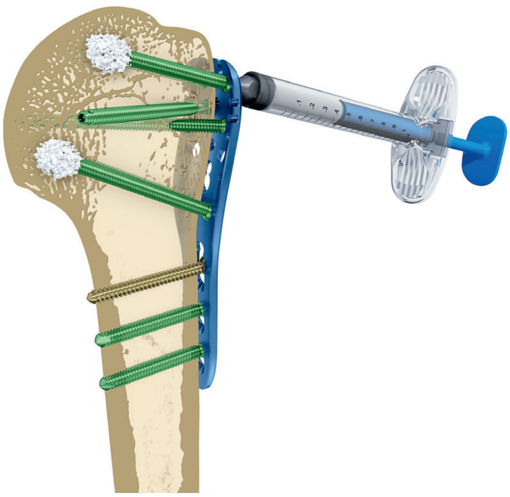


Fig 1
PHILOS augmentation.

PHILOS Augmentation—post launch product review

Proximal humeral fractures are frequent injuries in the elderly. Despite medical advances, these injuries remain a constant challenge and as a result, several predictors for the failure of surgical intervention have been identified [1, 2]. A common risk factor is poor bone quality, which can impede the fixation of implants. A recent development to overcome this problem is the augmentation of screws used for open reduction and internal fixation with PHILOS (Proximal Humeral Internal Locking System) (Fig 1). This technology is well known and has been a proven success. Recent biomechanical studies have demonstrated the enhanced anchorage of PHILOS with augmentation in the presence of low-density-bone [3–5]. Low heat distribution and its potential consequences have also been tested [6].

The first case using PHILOS augmentation was performed in January 2013. The practice of electing to augment PHILOS with PMMA cement has since developed into a routine procedure in patients aged 65 and above with poor bone quality. The use of augmentation in elderly patients with marked varus and valgus displaced proximal humeral fractures is particularly evident. However, when considering augmentation in cases involving a head-split fracture, caution is required in order to avoid the risk of intraarticular cement distribution.

The basic principles of anatomic reduction and angular stable fixation remain the same. Following the completion of a leakage test using radiopaque contrast dye, and subsequent confirmation that no joint perforation is evident, augmentation is performed using Traumacem V under fluoroscopic controls. The augmentation should take no more than 10 minutes surgery time.

Upper Extremity Expert Group study

The AO Upper Extremity Expert Group (UEEG) initiated a prospective randomized international multicenter study in order to investigate the outcome of PHILOS augmentation in the presence of displaced three and four-part proximal humeral fractures. The initial results reveal a promising outcome when using this new technique. Of course, not all problems in the treatment of proximal humeral fractures are resolved with augmentation. Some issues, such as multiple fragmented tuberosities and the development of avascular necrosis remain a constant challenge.

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Cases provided by Martin Jaeger, Freiburg, Germany

Case 1: 79-year-old with four-part dislocation

A 79-year-old man suffered a four-part dislocation fracture after a fall from standing height (Fig 2a). Closed reduction was achieved in the technique according to Stimson (Fig 2b). Intraoperative fluoroscopic controls document an anatomic reduction and internal fixation with PHILOS (Fig 3).

Intraoperative leakage testing with radiopaque contrast dye was performed (Fig 4). The Traumacem V was then prepared (Fig 5). Intraoperative screw augmentation with Traumacem V was then conducted (Fig 6). Final fluoroscopic controls document an extraarticular cement distribution (Fig 7). The 3-month postoperative x-rays are shown (Fig 8).

Fig 2a–b
Images of the injury (a) and performing closed reduction (b).

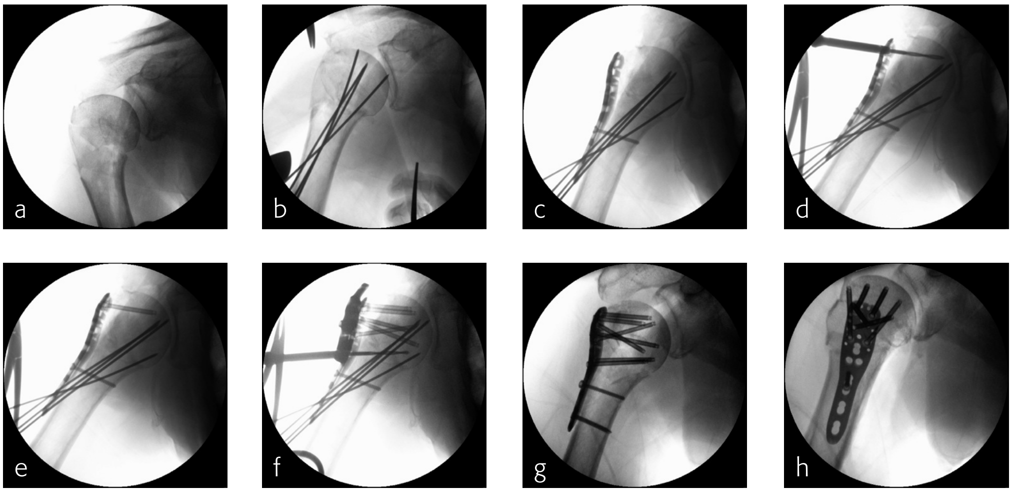


Fig 3a–h
Intraoperative images introducing the PHILOS implant.

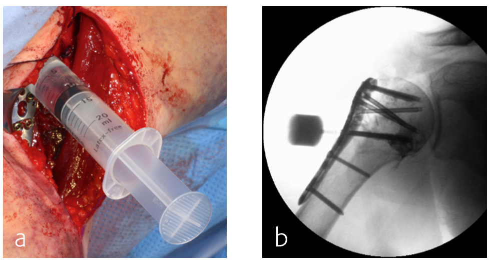


Fig 4a–b
Intraoperative leakage testing.

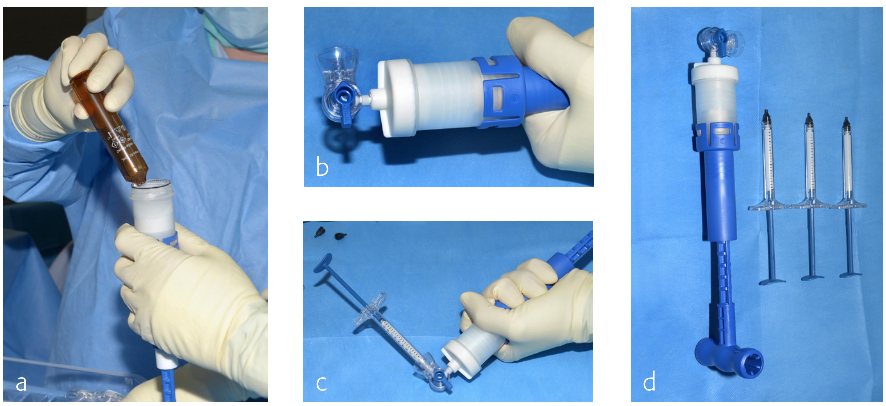


Fig 5a–d
Traumacem V preparation.

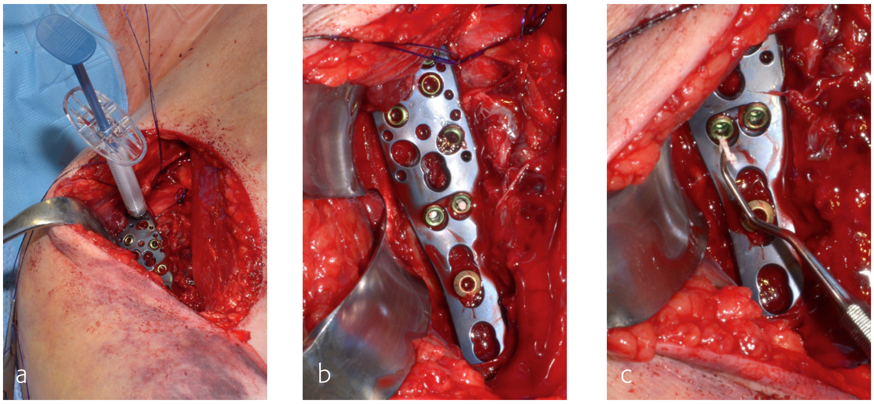


Fig 6a–c
Screw augmentation.

Fig 7
Final fluoroscopic controls.

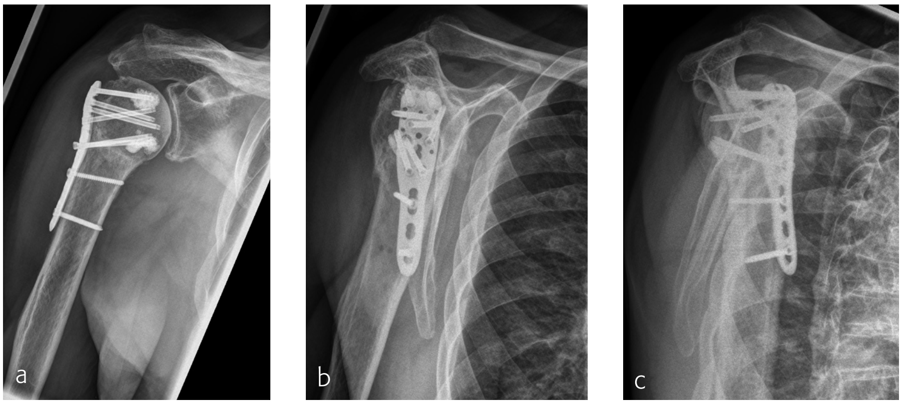


Fig 8a–c
Postoperative x-rays.

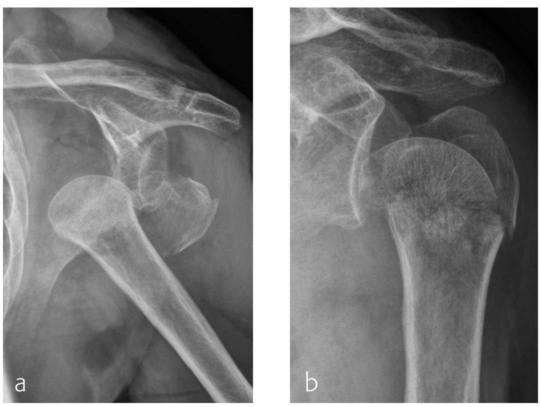


Fig 9a–b
Images of the injury (a) and closed reduction (b).

Case 2: 94-year-old man fell

A 94-year-old male patient suffered a four-part dislocation fracture after a fall from standing height (Fig 9a). Closed reduction was achieved in the technique according to Stimson (Fig 9b). The intraoperative fluoroscopic controls document an anatomic reduction and fixation with PHILOS augmentation (Fig 10).

The postoperative x-rays at day 0, day 2, week 6, and month 6 demonstrate an increasing secondary dislocation of the greater tuberosity. Note that the humeral head segment remains at its initial anatomic position (Fig 11).

A reverse shoulder arthroplasty was performed (Fig 12). Images showing the clinical outcome 8 months after the arthroplasty are shown (Fig 13).

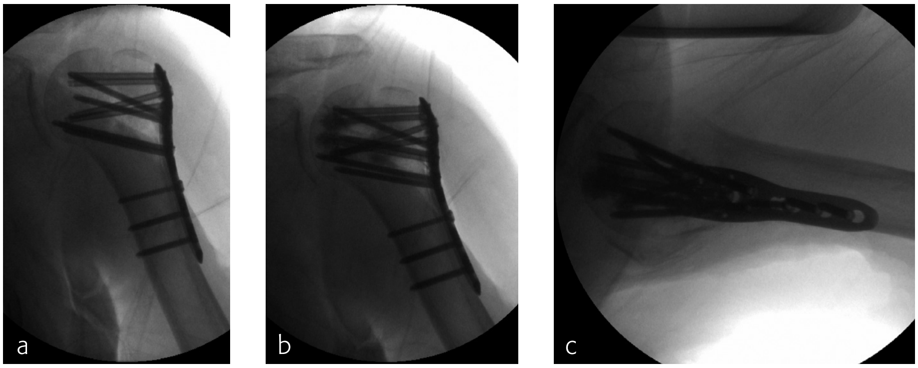


Fig 10a–c
Intraoperative fluoroscopic controls.

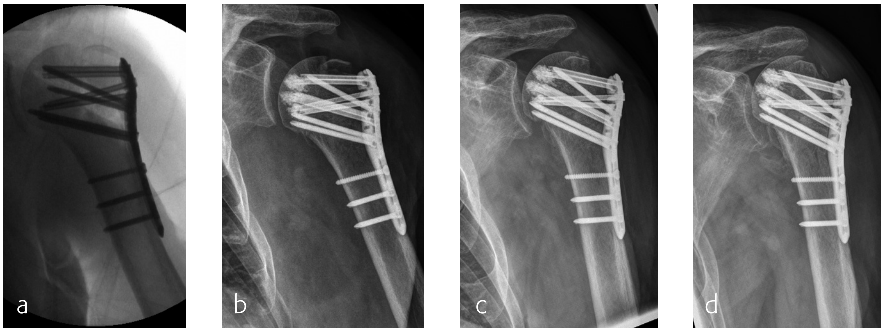


Fig 11a–d
Postoperative images.

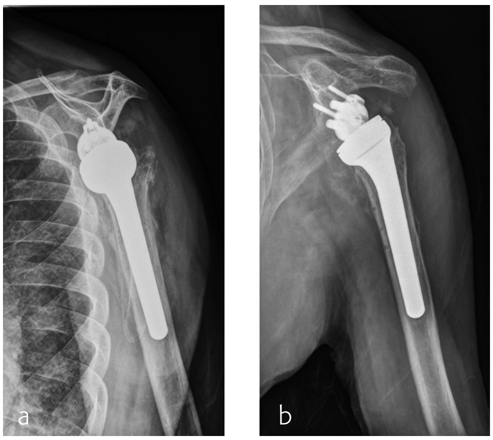


Fig 12a–b
X-rays demonstrate the situation 8 months after conversion to a reverse shoulder arthroplasty.

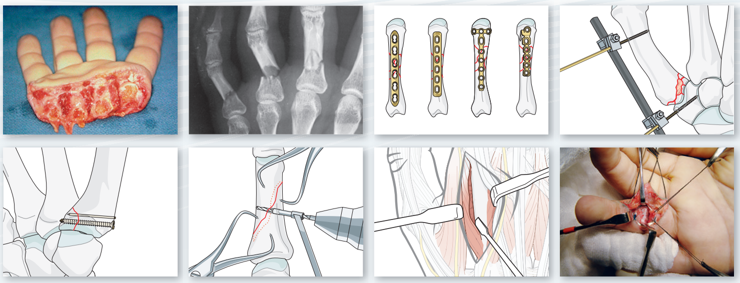
Fig 13a–d
Clinical outcome 8 months postoperative.

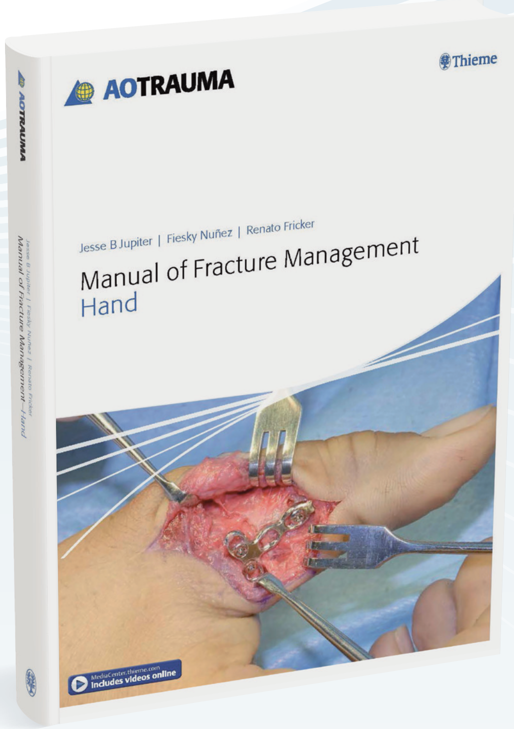
AOTRAUMA

NOW AVAILABLE!

Jesse B Jupiter | Fiesky Nuñez | Renato Fricker

Manual of Fracture Management
Hand





The management of traumatic and reconstructive problems of the hand has become an ever more complex field. Advances in basic science and technology together with a growth in clinical expertise have resulted in recent dramatic changes in many of the implants, instruments, and techniques used in modern hand surgery.

Manual of Fracture Management–Hand by Jesse Jupiter, Fiesky Nuñez, and Renato Fricker is a principally case-based publication designed to instruct and introduce new technologies and methods to both new and experienced hand surgeons. The book's key features include:

- Detailed case descriptions and recommended treatment options for a wide variety of fracture and injury types, from spiral to transverse, and multifragmentary to malunion, involving the proximal middle and distal phalanges of the fingers and thumb, the metacarpals, and the joints
- More than 2250 high-quality illustrations and clinical images
- Access to an online video library of dozens of hand surgery approaches and clinical demonstrations.

Using the principles and techniques developed by leading surgical specialists from the renowned AO Foundation, AOTrauma is proud to bring you this exciting update, which will be an ideal resource for trauma and orthopedic surgery professionals, residents in training, and medical students around the world.

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includes videos online

Number of pages: **568**
Number of illustrations and images: **2250**
ISBN: 978-3-13-221581-8
e-ISBN: 978-3-13-221591-7
Publication date: **December 2015**
Retail price: **EUR 299.99 / USD 349.99**
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Andrew Sands, Michael Castro, Juan Gerstner, Leslie Grujic, Stefan Rammelt, Michael Swords, Ian Winson

TRAUMA, LOWER EXTREMITY

Fig 1
VA Locking Calcaneal Plate.

Fig 2
VA Locking Anterolateral Calcaneal Plate.

Fig 3
VA LCP Medial Column Fusion Plate.

VA LCP Midfoot/Hindfoot System

The new Variable Angle Locking Calcaneal Plate (Fig 1) is indicated for traditional plate fixation of calcaneus fractures. The benefits of such locking technology include an ability to insert a screw at the best angle for the most optimal purchase in smaller bone fragments and a minimized risk of joint penetration in cases where fracture patterns demand screw placement in close proximity to an articular surface.

The new Variable Angle Locking Anterolateral Calcaneal Plate (Fig 2) is indicated for minimally invasive posterior calcaneus fracture fixation in combination with 3.5 mm or 4.0 mm cortex screws. The Anterolateral Calcaneal Plate is used to support the articular surface of the subtalar joint. The additional screws are used to fix the fragments of the calcaneus required by the specific fracture pattern. The number and size of screws used to fix the fracture is dependent upon the fracture pattern, bone quality, and the weight of the patient. A minimum of three screws should be used in divergent positions to provide sufficient stability.

Medial column fusion

The new Variable Angle LCP Medial Column Fusion Plate system (Fig 3) is indicated for advanced stabilization and fusion in Charcot foot and severe arthritis. The system comprises plates for application on the dorsomedial, medial, and plantar aspects of the foot as well as medial placement with talus extension. Using the compression/distraction instrument enables independent compression of selected joints.

Compression/Distraction Device set

The Compression/Distraction Device is a very versatile instrument that can be used across numerous applications to reduce fractures or optimally align bones in preparation for fusion. Multiple devices can be used in combination for multifragmentary fractures or for the control and alignment of several affiliated bones. This set is not limited to use in the foot and ankle and is regularly used as an intraoperative holding device for fractures and osteotomies to obtain optimal alignment prior to fixation.

Note

The VA Locking Anterolateral Calcaneal Plate is awaiting regulatory approval outside the USA.

Case provided by Michael Swords, East Lansing, USA

Fig 4a–b
Preoperative patient x-rays.

Case 1: Ladder fall

A 58-year-old woman (Fig 4), who had fallen from a ladder 9 weeks earlier, had indications of a malunited fracture and was referred to the clinic by a family physician.

The malunion had to be treated with an osteotomy to reconstruct the joint and regain normal function. The osteotomy was fixed with the VA Locking Calcaneal Plate (Figs 5 and 6).

Fig 5
Intraoperative image of the procedure.

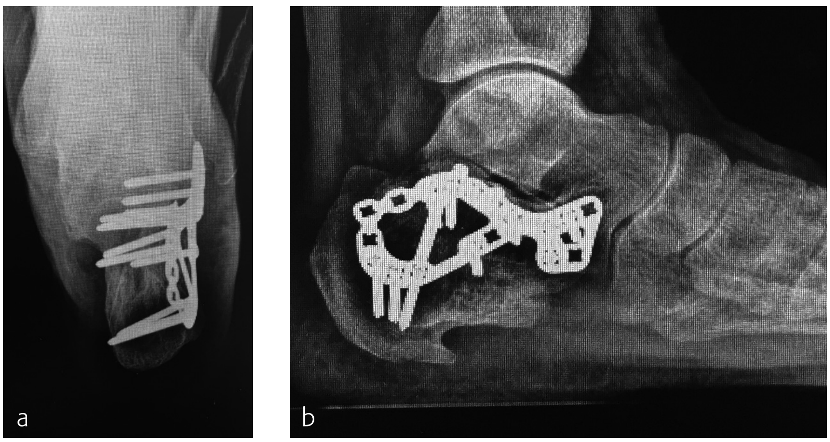

Fig 6a–b
Postoperative images showing the VA Locking Calcaneal Plate.

Case provided by Andrew Sands, New York, USA

Fig 7a–b
Patient images.

Case 2: 70-year-old patient

A 70-year-old female patient (Fig 7) had a long history of increasing painful deformity of her foot. She also noted increasing gait problems. There was no history of initial trauma. The examination showed severe rigid flatfoot deformity.

An extended triple arthrodesis was performed. Medially, the new Medial Column Plate was used, securing the talonavicular, naviculocuneiform, and tarsometatarsal joints (Fig 8). The X-plate is lateral and secured the calcaneo-cuboid joint. Two 7.3 mm screws were used to secure the subtalar joint.

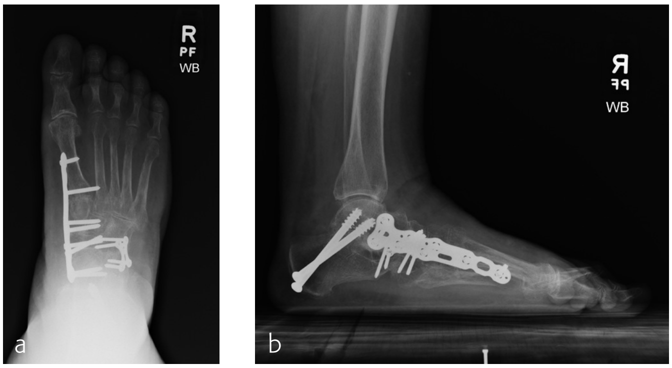

Fig 8a–b
Postoperative images.

Image provided by Juan Gerstner, Cali, Colombia

Case 3: Compression/Distraction Device

The picture shows the use of the Compression/Distraction Device in the midfoot (Figs 9 and 10).

Fig 9
Compression/Distraction Device.

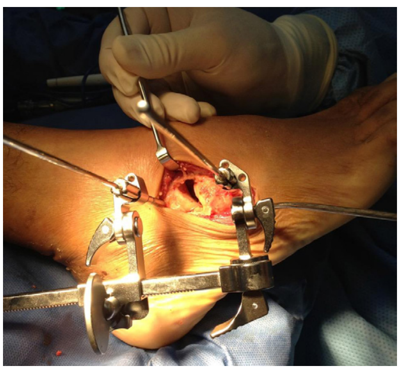

Fig 10
Compression/Distraction Device being used.

Carl-Peter Cornelius, John Hardeman

CRANIOMAXILLOFACIAL

Fig 1a–b
MatrixWAVE plates are available in two heights, short (a) and tall (b). The image shows the plate correctly oriented for application to the maxilla. Plates are inverted for fixation to the mandible.

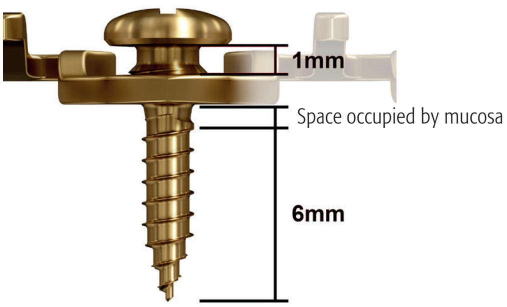

Fig 2
The MatrixWAVE plate should be attached with 1.85 mm self-drilling locking screws with an accessible screw head. The screws are available in 6.0 mm or 8.0 mm thread length. By virtue of the locking mechanism, the screws do not touch the mucosal tissues, thereby avoiding complications caused by compression and ischemia.

Fig 3
Horizontal expansion of the MatrixWAVE plate prior to application.

MatrixWAVE MMF

Maxillomandibular fixation (MMF) is a vital step in the management of maxillofacial trauma. In order to fixate fractures correctly and achieve adequate fracture reduction, the maxillary and mandibular dentition must be put into occlusion. Various methods can be used to achieve MMF including arch bars secured with interdental wires and intermaxillary fixation (IMF) screws, but these methods have several disadvantages.

Limitations of arch bars

The limitations of arch bars include prolonged operating room time and expense to apply and remove the device; difficulty in fragment alignment once the arch bar has been put in place; the risk of "needle stick" type injuries; difficulty in maintaining oral and gingival hygiene; and the risk that tightened wires may cause ischaemic necrosis of the mucosa and periodontal membrane, causing tooth loss.

Limitations of IMF screws

The limitations of IMF screws include posterior mandible fractures being more prone to poor reduction and subsequent malocclusion; and the risk of unnoticed lingual tilting of fragments due to the distance between anchoring points.

Design features and benefits

MatrixWAVE MMF (Figs 1–7) is a novel bone-borne MMF system that combines the strength and rigidity of arch bars with the speed and simplicity of IMF screws, and consists of a wave shaped plate that is attached to the mandible and maxilla with self-drilling locking screws (Fig 2). The plate is adaptable and can be expanded horizontally (Fig 3) to enable screw hole placement in the optimal location to avoid tooth roots and nerves. The locking mechanism avoids compression and ischemia by keeping the plate away from the mucosal tissues. The dental arches are brought into occlusion by wiring around the plate hooks and/or accessible screw heads. The self-drilling locking screws sit proud to the plate. This minimizes soft-tissue growth over the screw, and provides additional anchor points for optional bridle wires. Upon insertion, screws can be angled at up to 15°.

Following application and wiring, the wave plate pattern allows the alignment of bone segments to be adjusted by crimping without repositioning the screws. The plate is available in two heights to allow the positioning of the hooks at the level of the tooth equators according to individual patient anatomy, and to accommodate the use of rigid internal fixation (Fig 1).

Fig 4
MatrixWAVE plate adjustment to align location of remaining screws.

Maxillomandibular fixation can be achieved rapidly using the MatrixWAVE plate. Removal is simple, and can be done in a non-OR setting. The MatrixWAVE plate design eliminates the need for circumdental wiring. This has several advantages, including reduced risk of needle stick-like injuries and reduced risk of tooth loosening. Additionally, the MatrixWAVE MMF system covers less tooth surface, allowing better access to the teeth and periodontal tissues for cleaning. The design of the plate maximizes patient comfort, as it has rounded smooth edges. The screw heads are also rounded, and the plate hooks can be bent towards the gingiva after wiring.

Indications

The MatrixWAVE MMF system is indicated for the temporary stabilization of mandibular and maxillary fractures and osteotomies in adults and adolescents (age 12 years and higher) with full permanent dentition. The system is intended to maintain proper occlusion during intraoperative bone fixation and postoperative bone healing (approximately 6–8 weeks). The system affords the ability to align bone fragments. However, MatrixWAVE MMF plates do not have a tension band function, unless additional bridle wire loops are used on the screw heads across the fracture line.

Fig 5
Insertion of remaining screws through the plate into the inter-root spaces, with engagement of the locking threads.

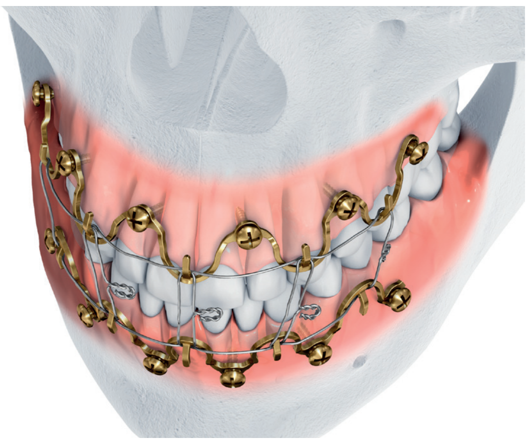

Fig 6
Application of wire, using plate hooks as anchor points. Screw heads can serve as additional anchor points.

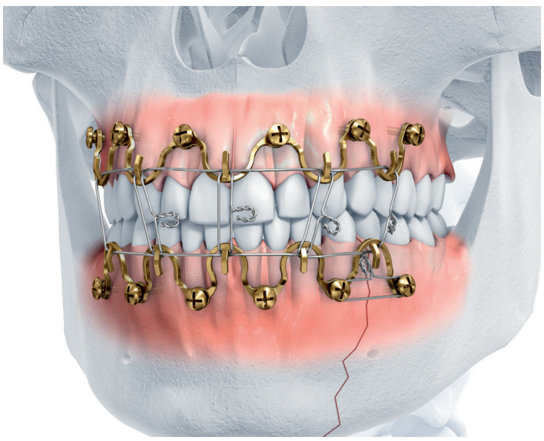

Fig 7
Completed wiring. MMF wire ligatures secure the dental occlusion with bridle wire, providing tension banding across the fracture line.

Case provided by John Hardeman, Florida, USA

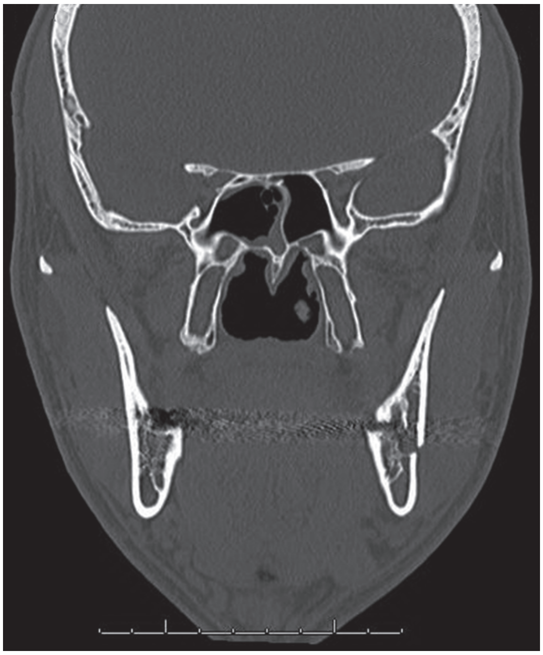

Fig 8
Preoperative coronal CT slice, showing left mandibular angle fracture.

Case: Left mandibular angle fracture caused by assault

A 28-year-old white male patient was assaulted, suffering a left mandibular angle fracture (Fig 8). The fracture was prestabilized with the MatrixWAVE system and then fixated with a 4-hole miniplate 2.0 on the superior border and a 4-hole angulated universal fracture plate 2.4 along the inferior border. A preexisting anterior open bite was noted and confirmed with the patient prior to presentation to the operating arena.

The MatrixWAVE plate was attached to the maxilla with screw placement in the inter-root spaces (Fig 9). A second MatrixWAVE plate was attached in corresponding position to the mandible, with screw placement in the inter-root spaces (Fig 10). Wires were placed around the plate hooks to bring the dental arches into occlusion. Note the preexisting anterior open bite (Fig 11). Careful adjustment of the MatrixWAVE plate and wiring in the region of the mandibular fracture allowed the bone fragments to be precisely aligned without the requirement for screw repositioning (Fig 12). The postoperative panoramic x-ray (Fig 13) shows the two MatrixWAVE plates in situ, with other plates used to fixate the left mandibular angle fracture. Note that a portion of the MatrixWAVE plate was removed from the left molar region in the mandible (Fig 13).

Fig 9
The MatrixWAVE plate was attached to the maxilla, with screw placement in the inter-root spaces.

Fig 10
A second plate was attached in corresponding position to the mandible.

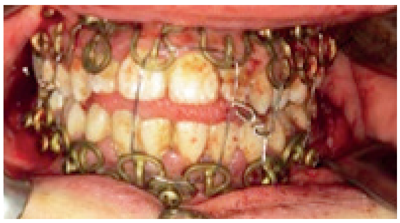

Fig 11
Placement of wires around the plate hooks.

Fig 12
Adjustment of the plate and wiring in the region of the fracture.

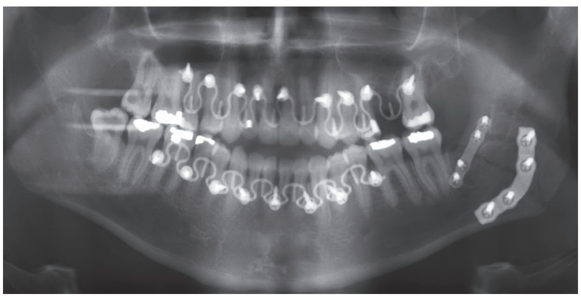

Fig 13
Postoperative panoramic x-ray showing the completed fixation.

Geoffrey Manley

NEURO

MatrixNEURO Preformed Mesh

MatrixNEURO Preformed Mesh is an anatomically contoured rigid mesh implant for the reconstruction of medium to large cranial defects. It is intended for use in the fixation of cranial bones in procedures such as reconstruction, fracture repair, craniotomies, and osteotomies.

Design Features and Benefits

Unlike contourable reconstruction meshes, which must be bent to shape in the OR, MatrixNEURO Preformed Mesh is available in a range of anatomical shapes to fit temporal (Fig 1), fronto-temporo-parietal (Fig 2), and frontal areas (Fig 3). The preformed nature of the mesh reduces bending and overall procedure time (compared to MatrixNEURO Reconstruction Mesh) in the operating room.

The specific contouring of the mesh is based on data from a clinical CT study of 80 patients [1], which established a statistical mean of anatomical cranial features. The development of the full range of MatrixNEURO Preformed Mesh implants was informed by data that identified the most common locations and sizes of cranial defects. The implants are manufactured using a proprietary process designed to create smooth contours without bending or kinking. The mesh is designed for use with MatrixNEURO self-drilling screws.

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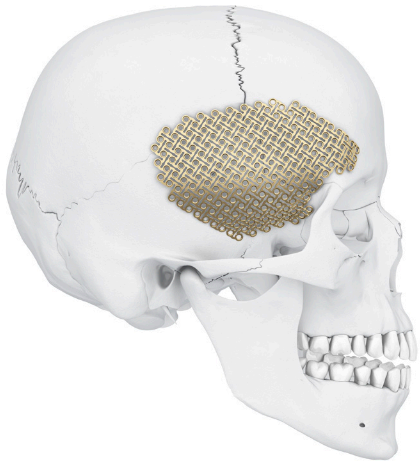

Fig 1
Temporal preformed mesh.

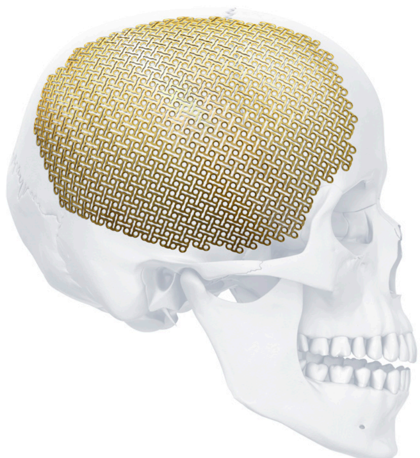

Fig 2
Fronto-temporo-parietal (FTP) preformed mesh.

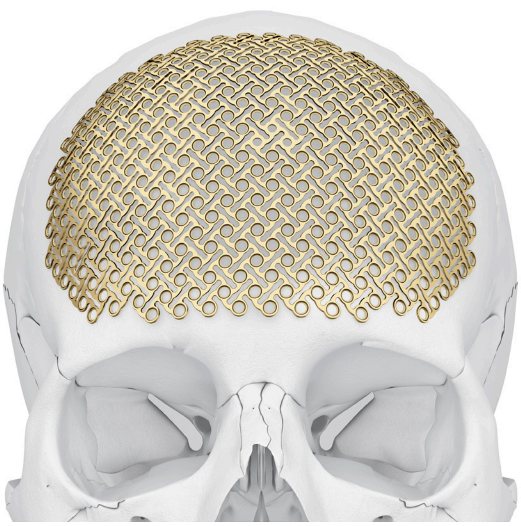

Fig 3
Frontal preformed mesh.

Christian Matula

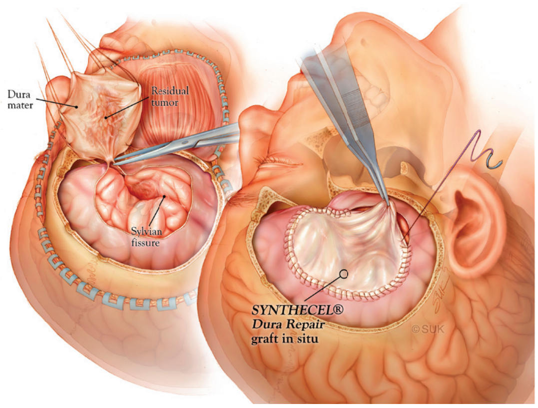

Fig 1
SYNTHECEL Dura Repair can be used as a dural substitute following neoplastic damage.

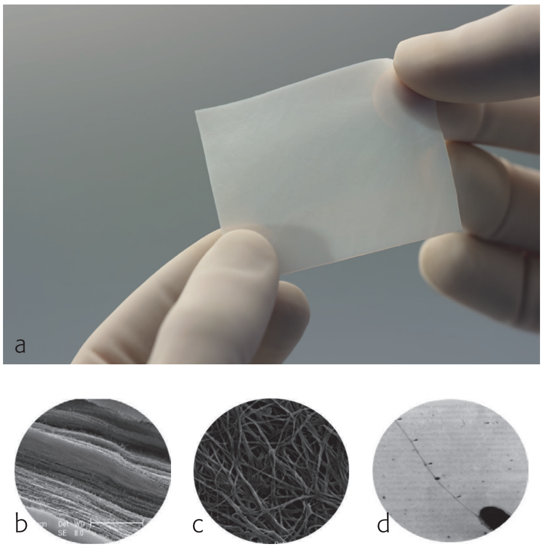

Fig 2a–d
Material composition.
a Composed of biosynthesized cellulose and water, SYNTHECEL Dura Repair is similar in thickness to human dura.
b Layers of biosynthesized cellulose (high magnification).
c Interconnected cellulose fibers that comprise SYNTHECEL.
d Cellulose fibers are naturally produced by Glucoacetobacter xylinus.

SYNTHECEL Dura Repair

SYNTHECEL Dura Repair (Figs 1–2) 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.

Unmet clinical needs in dural repair

Materials currently used for dura replacement include human tissues (eg, pericranium or fascia lata), animal tissues, polymers, and biosynthetic substances. However, use of these materials can be problematic. Autologous tissue grafts can perform well as they do not provoke inflammatory or immunological reactions, but can present difficulties in achieving watertight closure and in the formation of scar tissue. Autologous tissues may provide insufficient graft material to close large dural defects and cause morbidity at the harvest site. Synthetics have been associated with deep wound infections, as polymers can become chronically colonized. Xenografts can cause adverse effects such as graft dissolution, encapsulation, foreign body reaction, scarring, or the formation of adhesions. Following decompressive craniectomy, adhesions can develop between dura mater, cortex, temporalis muscle, and galea. Such adhesions can act as epileptic foci and can increase the surgical risk of subsequent cranioplasty. Additionally, xenografts have been associated with the transmission of viral infections and hydrodynamic complications including persistent cerebrospinal fluid (CSF) leakage, pseudomeningocele, aseptic meningitis, and delayed hydrocephalus.

To function effectively, dural substitutes should:

- Prevent CSF leakage
- Minimize risk of infection
- Have mechanical properties similar to human dura and good intraoperative handling properties
- Have no harmful foreign body reaction
- Be readily available
- Be storable
- Be biocompatible.

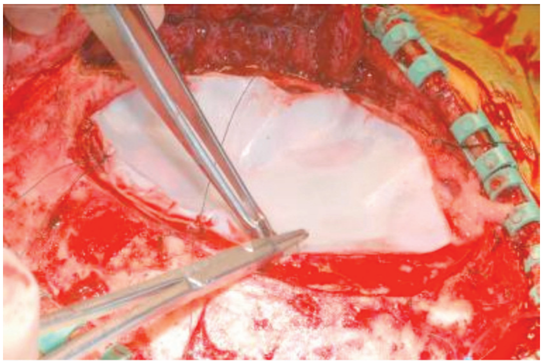

Fig 3
Investigational device exemption (IDE) intraoperative image showing a dural repair using SYNTHECEL Dura Repair (courtesy of Barrow Neurosurgical Associates).

Development of SYNTHECEL Dura Repair

SYNTHECEL was developed as a superior dural substitute, with the aim to eliminate or reduce many of the adverse events mentioned above. SYNTHECEL Dura Repair is an implant based on biosynthesized cellulose technology. Cellulose pellicles of specified weight and cellulose content are produced by the bacterium Glucoacetobacter xylinus when propagated in nutritive culture media.

Comprised of nonwoven, interconnected cellulose fibers, SYNTHECEL has excellent tensile strength and functions as a mechanical layer to protect and repair dural defects while preventing CSF leakage (Fig 3). SYNTHECEL is immunologically inert, allows healing without adhesion formation, and avoids the complications inherent in the use of autologous tissue in duraplasty. SYNTHECEL is nonanimal derived, meaning there is no risk of transmissible diseases.

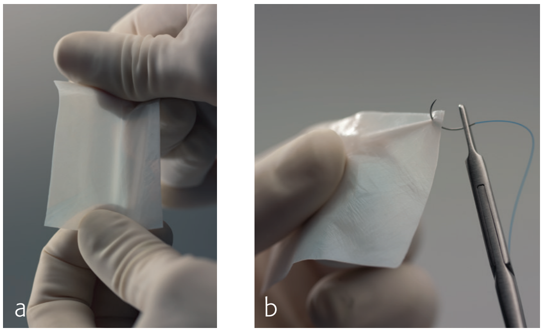

Fig 4a–b
Demonstrating the product's strength (a) and sutureability (b).

Clinical performance of SYNTHECEL Dura Repair

Clinical studies have shown that SYNTHECEL Dura Repair is not inferior to other commercially available dural replacement products in terms of surgical site infection, wound healing assessment, or radiologic endpoints (absence of pseudomeningocele and CSF fistula) [1]. Furthermore, SYNTHECEL was shown to be superior in terms of product strength, sutureability and seal quality (Fig 4). Indeed, a prospective randomized controlled study found SYNTHECEL to exhibit superior strength and sutureability (Figs 5–6) [1]. In terms of surgical handling, SYNTHECEL is similar in thickness to human dura and conforms easily to the brain.

References

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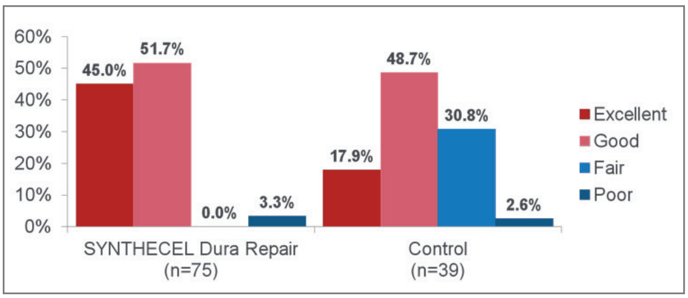

Fig 5
SYNTHECEL Dura Repair exhibited superior device strength compared to a control group, in an assessment of device handling characteristics [1].

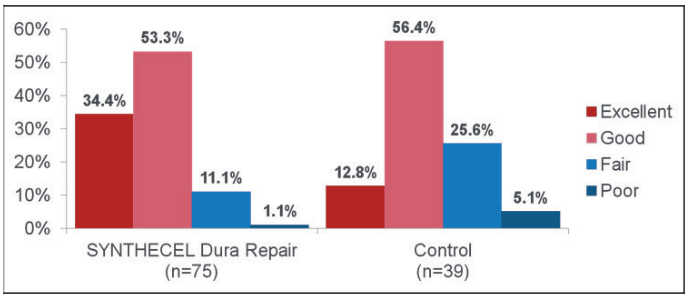

Fig 6
The product also exhibited superior seal quality compared to the control group [1].

Stephen Lewis

POWER TOOLS

Fig 1
The EG1 Electric High Speed Drill system, including electric console and foot control.

EG1 Electric High Speed Drill System

The Anspach EG1 Electric High Speed Drill is a high precision electric system designed for cutting and shaping bone in the spine and cranium (Fig 1). It has a broad range of applications within neurosurgery, neurotology surgery, skull base surgery, otolaryngology surgery, and spinal surgery.

The drill has a variable operating speed of 10,000 to 80,000rpm and offers a power output 30% higher than existing Anspach high speed drills (eg, XMax and eMax2Plus systems), while operating at minimal sound levels. It has a small, lightweight handpiece to minimize hand fatigue (Fig 2), minimal start-up kick, low vibration for increased cutting precision, and an integrated air cooling system.

The drill is versatile with a wide range of dissection tools (Fig 3), including craniotomes, burrs, and straight or angled attachments. The coupling mechanism is simplified (place and lock attachments and push to lock dissection tools) for greater ease of use and effortless assembly. Other features include a new irrigation tube, a hose swivel elbow, and increased reliability.

Fig 2
The aircooled handpiece, showing the coupling system for attachments and dissection tools.

Fig 3
The portfolio of Anspach attachments for the EG1 Electric High Speed Drill, including straight attachments of various lengths, heavy duty attachments of various lengths, craniotomies, angle attachments, and perforator driver.

Frank Kandziora, Maarten Spruit

SPINE

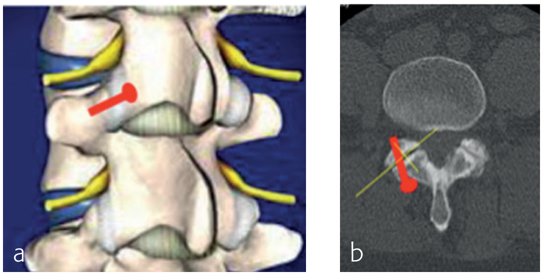

Fig 1a–b
Screws across the facet joint.

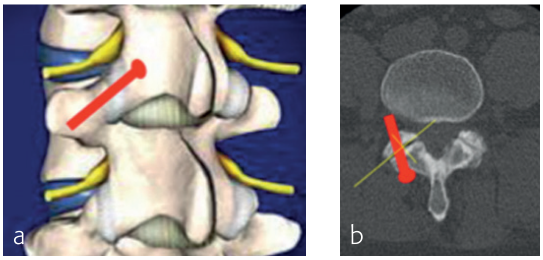

Fig 2a–b
Transfacet pedicle screw.

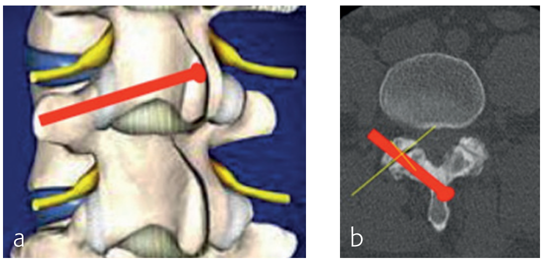

Fig 3a–b
Translaminar screw fixation.

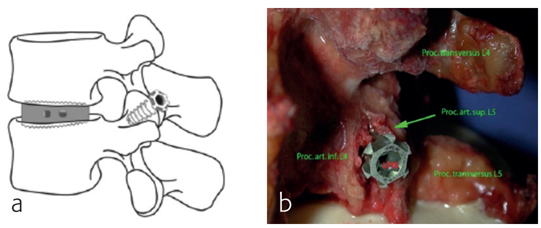

Fig 4a–b
Facet interference screw.

Facet Wedge Spine System

The treatment of chronic low back pain or any neurological deficit due to degenerative conditions of the spine is well established. However, there remains no clear consensus on when a 360° fusion is required or when postero lateral fusion (PLF) will suffice. In patients with a high degree of degeneration and instability, a combined anterior and posterior column fusion is often appropriate. When the degeneration is less and there is minimal instability, PLF may be more suitable.

With many of these surgical treatments, the posterior fixation may be performed with translaminar facet screws (TFS) [1]. Posterior fixation of the lumbar motion segments with TFS is a less invasive option than the more commonly used pedicle screws and rods. It is also accurate to suggest that this technique helps to promote minimal soft tissue damage.

History of Translaminar Facet Screws (TFS)

Use of TFS was first described by King [2] in 1948. His technique involved the insertion of short screws across the facet joint (Fig 1). This approach was further modified by Boucher [3] in 1959 through the use of a longer screw, the transfacet pedicle screw, directed towards the pedicle (Fig 2).

The approach most commonly used today, however, is Magerl's technique, which involves the use of an even longer screw [4]. This screw enters through the base of the spinous process, traverses the length of the lamina, crosses the facet joint, and fixates in the base of the transverse process. This procedure, translaminar screw fixation, is discussed extensively in the literature [5–14] (Fig 3).

A second option for the achievement of primary stability is by locking the facet joints with a facet interference screw (FIS) (Fig 4). Biomechanical investigations have illustrated a similarity between FIS fixation and TFS fixation in terms of primary stability.

Biomechanical studies [1, 15–17] have provided evidence supporting the use of TFS as a fixation technique for spinal motion segments. Fusion rates associated with TFS range from 83% to 100% [5, 7, 11, 18-20]. The number of re-operations for various reasons ranges from 2-37% [5–7, 13, 21]. TFS fixation is also associated with smaller incisions, ease of procedure and learning curve, less instrumentation, and lower costs [7, 9, 12, 19, 22, 23]. Postero lateral fusion with TFS fixation should, similarly to pedicle screw fixation, only be performed with an intact anterior column. The disc therefore needs to be intact.

Facet Wedge—design concept, benefits, and advantages

The Facet Wedge (FW) spinal system was developed to enhance the advantages already offered by the TFS. The intended use, indications, and contraindications for FW fixation are very similar to TFS fixation. Facet Wedge is intended for the fixation of the spine as an aid to fusion through the immobilization of the facet joints, with or without bone graft, at single or multiple levels, from L1 to S1. It can be inserted through a minimally invasive approach either to augment other fusion techniques or as a stand-alone device for cases without segmental instability.

The FW system is designed as a press fit block with friction rails to stop translational motion in the facet joints. In addition to the wedge, two screws are inserted divergently at 30° angles in order to increase pull out resistance.

The advantage of the FW design over the TFS is the direct visualization of the facet joint, which facilitates accurate implant insertion and may reduce the risk of damage to neural structures. The specific instruments used in conjunction with the FW allow facet joint preparation (eg, cartilage removal) to improve the likelihood of successful fusion.

Preclinical biomechanical tests demonstrate that the biomechanical properties (stiffness and ROM) of FW are comparable to pedicle screw and rod fixation, as well as TFS fixation in all motion directions.

Indications

- Stand-alone (bilateral) in situ facet fusion with or without decompression
- Facet arthritis: fixation and fusion of facet joint
- Supplementary fixation after anterior cage or nonunion of ALIF
- Supplementary contra lateral fixation after MISS TLIF.

Contraindications

- Unilateral application, except in combination with pedicle screw fixation on the contralateral side
- Compromised facets due to decompression techniques
- Spondylolisthesis
- Fracture or other instabilities of the posterior elements
- Tumor
- Acute or chronic systemic or localized spinal infections.

Tips for safety and effectiveness

The FW Spine System Risk Assessment identified that incorrect placement of the K-wire for rasp or FW positioning could result in damage to soft tissue, neural structures, or large blood vessels. A second risk involves the use of the facet opener. Excessive force or inappropriate

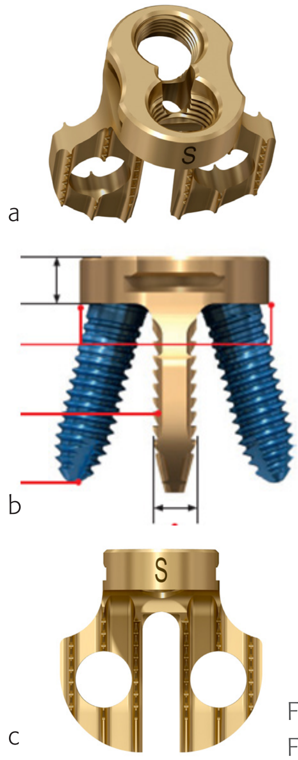

Fig 5a–c
Facet Wedge implants.

manipulation may also lead to the damage of neural structures. Several control measures are incorporated into the Facet Wedge system to minimize these risks and plans are also in place to conduct a study that will measure their occurrence.

Description

The Facet Wedge spine system includes the following implants and features (Fig 5):

- Kirschner wire hole enables guided insertion over K-wire (a)
- Rails stop translational motion and generate contact between subchondral bone and implant (a)
- Low profile decreases muscle irritation (b)
- Implant shoulder that controls insertion depth (b)
- Teeth keep the implant in the desired position prior to screw insertion (b)
- Divergent angular stable locking screws for primary fixation (b)
- Various implant sizes to accommodate patient anatomy (b)
- Perforations create optimal fusion conditions (c).

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Case provided by Frank Kandziora, Frankfurt, Germany

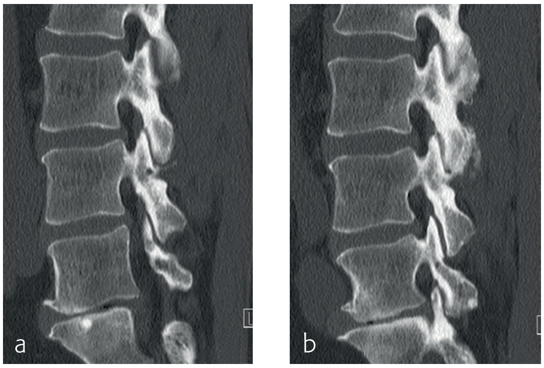


Fig 6a–b
Preoperative CT scans.

Case 1: 45-year-old

A 45-year-old healthy male patient had experienced load dependent lower back pain (LBP) for 6 years, with no radicular pain and no neurologic deficit. Multilevel facet pathology is shown in Fig 6. Intraoperative and postoperative images are shown (Figs 7–9).

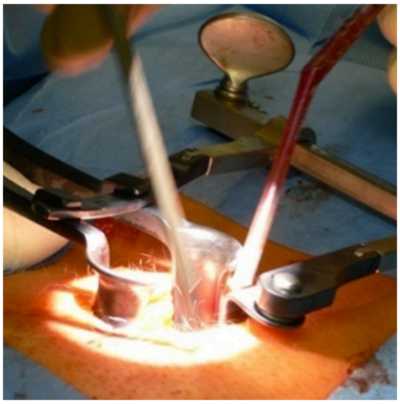


Fig 7
Intraoperative image.

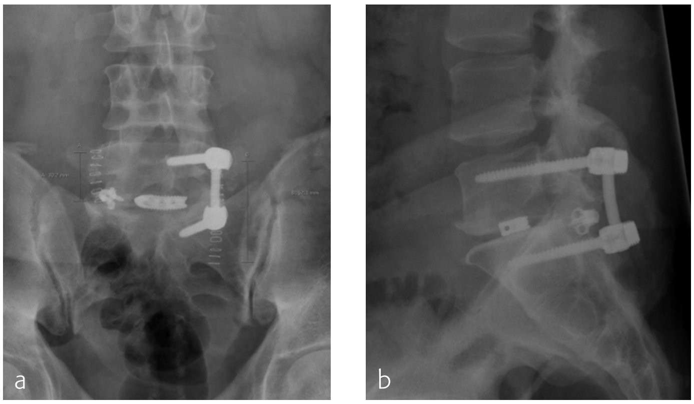


Fig 8
Postoperative X-rays at the 1-week follow-up.

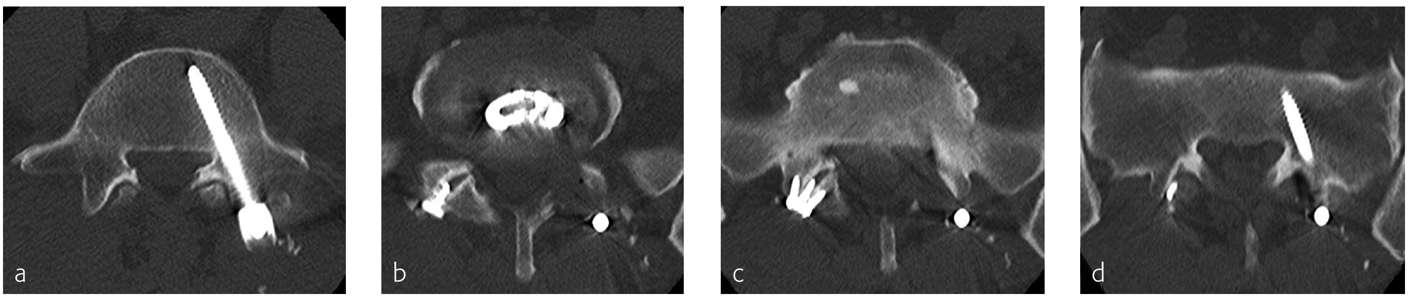


Fig 9a–d
The postoperative CT scans at the 1-week follow-up.

Case provided by Frank Kandziora, Frankfurt, Germany

Case 2: 51-year-old

A 51-year-old female patient had been experiencing LBP for 3 years (Fig 10).
PNS right. Now L5 radiculopathy left.

Fig 10a–d
Preoperative CT scans.

Fig 11
Intraoperative image.

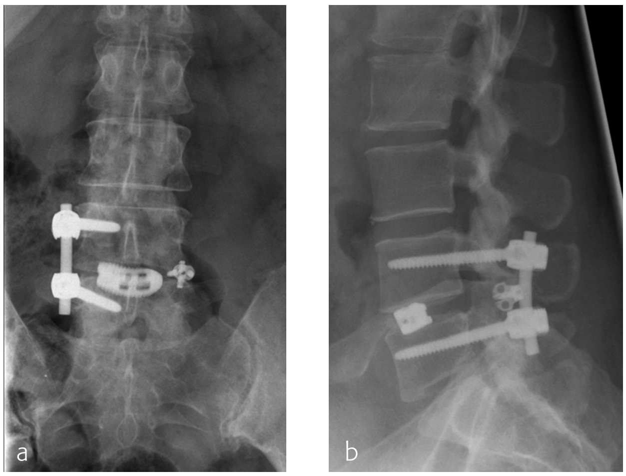


Fig 12a–b
Postoperative x-rays at the 1-week follow-up.

Case provided by Frank Kandziora, Frankfurt, Germany

Case 3: 66-year-old

A healthy 66-year-old female patient had been experiencing LBP for 5 years (Fig 13).

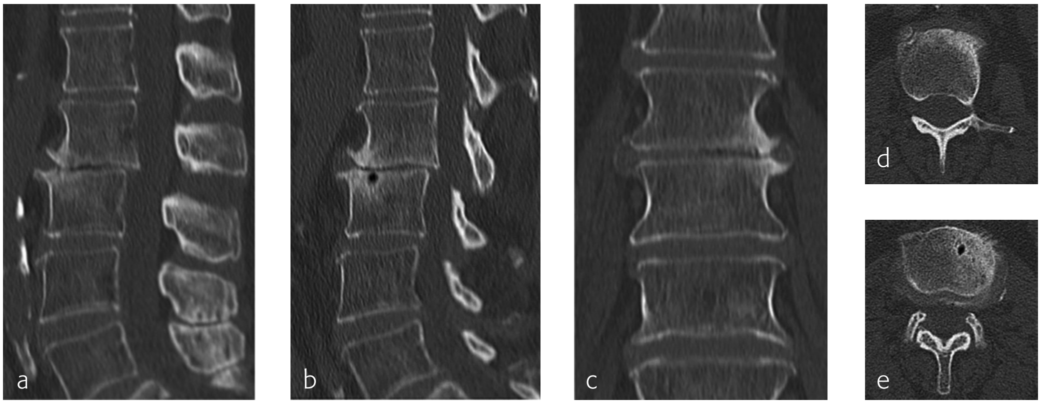


Fig 13a–e
Preoperative CT scans.

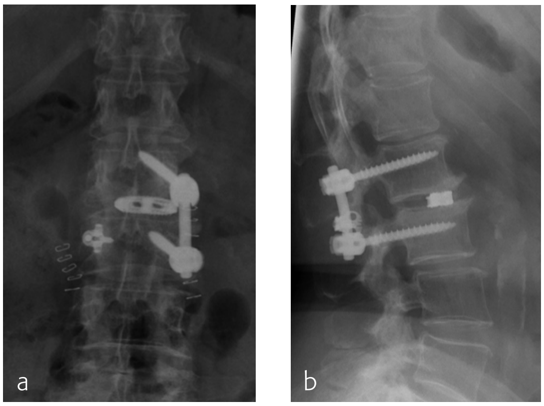


Fig 14a–b
Postoperative x-rays.

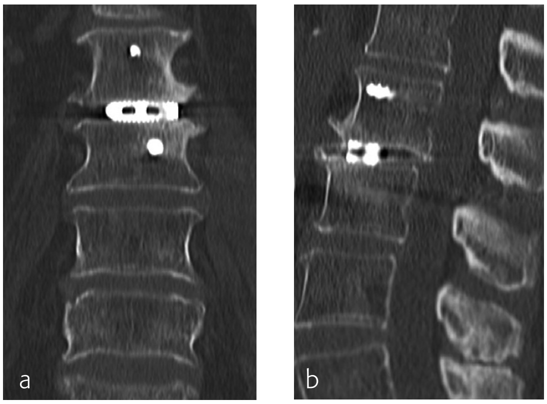


Fig 15a–b
Postoperative CT scans.

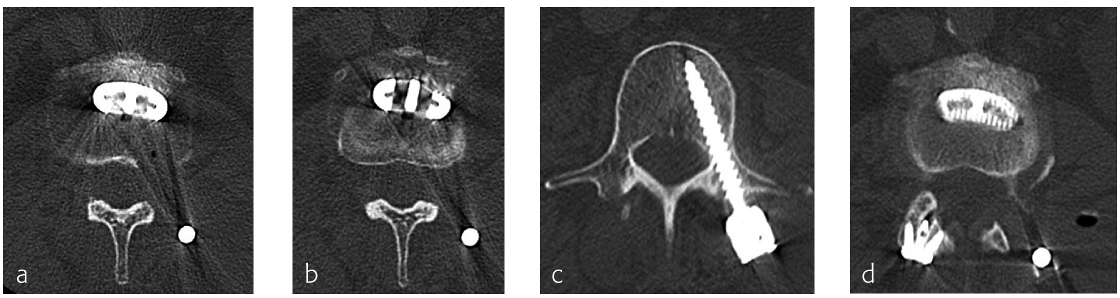


Fig 16a–d
Postoperative images.

Cases provided by Maarten Spruit, Nijmegen, Netherlands

Case 4: ALIF L4–5 nonunion

A 40-year-old man had ALIF L4–5 with SynFix 5 years previously. He had axial low back pain. The CT scan showed 'locked pseudartrosis' (Fig 17). Nonoperative treatment failed. The treatment option was bilateral Facet Wedge at L4–5.

Facet wedge surgery

A less invasive approach was used with Insight Retractor, and using the bilateral Facet Wedge. No bone graft. X-ray follow-up after 3 months and CT assessment after 6 months (Figs 18–19).

Fig 17
Preoperative CT scan.

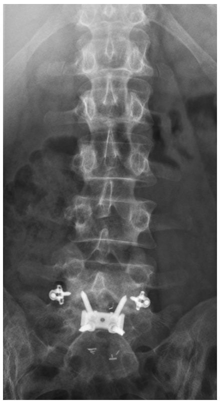


Fig 18
X-rays at the 3-month follow-up.

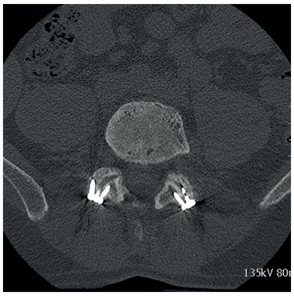


Fig 19
The CT scan at the 6-month follow-up.

Case 5: Degenerative scoliosis

A female patient 66-years-old had back pain, leg pain, and degenerative deformity. The x-rays showed left convex degenerative scoliosis Cobb T12–L3 38°. Nonoperative treatment failed. Treatment option was posterior fusion T11–L5, with URS, Facet Wedge L2–3 unilaterally.

URS/Facet Wedge surgery

A conventional approach for posterior correction was taken, with indirect foraminal decompression and Facet Wedge fusion (apex curve). Facet Wedge introduction after curve correction with rod in situ. X-ray follow-up initially (Fig 20), with CT assessment of Facet Wedge fusion after 6 months (Fig 21).

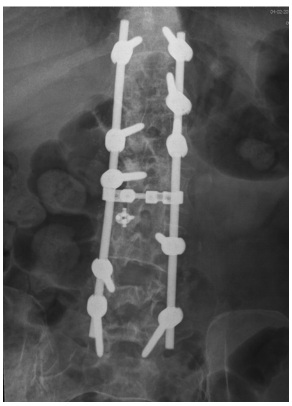


Fig 20
Postoperative x-ray.

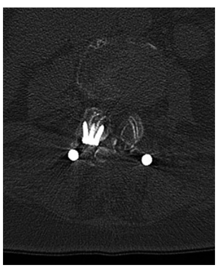


Fig 21
CT scan at the 6-month follow-up.

Innocent Njoku Jr, Roger Härtl

Minimally Invasive 2D–Navigation-Assisted Spine Surgery in East Africa

Spinal surgery under Eastern African circumstances is technically demanding and associated with significant complications such as blood loss, infection, and wound breakdown. We report a spinal trauma case that was performed using minimally invasive surgery (MIS) and navigation, and hypothesize that these newer techniques may enable surgeons to perform effective spinal surgery with minimal complications and good outcomes.

In previous reports, we have shown that neurotrauma is one of the most apparent neurosurgical problems in Africa, and especially so in Tanzania. The delivery of surgical care in these environments is a major global health concern. Macrosurgical approaches in this context are associated with adverse effects such as muscle damage, bleeding, neuromuscular denervation, and increased pain. Minimally invasive surgery with navigation can provide a beneficial alternative to open surgery particularly with respect to decreasing infection rates and prolonged bed immobility. In addition, MIS with navigation increases the accuracy of pedicle screw placement in the thoracic and lumbar spine, and can enable surgeons to perform complex operations with fewer complications by decreasing postoperative pain, reducing infection rates, and overall morbidity.

During the 2014 hands-on neurotrauma course held in Dar Es Salaam, we operated on a 47-year-old patient with a complex thoracic spine injury (Fig 1) using a portable navigation system in conjunction with fluoroscopic imaging. The surgery was done under general anesthesia with minimal blood loss and no intraoperative complications (Fig 2). The patient remained neurologically intact postoperatively when compared to baseline, and was discharged two weeks following surgery. Imaging performed one year after surgery demonstrates adequate fusion with a stable neurological exam (Fig 3).

Despite the challenges and limitations involved in introducing complex minimally invasive spinal surgery to under-resourced countries, such technologies offer important benefits to global neurosurgical health. By performing the first MIS instrumentation and decompression procedures with 2D navigation together with our Tanzanian partners, we have shown promising opportunities in spinal surgeries in emerging nations.

Case provided by Roger Härtl, New York, USA

Fig 1
Patient image.

Case: 47-year-old from Tanzania

The following images are of a 47-year-old patient with a complex thoracic spine injury.

Fig 2
Intraoperative image.

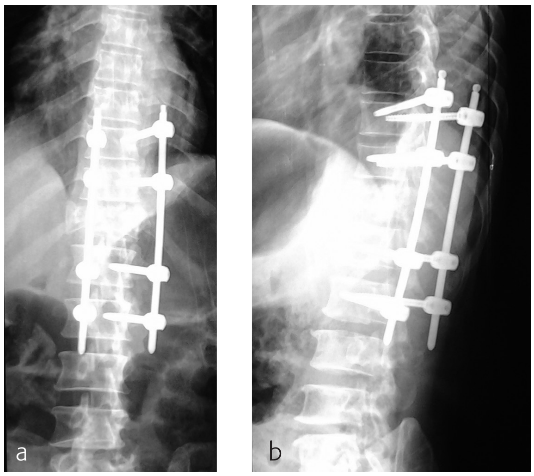
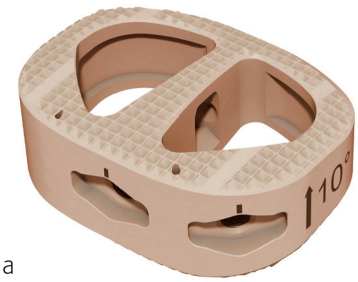
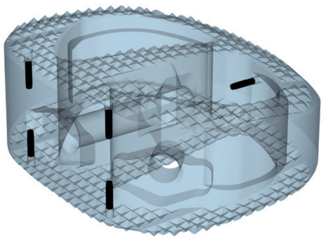


Fig 3a–b
Postoperative images at the 1-year follow-up.

Paul Heini, Khai Lam



a



b

Fig 1a–b
The Syncage Evolution interbody cage.

Syncage Evolution

Syncage Evolution represents a new direct anterior or anterolateral interbody cage for the lumbar spine (Fig 1). The anatomical design and wide range of sizes (available in various foot prints, heights, and angulations) facilitate the correction of any anterior interbody problem. Specific and sophisticated instrumentation enables safe and controlled application of the implant.

Primary indications for use include:

- Degenerative disc disease
- Revision procedures for postdiscectomy syndrome
- Pseudoarthrosis or failed fusion
- Degenerative spondylolisthesis
- Isthmic spondylolisthesis
- Anterior column support for osteotomies.

The Syncage Evolution spacer must be applied in combination with supplementary fixation, such as an anterior plate system or pedicle screws.

Contraindications include:

- Vertebral body fractures
- Spinal tumours
- Osteoporosis
- Infection.

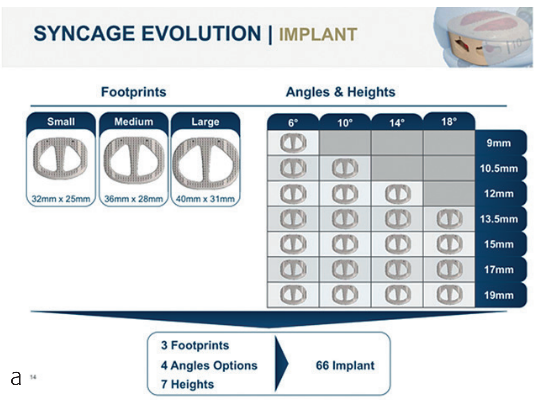
Design features

The design of the implant offers increased stability. Its pyramidal teeth provide primary resistance to implant migration, and the large graft volume allows for undercuts and openings in struts to increase graft volume. The middle strut design allows for an improvement to ratio of graft volume to endplate contact, and the diamond shaped anterior and anterolateral interface provides for optimal force distribution from the implant holder to the implant.

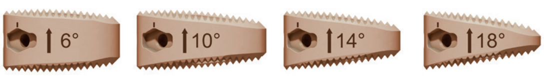
Other features include a self-distracting nose, which allows for ease of insertion. The tantalum radiographic marker pins enable visualization of the implant position during insertion. Material: available in PEEK with 0.8 mm tantalum marker pins.

The comprehensive and competitive Syncage Evolution portfolio (Fig 2) boasts an asymmetric anatomical shape for more patient specific implants:

- Footprints: small (32.0 x 25.0 mm), medium (36.0 x 28.0 mm), large (40.0 x 31.0 mm)
- Heights: from 9.0 mm to 19.0 mm (9.0 mm, 10.5 mm, 12.0 mm, 13.5 mm, 15.0 mm, 17.0 mm, 19.0 mm)



a



b c d e

Fig 2a–e
The Syncage Evolution has a comprehensive portfolio of sizes and angles.

- Angles: 6° to 18° (6°, 10°, 14°, 18°)
- Asymmetric cranial and caudal surfaces with a 3-D convex shape for optimized endplate contact.

The improved instrumentation enhances ease of use compared with other systems in specific surgical phases.

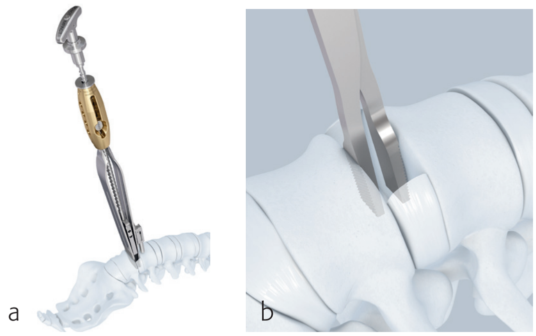


Fig 3a–b
Posterior release tool.

Posterior release tool

The posterior release tool (Fig 3a) is used as an alternative to standard spreaders (Fig 3b). Features include:

- Allows for progressive and controlled distraction and posterior release
- Broad tips avoid subsidence of the instrument
- Posterior release height is reproducible
- Changeable inserts for mobilization prevent over-distraction.

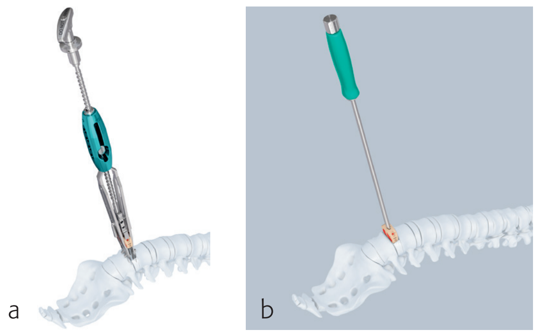


Fig 4a–b
The evolution squid.

Evolution Squid

The evolution squid (Fig 4a) is used as an alternative to implant holders (Fig 4b):

- Distracts and inserts the implant in one simple step without impaction
- Offers multiple positioning options to recess implant in disc space
- Rails provided for safe implant guidance during insertion
- Thin blades prevent over-distraction during implant insertion.

Fig 5
Evolution trial rasp.

Evolution trial rasps

Evolution trial rasps (Fig 5) have been specifically designed to help smooth the end-plates and create bleeding to aid with the inter-body fusion. Each trial rasp correlates with the final desired implant for insertion.

Case provided by Paul Heini, Bern, Switzerland

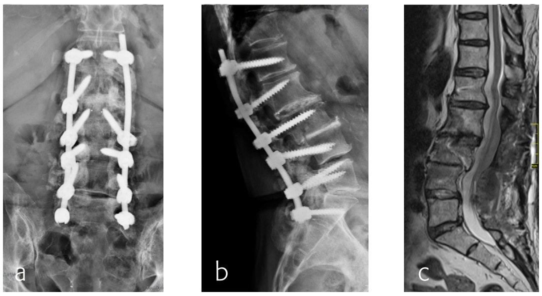


Fig 6a–c
Preoperative standing images.

Case 1: 75-year-old patient

A 75-year-old female patient presented with postoperative back pain. She had been initially operated on eight years earlier with a laminectomy and fusion from L2 to L4. This proved to be successful for a number of years until a second operation was required for secondary back pain and left side leg pain. An extension of the decompression was performed with stabilization and fusion from L1 to S1. The rationale for this operation was unknown and the surgery failed to improve her symptoms.

The problem to be addressed was the patient's back pain and left side leg pain, inclusive of some weakness in her left foot. The pain was present upon weight-bearing, with a pain scale of 9. Her discomfort remained at night. The patient was of slim build and was in good general health. She presented with a limp from her left hip and the dorsiflexion of the left foot was weak (M4).

The preoperative standing image of the lumbar spine revealed a flat back with no obvious degeneration of the adjacent segment L1/L2 (Fig 6a–b). The implants seemed regularly placed. After wide laminectomy, the spinal canal was open over the whole lumbar spine, illustrated on the MRI scan (Fig 6c).

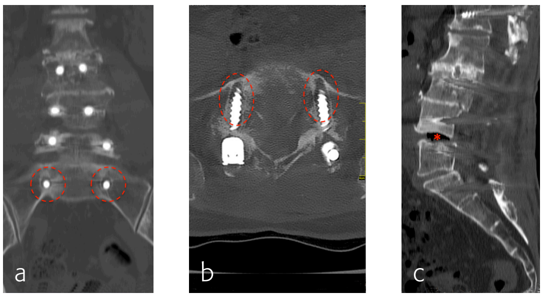


Fig 7a–c
CT scans.

A CT scan allowed a more detailed assessment (Fig 7). There was an obvious nonunion at L5/S1, with loose screws in the sacrum (red circle). Furthermore, there was instability at L4/L5 as the intervertebral disc presented with an important vacuum phenomenon (asterisk). Foraminal stenosis at L5/S1 (not shown) seemed to be the reason behind the persistent leg pain.

The treatment plan was an anterior height restoration and fusion of L5/S1 and L4/L5. A posterior revision surgery was not considered due to the wide decompression and obvious scar formation. For the correction of level L4/L5, an oblique anterolateral approach (OLIF) was selected due to considerable calcification of the aorta and the iliac vessels. At the L5/S1 level, a straight anterior approach was selected and an additional plate fixation (ATB) was performed. At level L5/S1, a large cage with an angulation of 14° was selected and for L4/L5, a large cage with an angulation of 10° was placed. In order to perform a fusion, the cages were each filled with 6 mg of BMPII.

From six months postoperatively, leg discomfort decreased. Within an additional four months, pain disappeared completely and both foot and hip weakness recovered. The back pain persists to a certain extent but is not impeding the patient in her daily activities. The x-ray taken 10 months after the anterior revision surgery revealed a complete and solid fusion on both levels (Fig 8, asterisk). This is confirmed by the appearance of dense bone in the radiolucent cage.

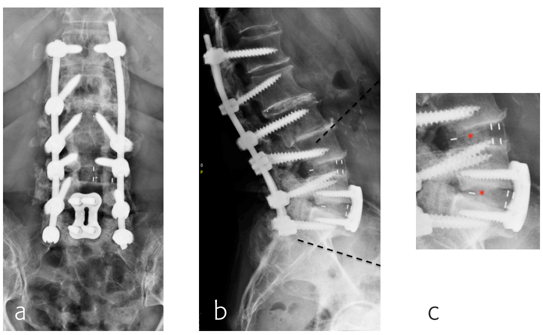


Fig 8a–c
Postoperative images.

Cases provided by Khai Lam, London, UK

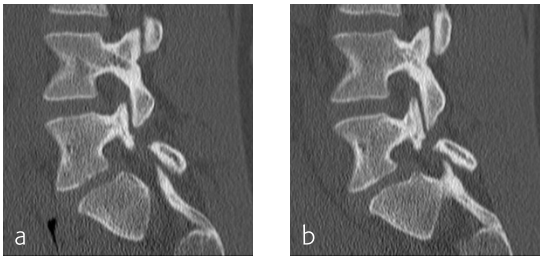


Fig 9a–b
Left and right sided L5 lytic defect.

Case 2: 19-year-old hockey player

A 19-year-old high-level college hockey player had experienced 12 months of severe lower back pain (LBP), and was unable to play sport due to high disability and pain (Fig 9). Nonoperative treatment with physiotherapy and injections had failed.

The CT showed bilateral L5 spondylolysis with grade I spondylolisthesis (Fig 10).

The patient underwent minimal access L5/S1 anterior interbody fusion with BMP followed by minimally invasive Matrix percutanous screw fixation (Fig 11).

Fig 10
Sagittal T2 MRI showing grade III L5/S1 disc degeneration over grade I L5/S1 lytic spondylolisthesis.

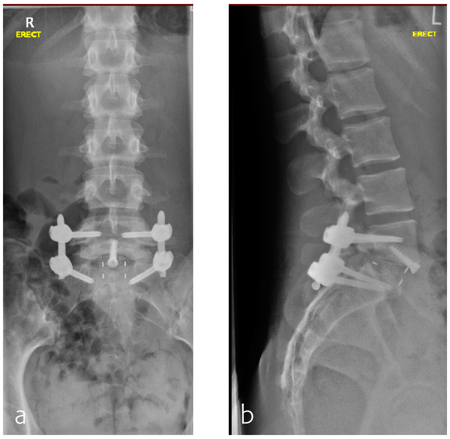


Fig 11a–b
Postoperative AP and lateral x-rays.

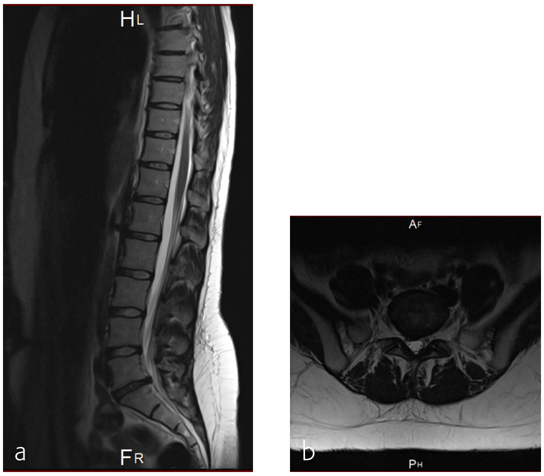


Fig 12a–b
Sagittal and axial T2-weighted MRIs.

Case 3: 23-year-old student

A 23-year-old female college student had experienced 3 years of severe LBP with some right S1 sciatica. She presented with high disability, failed nonoperative treatment, injections, and pain killers. She was unable to lead a normal life and conduct activities of daily living.

The sagittal and axial T2-weighted MRI showed grade III disc degeneration with diffuse right-sided disc bulging (Fig 12).

The postsurgery AP and lateral images show stand-alone locked L5/S1 anterior fusion using Syncage Evolution with BMP-2 and an Aegis locking plate (Fig 13).

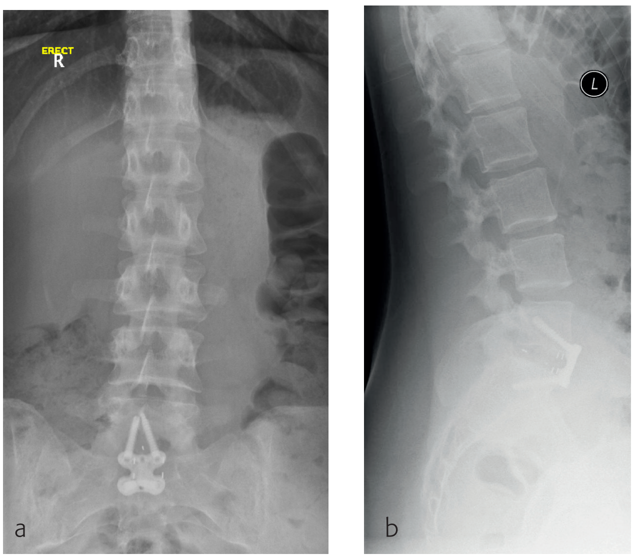


Fig 13a–b
Postoperative AP and lateral x-rays.

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

VETERINARY

Fig 1
llustrating a DPO procedure with a veterinary DPO/TPO plate on a canine pelvis.

Double/Triple Pelvic Osteotomy (DPO/TPO) Plate

The Double/Triple Pelvic Osteotomy (DPO/TPO) plate (Fig 1) is indicated for treating coxofemoral joint instability and subluxation in immature dogs prior to the onset of osteoarthritis. The DPO/TPO plate is 3.2 mm thick and available in right and left versions with angulations of 20°, 25°, and 30° between the plate surfaces to facilitate the rotational osteotomy of the acetabular bone segment.

Background

At least 3.5% of the global dog population suffers from hip dysplasia [1] and this can reach 50% in larger breeds [2]. Rotational pelvic osteotomies constitute prophylactic surgical interventions intended to decrease abnormal hip joint laxity, normalize articular stresses, and improve hip joint congruity. Currently, the DPO and TPO are the most popular corrective procedures. However, despite technique modifications and the development of new plates, complications such as implant loosening, reduction of the pelvic inlet diameter, over- or under-rotation of the acetabular rim, and delayed healing of the osteotomies can occur.

Plate design

The recently launched DPO/TPO plate offers substantial improvements to existing bone fixation plates to overcome these complications (Fig 2). Features of the plate include:

- Screw trajectories designed to optimize screw purchase into the relatively soft bone
- Anatomically contoured to match the ilial shaft and to allow clearance for acetabular flare and the tuberosity at the origin of the rectus femoris muscle
- Plate design includes two distinct screw-hole technologies to accommodate all plating modalities (stacked combi holes and coaxial combi-hole)
- Incorporation of locking technology permits a fixed-angle device to increase construct strength.

References

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Fig 2a
Side view of the DPO/TPO plate showing the optimized screw angulations.

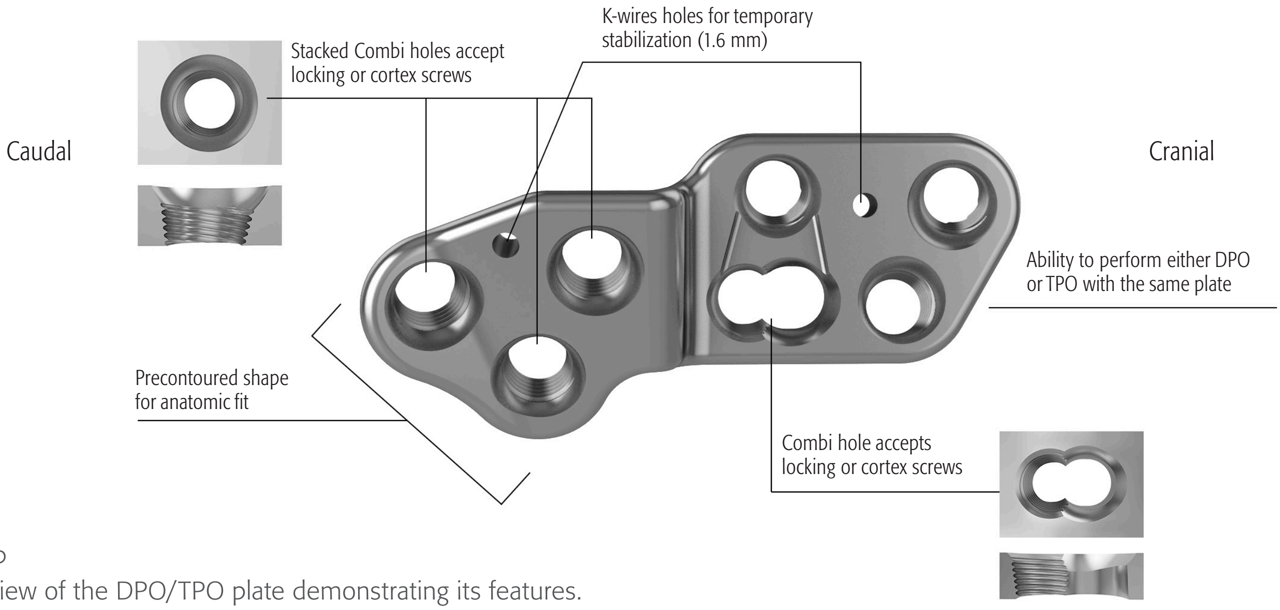

Fig 2b
Top view of the DPO/TPO plate demonstrating its features.

Case provided by Brian Beale, Houston, USA

Fig 3
A distraction x-ray view revealed bilateral hip joint laxity.

Case 1: Labrador retriever puppy

A 5½-month-old spayed female labrador retriever puppy weighing 22.0 kg presented with bilateral hind limb weakness and a bunny-hopping gait in the hind limbs. Physical examination revealed bilateral hip instability (positive Ortolani sign) and mild pain on full extension of the hips. Slight crepitus was palpated in the left hip. The gluteal muscles appeared to have mild atrophy. The neurological exam was normal. X-ray examinations revealed bilateral hip subluxation and a distraction index of 0.5 of the right hip and 0.7 of the left hip (Fig 3). No evidence of osteoarthritis was observed.

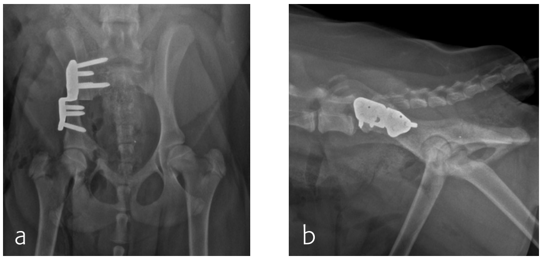

Fig 4a–b
Postoperative x-rays. A DPO was performed on the right hip using a 25° DPO/TPO plate. Excellent femoral head capture (reduction) was achieved.

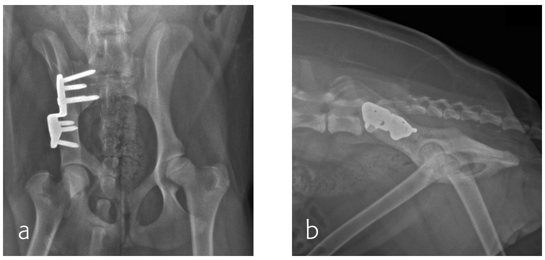

Fig 5a–b
Postoperative x-rays at 7 weeks.

Fig 6
Postoperative x-rays at 6 months following surgery.

A diagnosis of juvenile hip dysplasia was made. The right hip was considered an acceptable candidate for double pelvic osteotomy (DPO; note that in a 5½-month-old dog, an osteotomy of the pubis (as performed in a TPO) is not necessary due to the bony compliance at this young age). The left hip conformation was considered too abnormal for a corrective osteotomy and was not treated. The owner was counseled that a total hip replacement (THR) may be needed in the future on the left hip.

Angles of subluxation (10°) and reduction (30°) of the right hip were measured under anesthesia and the patient was placed in dorsal recumbency. A 7 mm portion of the right pubic body was excised. The patient was repositioned into lateral recumbency. A right ilial osteotomy was made immediately caudal to the sacrum. A 25° DPO/TPO plate was attached to the caudal ilial bone segment using locking 3.5 mm screws in the three stacked combi holes. The caudal acetabular segment was rotated laterally until the cranial aspect of the plate was in contact with the lateral aspect of the cranial ilial segment. The osteotomy site was compressed, and the plate was secured to the cranial ilial bone segment using a 3.5 mm cortical screw in the LCP combi hole in the cranial side of the plate. Three additional 3.5 mm locking screws were placed in the remaining stacked combi holes in the cranial segment of the plate.

Postoperative x-rays revealed reduction in subluxation with capture of the femoral head in the right coxofemoral joint (Fig 4). Palpation of the hip revealed good stability of the right hip. Activity was restricted to leash walk only for 6 weeks postoperatively. The x-rays at 7 weeks following surgery revealed healing of the ilial osteotomy, stable implants, and excellent coxofemoral conformation and stability (Fig 5).

The x-ray examination at 6 months postsurgery revealed stable implants, excellent coxofemoral conformation, and no evidence of osteoarthritis of the right hip. The left acetabulum was mildly shallow and mild subluxation of the femoral head was present at follow-up examination (Fig 6). Early osteophytosis in the region of the left femoral neck was evident. The dog was using the right hind leg normally and was showing no signs of instability or pain of the right hip. Mild instability and pain of the left hip was present on palpation. The dog's left hip was treated with a joint supplement and NSAIDs as needed. Future THR will be performed if clinical signs no longer respond to medical treatment.

Case provided by Erik Asimus, Toulouse, France

Fig 7
A distraction x-ray revealed bilateral hip joint laxity.

Fig 8
Femoral head coverage is demonstrated by the dorsal acetabular rim view.

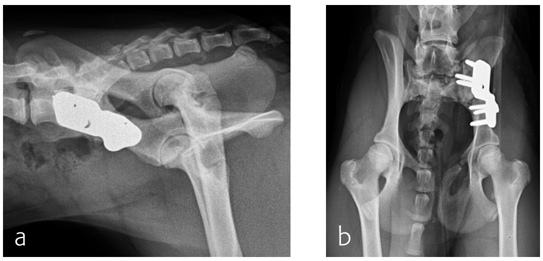

Fig 9a–b
1-month postoperative x-rays of the DPO performed first on the left hip using a 25° DPO/TPO plate. Excellent femoral head capture and stability were achieved.

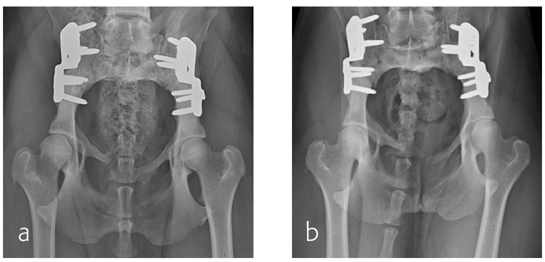

Fig 10a–b
X-rays at 4 (a) and 6 months (b).

Case 2: Boxer puppy

A 4½-month-old female boxer puppy weighing 15.0 kg presented with bilateral hind limb weakness and reluctance to walk. Physical examination revealed bilateral hip instability (positive Ortolani sign) and severe pain on full extension of the hips. The neurological exam was normal. The x-rays revealed bilateral hip subluxation and a distraction index of 0.65 of the right hip and 0.6 of the left hip (Fig 7). Very mild osteoarthritis was seen and femoral head coverage by the dorsal acetabular rim was good (Fig 8). Angles of subluxation (10° R and 20° L) and reduction (30° R and 40° L) of the hips were measured under anesthesia.

A diagnosis of juvenile hip dysplasia was made. Both hips were considered as candidate for double pelvic osteotomy (DPO). Considering the difficulty to limit the activity of this active puppy, a simultaneous bilateral procedure was not performed. The left hip DPO was performed first, followed by the right hip 4 weeks later.

For each surgical procedure, the patient was placed in dorsal recumbency to enable the pubic ostectomy. The patient was repositioned in lateral recumbency to perform the DPO. A left ilial osteotomy was performed caudal to the sacrum. A 25° DPO/TPO plate was attached to the caudal ilial segment using locking 3.5 mm screws in the three stacked combi holes. The caudal acetabular segment was rotated laterally until the cranial aspect of the plate was in contact with the lateral aspect of the cranial ilial segment. The osteotomy site was compressed and the plate was secured to the cranial ilial bone segment using a 3.5 mm cortical screw in the LCP combi hole in the cranial side of the plate. Three additional 3.5 mm locking screws were placed in the remaining stacked combi holes in the cranial segment of the plate (Fig 9).

Activity was restricted to leash walks for 6 weeks postoperatively. The x-ray examination 1 month after each surgery revealed partial healing of the ilial osteotomy and stable implants. Postoperative x-rays at 6 months after both surgical procedures revealed complete healing of the ilial osteotomies, stable implants, and excellent coxofemoral conformation, with no subluxation of the femerol head. Mild osteoarthritis was observed, however. At both the 4 and 6 month evaluation, the dog was using both hind limbs without any evidence of lameness and was showing no signs of instability or pain of either hip (Fig 10).

AOTK MEET THE EXPERTS

Meet the Experts program

History and recent events

The AO Davos Courses "Meet the Experts" sessions started in 2011 as an informal way of introducing AOTK approved product innovation to the global orthopedic community. This product introduction, inclusive of approach and technique, has been largely performed by surgeons involved in the product development process and has become one of the most important activities organized by AOTK each year.

Successful change of location

As a result of both the popularity of Meet the Experts and the need to find a quiet environment, 2014 witnessed a change of venue within the Congress Centre for these sessions. Café Chamonix will remain the chosen space for 2015 across both weeks.

Meet the Experts sessions 2014

During AO Davos Courses 2014, Theddy Slongo and Spence Reid, both clinical members of the External Fixation Expert Group, presented the ring fixator as a tool for enabling distraction in long bones. The Distraction Osteogenesis (DO) was shown to be a versatile and modular ring system that allowed multiple frame options and offered viable alternatives for deformity corrections and fracture management. The presenters then successfully demonstrated how to utilize the DO frame for limb lengthening and singular angular correction.

Michael Blauth and Christopher Finkemeier, members of the Intramedullary Nailing Expert Group, demonstrated and explained the features of the new TFN-Advanced Proximal Femoral Nailing system (TFNA) (Fig 1) and demonstrated the importance of aiming guides for the insertion of both the nail and the femoral head fixation element. More information on the TFNA is found in the lead article of this edition of TK Innovations.

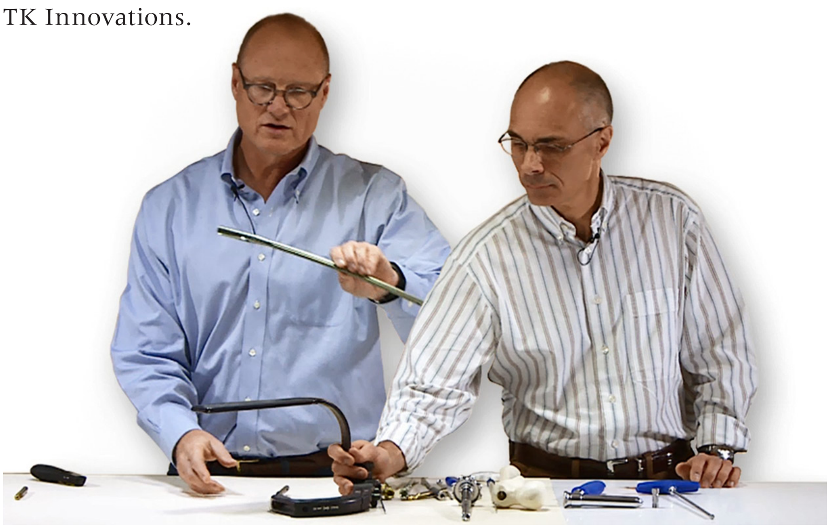

Fig 1
Michael Blauth and Christopher Finkemeier demonstrate the TFNA.

Andy Sands and Michael Castro from the Foot and Ankle Expert Group gave an overview of the treatment options available with the new Variable Angle Midfoot/Hindfoot system. The new system has the capacity to offer variable angle fixation in much the same way as the forefoot/midfoot system previously developed by the Foot and Ankle Expert Group. However, in comparison to older hindfoot plate options, the new VA calcaneal plates are now available in a variety of shapes to accommodate the multiple fixation strategies required for different fracture patterns.

Michael Raschke delivered a highly informative session outlining the properties of biomaterials such as antibiotic PMMA and antibiotic-coated implants and their use in the prevention of implant-related infections. The discussion emphasized both the importance of prophylaxis using both systemic and local antibiotics and the value of using biomaterials to eradicate pathogens and reconstruct bone in cases of established bone infection.

Stefano Fusetti led an interesting and interactive session describing the features of the MatrixWAVE plate (Fig 2), a newly approved device for maxillomandibular fixation (MMF). Indications for use of the plate were outlined, as were the advantages offered by the new device. Audience members were able to observe the MatrixWAVE plate being applied to a model skull and the requisite surgical instruments and techniques.

In 2014, AOVET participated in the Meet the Experts program for the first time, with Brian Beale and Mike Kowaleski (Fig 3) demonstrating the Double/Triple Pelvic Osteotomy Plates for treating coxofemoral joint instability and subluxation in immature dogs.

Fig 2
Stefano Fusetti demonstrates the new MatrixWAVE plate.

Fig 3
Brian Beale and Mike Kowaleski demonstrate the latest VET plates.

Roger Härtl gave a comprehensive overview of the cutting-edge navigation technology available for spine surgery (Fig 4) including Viper navigated instruments and the 2D Fluoro Navigation system. A leader in the field of navigation, Roger emphasized reference array fixation, imperative for the attainment of accuracy in navigated surgery, and screw model visualization, which offered the surgeon a choice between full and partial screw visualization (Fig 5). More information on computer assisted surgery can be found in the Minimally Invasive 2D article in the Spine section of this edition.

Neurosurgeons Christian Matula, Rocco Armonda, and Stephen Lewis concluded the program delivering a highly engaging webcast describing innovations in dural repair (Fig 6). They demonstrated the use of SYNTHECEL, a synthetic dural implant based on biosynthesized cellulose technology, and Duraform, another synthetic dural substitute. This session was broadcast live to AO members around the world and included immediate interaction from the internet audience.

Fig 4
Leading spine surgeon Roger Härtl demonstrates the latest navigation systems.

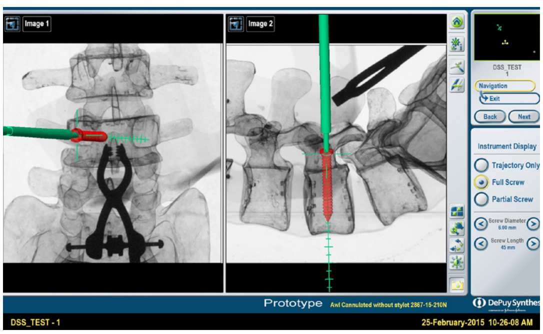

Fig 5
Navigation system used in spine surgery.

Fig 6
Christian Matula, Rocco Armonda, and Stephen Lewis outline the features of the latest synthetic dural implants.

Karl Stoffel, Christoph Sommer, Ivan Zderic, Ursula Eberli, David Mueller, Martin Oswald, Boyko Gueorguiev

NEWS FROM ARI

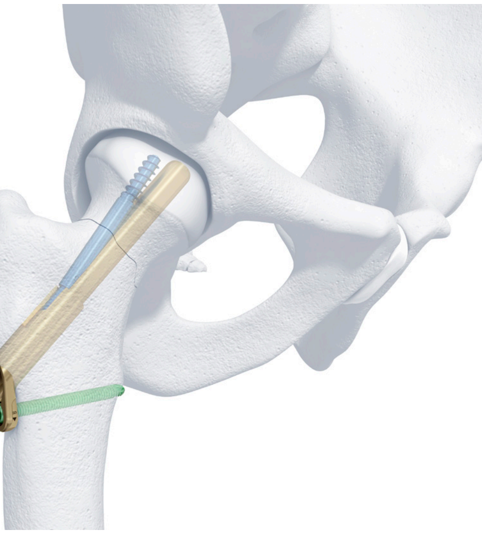

Fig 1
The new Femoral Neck System for femoral neck fracture fixation.

Biomechanical Evaluation of Femoral Neck Fracture Fixation with the new Femoral Neck System: Comparison with DHS-Blade, DHS with Antirotation Screw, and three Cannulated Screws

Clinical Background

The Dynamic Hip Screw (DHS) is considered the gold standard for the fixation of unstable subcapital or transcervical femoral neck fractures type AO/OTA 31–B. However, the prominence of the implant can be painful. As an alternative, three Cannulated Screws (3CS) may be used, however, the fixation might not provide enough stability in cases of displaced fractures. The aim of this project was to evaluate the biomechanical performance of the new less-invasive implant, the Femoral Neck System [1] (FNS) (Fig 1) and compare it to established fixation methods using DHS–Screw, DHS–Blade, and 3CS in a human cadaveric model.

Materials/methods

Twenty pairs of fresh-frozen anatomical specimen femora were instrumented with either DHS–Screw, DHS–Blade, FNS, or 3CS. A reduced unstable femoral neck fracture 70° Pauwels III, AO/OTA 31–B2.3 was set standardized with 30° distal and 15° posterior wedges in respect to the fracture plane using a custom saw-guide. Biomechanical assessment was performed with the specimens mounted on a material testing

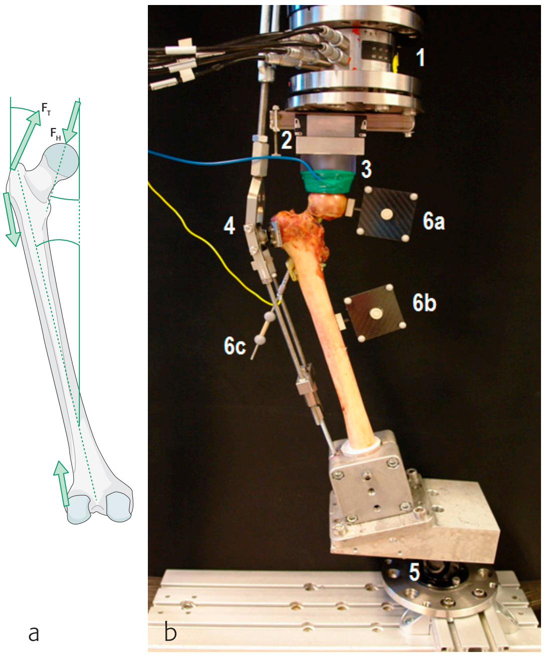

Fig 2a–b Biomechanical testing.

a A free body diagram of the femur.
  F_T) Abductor muscle force acting on the greater trochanter.
  F_H) Hip contact force.

b Test setup with a left femur specimen mounted for biomechanical testing and instrumented with FNS.
  1) Load cell.
  2) Linear guide assuring free centre of the femoral head rotation.
  3) PMMA shell simulating the acetabulum.
  4) Bracing attachment to simulate the iliotibial band of the abductor muscles.
  5) Cardan joint preventing displacement and axial rotation of the specimen.
  6a–c) Three retro-reflective marker sets attached to the femoral head, shaft, and implant for optical motion tracking.

machine in 16° femoral shaft lateral angulation (Fig 2). Starting at 500 N, cyclic compression loading along the transducer axis was applied to the femur, with increasing peak force at a rate of 0.1 N/cycle until construct failure. Machine data was used to calculate the axial construct stiffness immediately after test start. Relative interfragmentary movements along the femoral shaft and neck axis were evaluated with optical motion tracking (leg/femoral neck shortening). Statistical analysis was performed at a level of significance set to 0.05.

Results

The highest axial stiffness was observed, on average, using the FNS, followed by the DHS–Screw, DHS–Blade, and 3CS, with no significant differences between the implant systems. Cycles until 15 mm leg shortening were similar for DHS–Screw, DHS–Blade, and FNS, and significantly higher in comparison to 3CS ($p<0.001$). Similarly, cycles until 15 mm femoral neck shortening were comparable between DHS–Screw, DHS–Blade, and FNS, and significantly higher compared to 3CS ($p<0.001$). The results are summarized in Table 1.

Conclusion

The biomechanical performance of the FNS is comparable to either of the DHS implants, and as with them, significantly better than 3CS in terms of resistance to leg and neck shortening under cyclic loading. In addition, FNS is potentially less invasive than DHS, which makes it a competitive product for unstable femoral neck fracture treatment.

Note

[1]Regulatory approval for the Femoral Neck System is pending.

DHS–Screw	DHS–Blade	FNS	3CS
Axial stiffness [N/mm]			
688.8 ± 44.2	629.1 ± 31.4	748.9 ± 66.8	584.1 ± 47.2
Cycles until 15 mm leg shortening			
20,542 ± 2,488	19,161 ± 1,264	17,372 ± 947	7,293 ± 850
Cycles until 15 mm femoral neck shortening			
20,846 ± 2,446	18,974 ± 1,344	18,171 ± 818	8,039 ± 838

Table 1
Parameters of interest for the implant systems (mean ± SEM).

Manuela Ernst, Dankward Höntzsch, Ronald Schwyn, Stefan Döbele, Markus Windolf

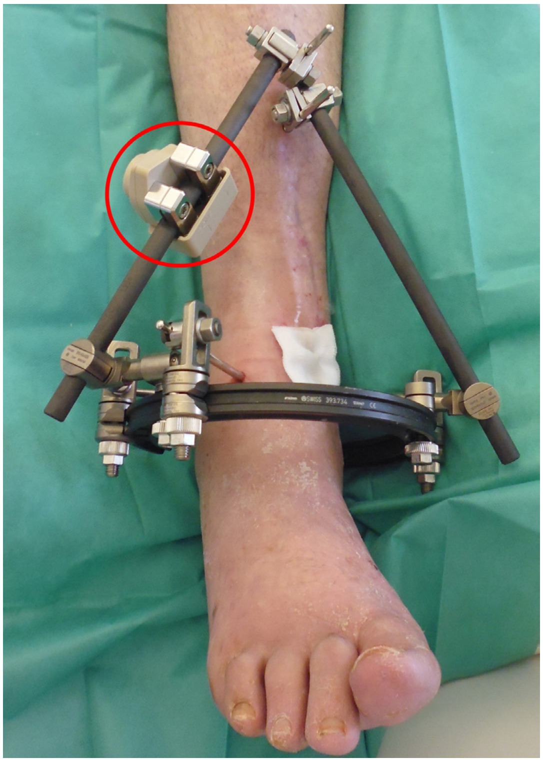

Fig 1
Clinical application of the AO Fracture Monitor attached to an external fixator side-bar (red circle).

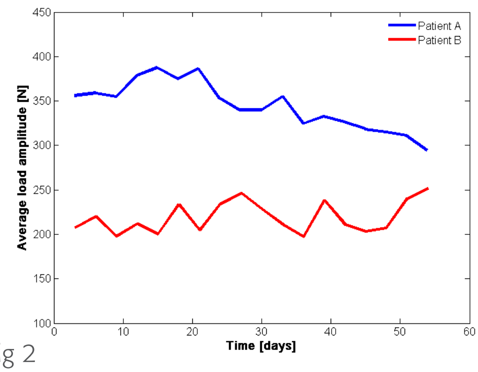

Fig 2
Average external fixator load in two patients over a period of two months. The drop of the curve over time in patient A indicates the onset of fracture healing.

AO Fracture Monitor: a sensory implant that transmits bone repair and healing information

Implants adopt the stabilizing function of bone for the duration of the fracture, and the loading on the implant changes throughout the course of bone repair. Recording implant loading is an indirect measurement of fracture consolidation and can contribute to an improved assessment of bone healing. The AO Research Institute (ARI) has developed the AO Fracture Monitor, which is a system capable of continuously measuring this load and transmitting the information to the physician [1]. The data assists the surgeon with decision making on corrective actions such as adapted aftercare, or reoperation at an early stage. The data can also help improve implant design to ensure proper bone healing.

The AO Fracture Monitor consists of a data logger unit with an interface for wireless communication using a computer or smartphone, and a web platform for collection, administration, and visualization of patient data. The logger itself comprises a sensor and an electronic unit for on-board processing of the data into meaningful parameters to assess healing progression. In contrast to alternative approaches, the AO Fracture Monitor can examine the course of healing autonomously and continuously over long periods of time. This allows for the recording of other important bio-data, such as patient activity profiles.

In an initial phase, a version of the AO Fracture Monitor has been developed for use with external fixation, measuring the deflection of a fixator sidebar under functional loading (Fig 1). This helps determine the feasibility of the technology, as measurements can be performed noninvasively and at minimal risk to the patient. A clinical trial is currently being conducted by AOCID in patients with external fixator treatment of tibial fractures.

Detecting the onset of healing—illustration

As an example, the healing curves of two patients are compared (Fig 2). Patient A shows an onset of healing (blue curve), indicated by a mild decline of the average loading amplitude over time, while patient B shows no signs of fracture healing during the monitoring period (red curve). There can be multiple reasons for the absence of healing, however, a distinct difference in weight-bearing becomes obvious. Patient A loads on average with 35–40 kg, whereas patient B only weight-bears at 20–25 kg (Fig 2). The situation is further visualized by activity histograms also delivered by the fracture monitor (Fig 3).

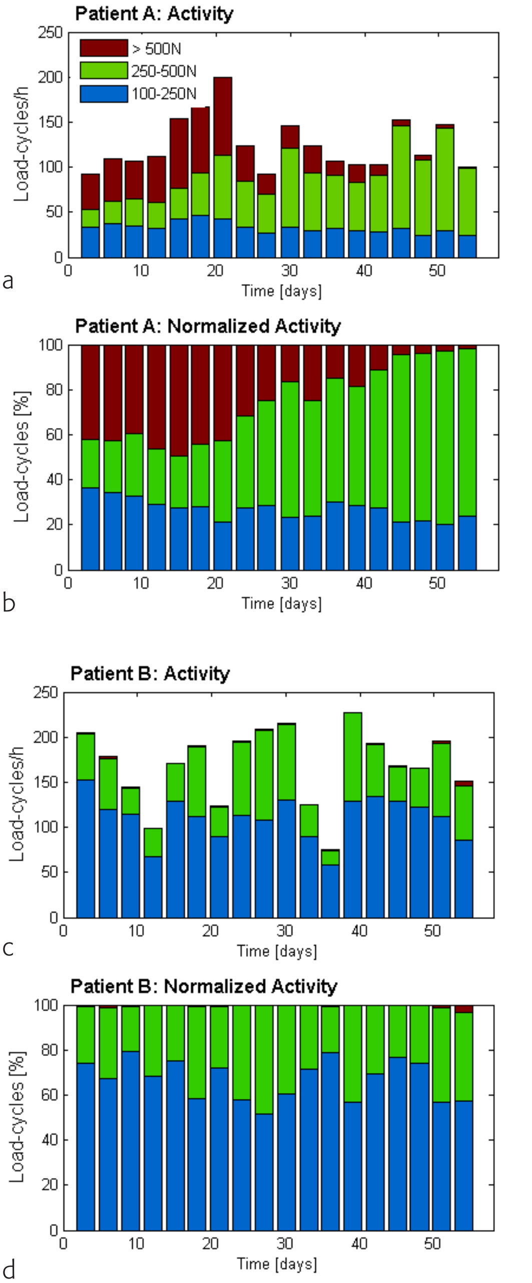

Fig 3a–d
Absolute (a, c) and relative (b, d) activity data of the two patients, sorted according to loading intensity. The onset of healing in patient A becomes apparent by fade-out of >500N loading events over time (b). In contrast, no signs of healing are detected in patient B (d).

Steps taken by the patient are counted and organized into three distinct bins according to loading intensity. While the overall activity of both patients is more or less comparable (in average 100–200 steps/h), the intensity distribution is quite different. While roughly 70% of all recorded steps of patient B are in the range of 10–25 kg, patient A load-bears only 20–30% in this range and approximately 40% at above 50 kg. The onset of healing in patient A is indicated by fade-out of the >50 kg loading events over time (Fig 3). Consecutive fade-out of the other loading bins is anticipated with ongoing healing. Healing diagnostics solely based on x-rays can be difficult in this case (Fig 4).

This example illustrates the capabilities of the system and stresses the importance of biofeedback for controlling fracture healing. The preliminary results are encouraging, and demonstrate that the system is capable of detecting healing even in cases displaying a history of delayed-union, infection, and pseudoarthrosis. As a result, the system could potentially offer an early warning of poor healing or nonunion. A version for application with internal fixation is currently under development and will enter the preclinical test phase soon.

References

1 **Windolf M, Ernst M, Schwyn R, et al.** A biofeedback system for continuous monitoring of bone healing. In: Proceedings of the International Conference on Biomedical Electronics and Devices. 2014: 243–248. DOI: 10.5220/0004913002430248.

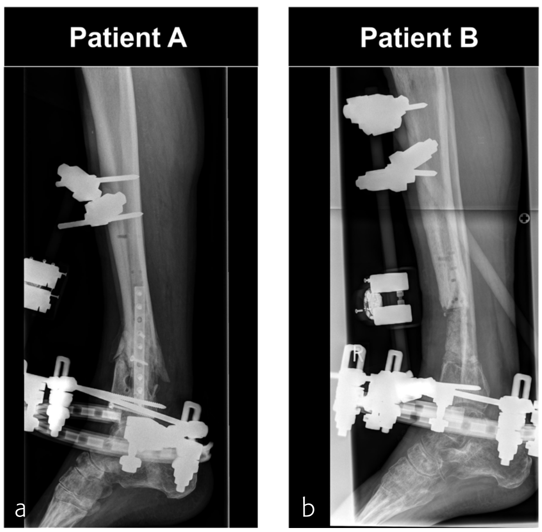

Fig 4a–b
Mediolateral x-rays of patients A and B at the end of the monitoring period.

NEWS FROM AO EDUCATION INSTITUTE

Fig 1
AOTrauma STaRT—engage, assess, browse.

AOTrauma STaRT (Surgical Training and Assessment for Residents)

The AO Foundation's very own AOTrauma STaRT (Surgical Training and Assessment for Residents) (Fig 1) is an award-winning interactive online learning hub for orthopedic trauma residents. Learning activities are based on typical patient problems, making it easier for residents to directly apply what they learn into their daily practice. It invites learners to be proactive in identifying knowledge gaps and offers resources to address them. Content is graded into various levels of complexity and is aligned with the AOTrauma Residents Education Program.

The main features of AOTrauma STaRT include:

- Interactive case discussions, which assist learning based on common patient problems
- Self-assessment questions to assist with the identification of knowledge gaps, where learners can test themselves with multiple-choice questions (from basic to complex) receiving immediate feedback
- Access to existing AO learning materials, which are labelled according to complexity, and inclusive of an extensive library of educational resources including videos, webinars, webcasts, eLearning modules, apps, and AO Surgery Reference.

Fig 2
Wa'el Taha and Kodi Kojima, AOTrauma STaRT Executive Editors.

Created by surgeons for surgeons

The content authors are experienced faculty from each of the AOTrauma regions and work in teams to achieve and maintain an international focus (Figs 2–6). These authors are involved in the teaching and training of residents on a daily basis, and are committed to providing content that is current, interesting, and evidence based.

Fig 3
Joyce Koh (from Singapore), Chanakarn Phornphutkul (from Thailand), and John Mukhopadhaya (from India), authors of the humeral shaft module, with AOTrauma STaRT Project Manager Kokeb Abebe (2nd from left), show the diversity of backgrounds that are brought together in developing the program.

Fig 4
Greg Bain from Australia presents a distal radius module.

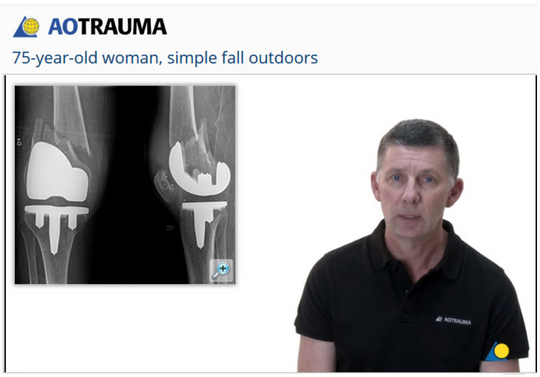

Fig 5
Michael Möller from Sweden presents a periprostetic fracture to test residents' knowledge of patient management.

International recognition and awards

Since its launch in 2014, AOTrauma STaRT has achieved international recognition and claimed a broad range of prestigious medical education awards. These include a Platinum award from the eHealthcare Leadership Awards, a Silver in the Physician/Clinician Portal Website category from the 2014 Web Health Awards, and an outstanding achievement award at the 2014 Interactive Media Awards. This success continued this year with two more outstanding achievement awards at the 2015 Interactive Media Awards.

AOTrauma STaRT applies proven educational strategies to support orthopedic trauma residents, and is committed to providing valuable feedback and fast access to relevant information. As a result, we believe that this program goes a long way to helping residents improve patient care in their community. You can find more about AOTrauma STaRT at www.aotrauma.org/STaRT or contact Project Manager Kokeb Abebe at kokeb.abebe@aofoundation.org for more information.

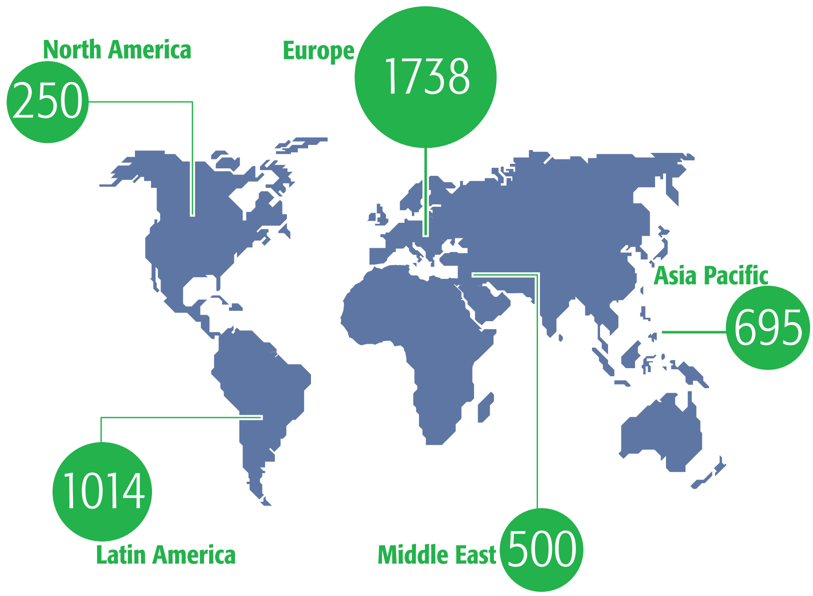

Fig 6
Approximately 4200 residents, junior practitioners, and even senior practitioners from all over the world have registered for AOTrauma STaRT (as at August 2015).

Fig 1
The two-book set of *Fractures of the Pelvis and Acetabulum—Principles and Methods of Management*-Fourth Edition.

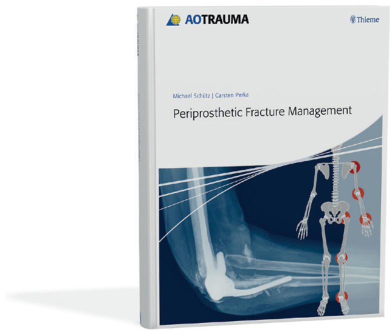

Fig 2
Periprosthetic Fracture Management.

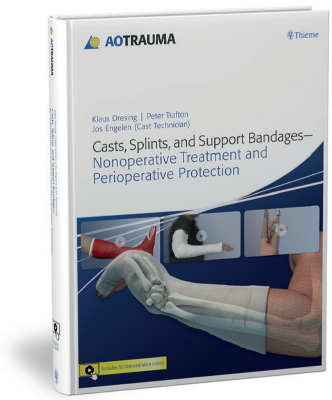

Fig 3
Casts, Splints, and Support Bandages—Nonoperative Treatment and Perioperative Protection.

New AO Publications

Fractures of the Pelvis and Acetabulum

In June 2015, the latest edition of AO Past President Marvin Tile's, *Fractures of the Pelvis and Acetabulum—Principles and Methods of Management*, was launched in Las Vegas. This fourth edition (Fig 1) is now a two-volume set based on the renowned AO principles of operative management of fractures in this area.

The book covers in great detail the management of acute pelvic and acetabular fractures, definitive treatment, and extensive discussion and analysis on expected outcomes. Including dozens of highly detailed cases and hundreds of images, this new edition of an existing gold standard publication is ideal for all surgeons interested and involved in pelvic and acetabular surgery.

Periprosthetic Fracture Management

With an ever aging population comes a growing demand for joint implant surgery. However, this growth has resulted in an increase in the number of patients with implant related fractures.

Bringing together the latest global knowledge on periprosthetic fractures, *Periprosthetic Fracture Management* (Fig 2) examines the approaches, treatment options, and surgical pitfalls involved with these types of fractures, and provides the reader with an overview of the typical problems, and a variety of interesting and complex cases, in each anatomical area. This publication also introduces the new Unified Classification System on Periprosthetic Fractures, ideal for helping to recognize and describe these often problematic fracture situations.

Casts, Splints, and Nonoperative Treatment

Casts, Splints, and Support Bandages—Nonoperative Treatment and Perioperative Protection (Fig 3) covers the principles of casting and bone healing, the unique features of cast materials, classifications and guidelines for nonoperative treatment, and step-by-step descriptions of dozens of individual cast, splint, orthosis, and bandaging procedures.

The publication also includes access to 55 cast, splint, and bandaging demonstration videos, covering the upper and lower extremities and the spine. This incredibly comprehensive text on nonoperative techniques will be of interest to a wide range of medical professionals, residents in training, and ORP.

For further information on any of the materials and publications produced by AO Publishing, visit the publishing section of the AO Foundation website.

NEWS FROM AOCID

Fig 1
X-ray image of the Proximal Femoral Nail Antirotation (PFNA) plus augmentation.

Clinical trials update

AO Clinical Investigation and Documentation (AOCID) is the main AOTK partner for the conduct of clinical trials. This year, AOCID is involved in a total of 76 clinical studies and registries, of which more than one-third are sponsored or cosponsored by AOTK. In this issue of TK Innovations, AOCID provides an outline of the PFNA augmentation study and the Trolley clinical investigation. There is also a focus on smart implants through a short description of the SmartFix focussed registry. Finally, we share some tips on elements that sites need to have to successfully contribute to a clinical investigation. More information on AOCID's work can be found at www.aocid.org.

Comparison of Proximal Femoral Nail Antirotation (PFNA) vs PFNA augmentation for the treatment of closed unstable trochanteric fractures: a randomized-controlled trial

The purpose of this study is to evaluate whether patients with trochanteric fractures treated with a Proximal Femoral Nail Antirotation (PFNA) plus augmentation (Fig 1) can be better mobilized than patients without augmentation.

In order to avoid the pain caused by relative movement between implant and bone, surgical techniques and devices enabling augmentation of the femoral head have recently been developed. Biomechanical studies have illustrated that augmentation leads to a better axial stability and increased pull-out strength. In clinical practice, this might facilitate early mobilization and full weight-bearing with less pain. Using the TUG test (Timed Up and Go), the study will also measure whether patients with an augmented PFNA are able to walk faster than nonaugmented patients.

The study evolved from the Intramedullary Nailing Expert Group (INEG), and the current estimated patient enrolment is 251. The study started in February 2012 and is predicted for completion by the end of 2015. Nine clinics from six countries have been participating.

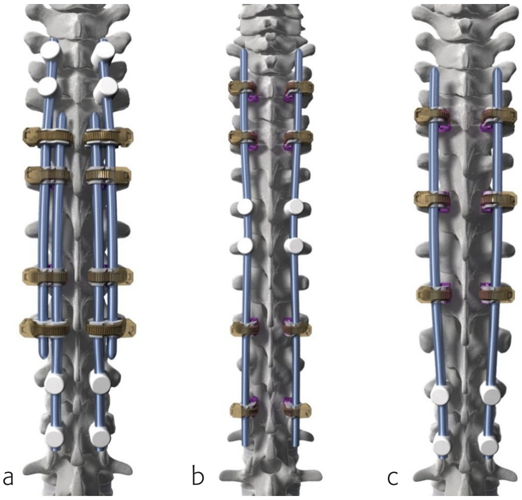

Fig 2
Trolley technique instrumentation.
a Four-rod technique.
b Two-rod tehnique with apical fusion.
c Two-rod technique with distal fusion.

Evaluation of a growth guiding construct vs standard dual growing rods and VEPTR for the treatment of early onset scoliosis patients: a prospective multicenter cohort study with a matched historical control (the Trolley study)

The primary challenge when managing early onset scoliosis (curve deformity before the age of 10) is to prevent curve progression while maintaining growth of the spine. Current treatment options require repetitive interventions as both the spine and child grow. This study will compare two techniques of growth modulation: standard dual growing rods versus the new Luqué Trolley screws.

One third of patients will be recruited in designated investigation sites using the Trolley system (Fig 2). For every patient receiving the Trolley implant, 1-2 comparative matched pairs will be taken from the Chest Wall and Spine Deformity Study Group (CWSDSG) and the Growing Spine Study Group (GSSG). The study hypothesis is that patients treated with the Trolley system will undergo fewer reoperations after 3 years of follow-up than patients included in the comparison group. Five clinics will partake in this investigation, which started in September 2015.

Clinical data collection with a novel biofeedback technology for continuous monitoring of bone healing (the SmartFix focused registry)

In this trial, a novel data logger device (AO Fracture Monitor), developed at the AO Research Institute in Davos, is used to continuously measure the decline in fixation hardware deflection under physiological loading as an indirect indicator for healing progress. Parameters obtained from the data logger device carry the potential to significantly improve the assessment of fracture healing in the future.

Meaningful interpretation of measurements requires a set of clinical reference data. Twenty patients that received an AO large external fixator for a tibial fracture will be equipped with a data logger device (AO Fracture Monitor), attached postoperatively. The device will continuously measure deformation on the fixator frame due to weight bearing for up to 4 months by means of a strain gauge. Several parameters are calculated from the recorded change in the strain signal and the data collected at follow-up visits by wireless data transfer. Together with additional variables such as treatment details, fracture healing, and pain reported by the patient, the collected data will be used to build up a database. Data from the AO Fracture Monitor will be correlated with patient data to investigate the capability of the device to track the course of fracture healing.

The SmartFix study began in January 2015 and is expected to continue until March 2018. A total of 20 patients are planned to be recruited for this focused registry. You can read more about the AO Fracture Monitor system in the "News from ARI" section (page 49) of this issue.

Fig 3
Reviewing the results in an AOCID conducted study.

Do you think your clinic has got what it takes to become a study site?

Possessing many years of experience in the conduct of clinical trials, AOCID highlights the following elements to be markers for success in clinical research (Fig 3):

- Dedicated Principal Investigator (PI)
- Availability of a study coordinator or Clinical Trials Unit (CTU)
- Realistic patient recruitment predictions
- Availability of implants and sets
- Legal situation conducive to the conduct of clinical trials
- Continuity, in terms of personnel etc
- Proactive recruitment (ie, no overreliance on residents to recruit)
- Appropriate source data collection processes and tools
- Frequent and open communication
- Motivated clinical research team members.

How does your clinic measure up to these criteria? If you would like to know more about what is expected of centers in a clinical trial, you can view an example site selection questionnaire from the TMT Fusion Plate study in the 'Resources' section of the AOCID website: www.aocid.org.

NEWS FROM AOTK

AOTK Experts' Symposia

Evolution and purpose

Product feedback from expert clinicians worldwide is a primary focus of the AOTK approach to research and development and quality assurance. AOTK regularly holds an "Experts' Symposium", inviting AO members to come together to evaluate AOTK approved product performance and to share experiences, of benefit both clinically and in the development of educational materials. Since its first Experts' Symposium held in 2000, AOTK has regularly organized such surgeon exchanges across the various AO regions and believes strongly that the value of this expert collaboration leads to continual improvement to both product development and patient care.

Fig 1
Participants of the 9th AOTK Experts' Symposium in Innsbruck, Austria.

9th European AOTK Experts' Symposium, Innsbruck, Austria, September 2014

Thirty nine expert surgeons from nine European countries attended the symposium in Austria (Fig 1), organized in cooperation with AOTrauma, with participants presenting their most challenging clinical cases in the areas of augmentation in the humerus and femur, fixation of the quadrilateral surface, tibia head fracture fixation, periprosthetic fracture management, patella fracture treatment, and reamer/irrigator/aspirator procedures.

There was a clear consensus that the AO tension band wiring of patella fractures was no longer the Gold Standard and that teaching materials had to be updated. Fixation with cannulated screws and tension band as well as plate application seemed to constitute the current trend for patella fixation. The periprosthetic fracture management session illustrated clinical situations that are insufficiently addressed with current hardware. In response, AOTK has now formed a Periprosthetic Fracture Task Force, which will work in collaboration with DepuySynthes on new implant development. Further discussions included the reamer/irrigator/aspirator (RIA) procedures and the importance of controlling the reamer head intraoperatively in anterior and lateral views.

Fig 2
Tim Pohlemann explains the function of smart implants for continuously monitoring fracture healing.

The event included two keynote lectures, firstly by Prof Tim Pohlemann, who presented his views on the future potential of "Smart Implants" to assess bone healing (Fig 2), while Prof Michael Wagner passionately reported on his experiences to improve trauma patient care in Iraq. Book awards were presented for the best case presentations at each of the two days of the symposium, with Dr Carlier (from Belgium) receiving his prize for his treatment strategy on reconstructing the quadrilateral surface, and Dr Saura Sanchez (from Spain) for his approach to the treatment of complex patella fractures with a calcaneus plate.

Fig 3
Participants of the 2nd Latin America AOTK Experts' Symposium in Lima, Peru.

Fig 4
Dr Rodrigo Pesantez, chair of the hip and knee breakout session, expressed verbally (and in his clothing) the importance of being creative in relation to product development.

2nd Latin America AOTK Experts' Symposium, Lima, Peru, March 2015

Thirty three expert surgeons from nine Latin American countries attended the symposium in Lima (Fig 3), which was chaired by Dr Juan Gerstner Garces (medical member of the AOTK Foot and Ankle Expert Group). After introductory lectures from Prof Jaime Quintero and Dr Rodrigo Pesantez (Fig 4), the participants split into breakout sessions to discuss clinical challenges and needs in the areas of foot and ankle, hand and upper extremity, hip and knee, pelvis, IM nailing, and external fixation.

The groups from each breakout session prepared a summary presentation with special emphasis on new product development and treatment ideas to improve patient care. These presentations were subsequently shared with all participants in a general assembly to allow in-depth discussion of the suggested ideas. The discussions were very lively and demonstrated the enthusiasm and dedication of the participants to create better treatment solutions.

The participants from the hip and knee breakout session suggested the development of a modular blade plate to facilitate surgical procedures. Furthermore, a concept for an aiming device designed to place guide wires more accurately received wide support from the audience. In hand and upper extremity, a modular plate solution was discussed for complex distal radius fractures. Interestingly, implant modularity was mentioned on several occasions during the symposium, which illustrates the importance of providing surgeons with a modular, easy-to-use implant toolbox to address a variety of fracture patterns in an optimal manner. In the foot and ankle session, a new implant design for tibio-talo-calcaneal arthrodesis was enthusiastically evolved through lively debate. The pelvic group discussed new treatment strategies to improve the fixation of the quadrilateral surface. Targeting devices to facilitate nail interlocking as well as tips and tricks for nailing proximal tibial fractures were discussed in the IM nailing breakout session. Finally, the external fixation discussion emphasized the potential benefits of a universal distractor set in the facilitation of reduction techniques across a variety of anatomical regions.

Tim Pohlemann

AOTK AWARDS

AOTK Innovation Prize 2014

The prestigious AOTK Innovation Prize is awarded in recognition of continued improvement to patient care. In 2014, it was awarded to Prof Michael Raschke and Prof Gerhard Schmidmaier (Fig 1) for their contribution to the development of the PROtect Nailing family.

The antibiotic coated Expert Tibial Nail PROtect (ETN PROtect) was developed as a solution to implant surface bacterial colonization in cases with an increased risk of local bone infection. It represents one of the first major attempts to address the issue of infection in fractures and will hopefully inspire further development in the future.

Profs Raschke and Schmidmaier receive their certificates at the TK Chairman's meeting in Davos. From left to right, Daniel Buchbinder (AOTK CMF Chairman), Michael Raschke, Gerhard Schmidmaier, Tim Pohlemann (AOTK Trauma Chairman), and Robert McGuire (former AOTK Spine Chairman).

Christoph Sommer

PORTRAIT: KARL STOFFEL

Karl Stoffel is a specialist orthopedic trauma surgeon whose enjoyment of a challenge is evident both professionally and personally. Born in 1968 and raised in the small village of Saas-Grund in Kanton Wallis, Switzerland, Karl undertook carpentry work during his school holidays demonstrating manual and practical skills from an early age. Following a short stint as a ski teacher, Karl studied medicine at the University of Bern, and later worked as a research fellow at the AO Research Institute (ARI) in Davos in 1992. During this time he focused on investigating the functional load of plates in fracture fixation in vivo and its correlate in bone healing. Continuous in vivo load measurement is still a hot topic within the AOTK today because it might allow for the more accurate monitoring of fracture healing.

Following graduation, Karl started his professional career at the Kantonsspital Graubünden, under the guidance of Prof Tom Rüedi and myself, where he was immediately recognized as an outstanding resident. He later pursued further training at the Kantonsspital in St Gallen, and as a research fellow at the University of Western Australia, which strengthened his continued interest in research.

Karl then decided to seek entirely new challenges and moved with his family to Australia more permanently in 2004, firstly working at Fremantle Hospital, and later in the position of Professor for Orthopedic Surgery at the University of Western Australia in conjunction with a consultancy post at Fremantle Hospital, Rockingham General Hospital, and St John of God Murdoch Hospital. He and his family eventually

Karl Stoffel presents on periprosthetic fracture fixation at the 2nd AOTK Experts' Symposium in Seoul, South Korea.

Karl during an LEEG anatomy lab with Christoph Sommer.

returned to Switzerland and relocated to Basel, where Karl currently occupies an Associate Professor post at the Kantonsspital Baselland, as well as a Team Leader role for Hip and Pelvis and Traumatology.

Karl's passion for innovation and development led him to join the AOTK Lower Extremity Expert Group (LEEG) in 2012. Under his leadership and guidance, a new implant for femoral neck fracture fixation is currently in development and will soon be released to the market. Karl's willingness to take over extra project tasks is so pronounced that he has to be slowed down from time to time in order to protect him from too many commitments. With a PhD in Biomechanics, Karl is the undisputed expert in the LEEG with regard to establishing realistic biomechanical tests for newly developed implant prototypes. Several ARI implant-related biomechanical studies are currently proceeding under his supervision.

Realizing the importance of offering better solutions for periprosthetic fracture treatment, the AOTK (Trauma) started a Periprosthetic Fracture Task Force in 2014 and elected Karl as Chair due to his experience as a trauma and orthopedic surgeon. After two successful task force meetings, the direction is set to design new nail and plate solutions to address periprosthetic femur fractures more effectively. Karl is also involved in a wide range of AO education activities and serves as faculty in up to six AO courses per year. He once mentioned that his grandparents were teachers, which explains why teaching lies in his blood and why he is so passionate about sharing his surgical knowledge with others.

Karl admits to having two influential people in his professional life, both of whom have provided invaluable technical and analytical support during his development. While Tom Rüedi nurtured Karl during his early career, I am equally honored to have worked with such a dedicated and conscientious surgeon. Since joining the Kantonsspital Graubünden in 1995, Karl has not only been a valued colleague but has become a great friend.

In his free time Karl enjoys skiing with his family, especially in the area around Saas-Grund. Karl and his wife Nadine, who works as an osteopath, have a son aged 15 and two daughters aged 14 and 11. The whole family are passionate and talented skiers and also like to go on hiking tours.

AOTK very much looks forward to continued successful collaboration with Karl.

Here he is as "the entertainer" during a departmental event in Chur in 2010.

Karl with wife Nadine and their children, enjoying a skiing trip in Switzerland.

Hazards

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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 2015
Photos and illustrations courtesy of Synthes partners and authors