Evolution of Bone Screws with special reference to AO screws

Part I: From history to DCP

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The early days of bone screws.

Initially bone screws were mainly used for “attaching” plates to bone (Fig. 1) *(1–3)*. Pressing the plate to the bone surface was the sole function of such plate screws, therefore, the undersurface of the screw head was flat. The screw thread outline was conical like in wood screws (Fig. 1 and Fig. 3). The Danis plate, the precursor to the AO screws, took advantage of a cylindrical thread outline and its single thread element was asymmetrical with a perpendicular surface in relation to the axial force exerted by the screw *(3)*. The stabilizing function of the Danis screw was still achieved by pressing the plate to bone, consequently the undersurface of the Danis screw head was flat (Fig. 2) and coupling the plate to the bone relied mainly on friction between the two elements. The Danis plate allowed to compress the fracture based on an included worm screw.

The AO screw developed by M.E. Müller and R. Mathys resolved several shortcomings *(4)*. The thread shape corresponded to the one developed by Danis *(3)* (Fig. 5a), which, at that time, was considered to be superior to the usual symmetric “machine” thread (Fig. 5b). The drive connection was changed from the simple slot, to the recessed hexagonal “INBUS”. This allowed to transfer more torque and, as the connection is angularly stable, it also allows to control the inclination of the screws. The latter helped to avoid conflict with preinstalled screws. At removal, the screw head INBUS could be easier and safer connected than the simple slot. Where the protrusion of the screw head was an issue, like in hand surgery, the standard Philips drive connection was used. Danis and Müller insisted on the use of a hand operated tap or which the thread shape corresponded to the one of the screw (Fig. 6). The connection between screw head and plate of the Müller AO plate was recessed and conical at 90o. This provided a solid fit at the expense of requiring a unique perpendicular orientation of the screw in relation to the plate (Fig. 7 and Fig. 8). Danis, Venable and Müller used to tension the plate thus compressing the fracture surfaces. Müller and Mathys developed a removable compressor (Fig. 8) and tooling for shaping the plate conform to the bone surface *(4)*. All these improvements were taught at practical courses including research, clinical aspects and hands on exercises.

Monitoring compression achieved by expert surgeons applying the AO compressor and round hole plates reviled an unexpected wide range of initial compression and a marked loss thereof when screws were inserted into the round plate holes *(5)*. The next step in the evolution of the AO plate and screw was initiated *(6)* installing a slope that allowed to produce compression without additional device and the unique spherical geometry was conceived that allowed inclined lagged plate screws. The animal studies at the ARI and the initial clinical testing of the DCP *(7)* proved the expected advantages also in the human application.

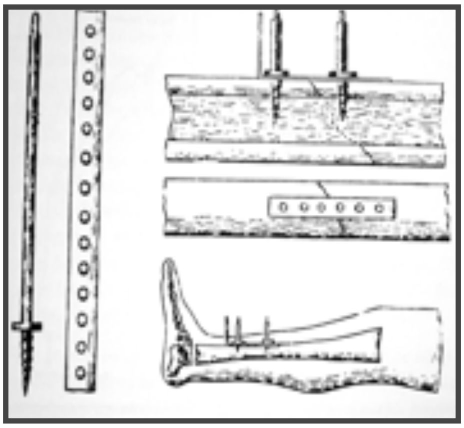

Fig. 1: **Unicortical, woodtype screw, external drive** (Hansmann 1886).

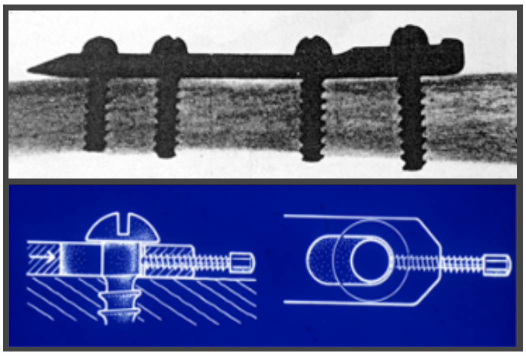

Fig. 2: **Solid plate, cylindrical outline of screw thread, asymmetrical thread, worm screw compressor, drive connection slotted** (Danis R 1947).

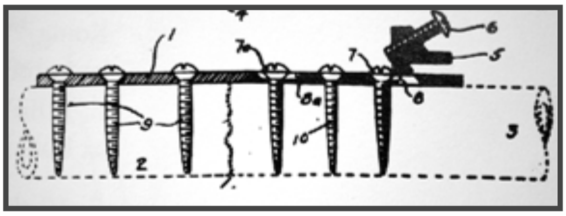

Fig. 3: **Conical outline of screw, compressor, still conical outline of thread** (Venable 1951).

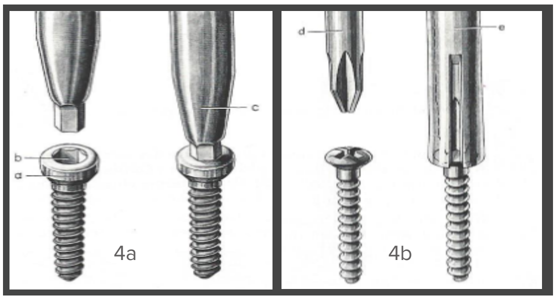

Fig. 4: **Drive connection of AO screws: Fig. 4a:** "INBUS" general application, good angular control. **Fig. 4b:** Philips flat head for hand surgery (Muller et al. 1963).

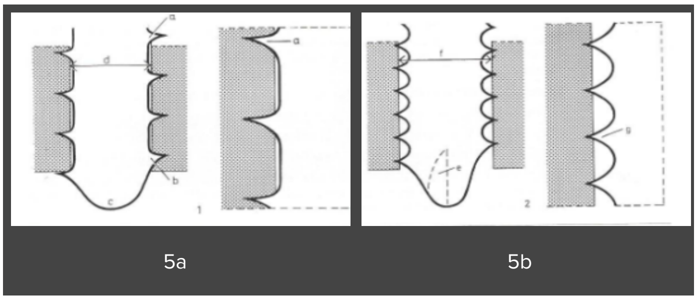

Fig. 5: **Thread shapes. Fig. 5a** Danis/AO asymmetrical thread shape. **Fig. 5b** Symmetric "machine" thread shape.

Fig. 6: **Tap for precutting the thread** which was identical to the one of the screw.

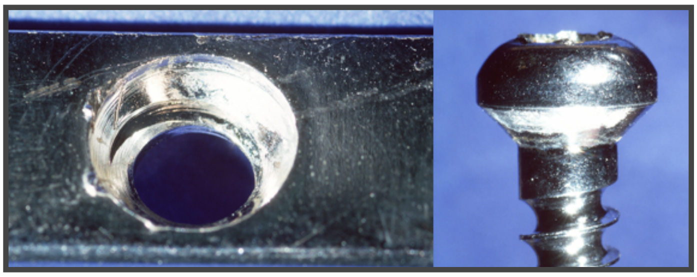

Fig. 7: **Initial AO screw to plate connection.** It consisted of a 90o precise conical fit. (Müller et al. 1963)

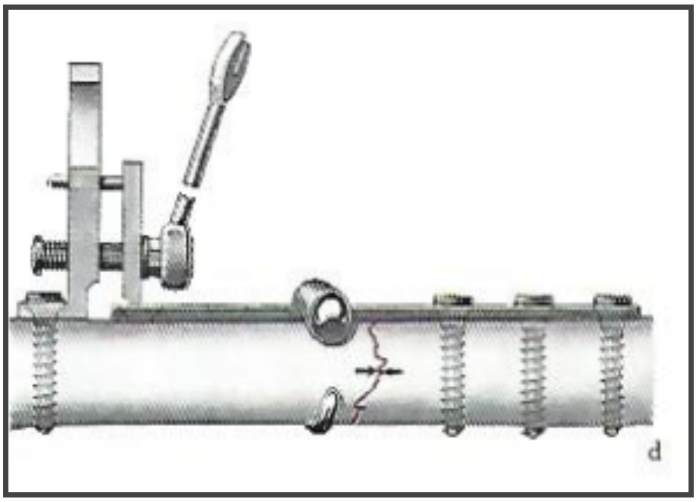

Fig. 8: **AO-Removable compressor** which allowed to compress the fracture as developed by Müller and Mathys (Müller et al. 1963).

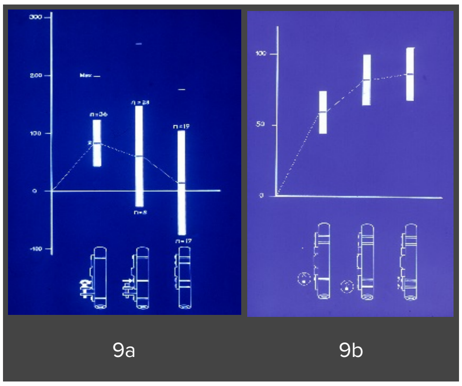

Fig. 9: **Observation by Cordey and Perren which led to the development of the DCP. Fig. 9a:** the compression exerted by tensioning the removable compressor followed application of screws in the round hole plate. **Fig. 9b:** Compression exerted at consecutive installation of DCP screws in eccentric position. (Cordey, J., et al. 1973)

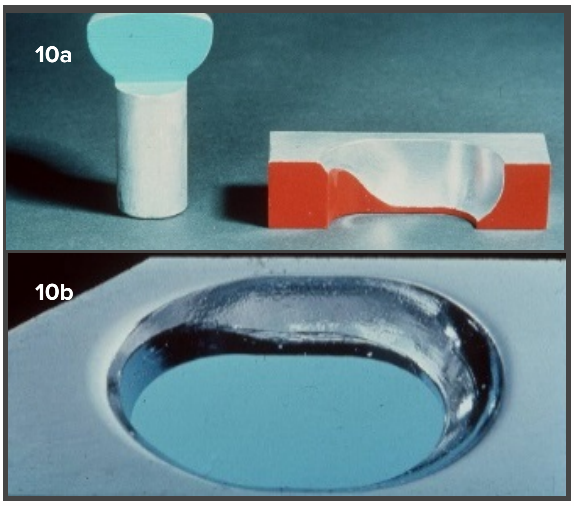

Fig. 10: **The Dynamic Compression Plate. Fig. 10a** Cuts through screw and plate. The spherical connection allowed to incline position of the screw while maintaining a perfect fit. In addition, the slope within the plate allowed to compress the fracture when the screw was driven home from an eccentric position. **Fig. 10b** shows the corresponding screw hole in the DC Plate. (Perren S. M., et al. 1969)

ICUC ID: 32-SI-436

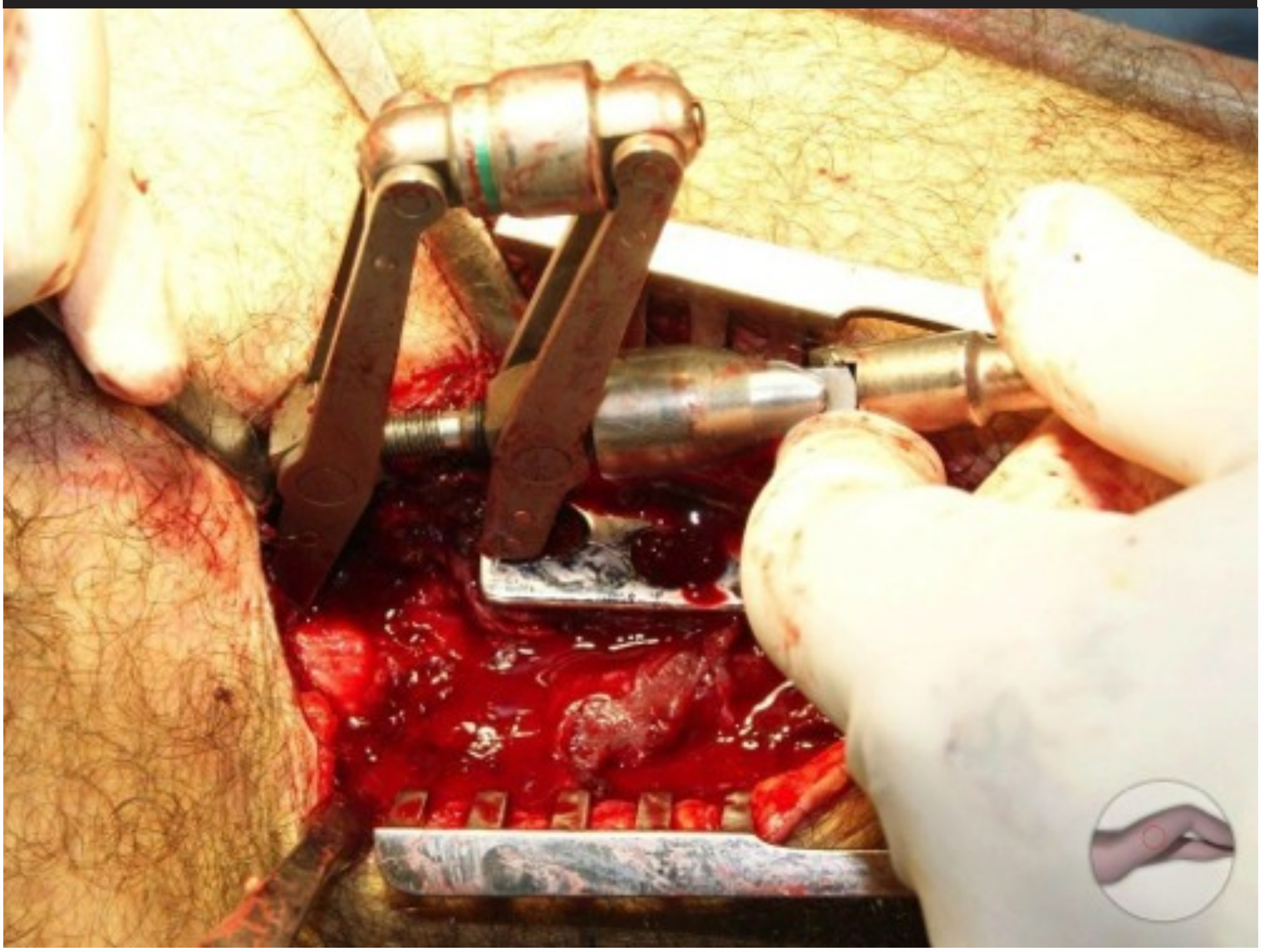

Fig. 11: **The use of the removable compressor for large distance reduction.** The picture is one out of 273 pictures of the surgical procedure of the case ID: 32-SI-436. The surgical procedure is recorded in detail and accessible through the use of the ICUCapp www.icuc.net: *ICUC Library/Femoral Shaft/Simple.* For reduction of less than 2 mm the consecutive use of the DCP does not require the removable compressor.

Fig. 12: **DCP straight plate, 4.5mm, c.p.Titanium, anodized.**

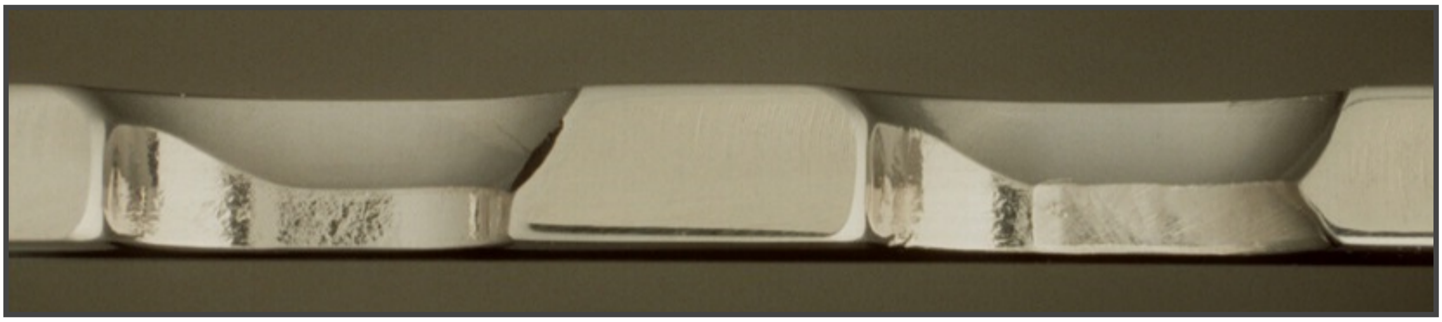

Fig. 13: **DCP cut open, at the left the inclined slope allowing compression,** the horizontal part allows gliding when a subsequent screw compresses.

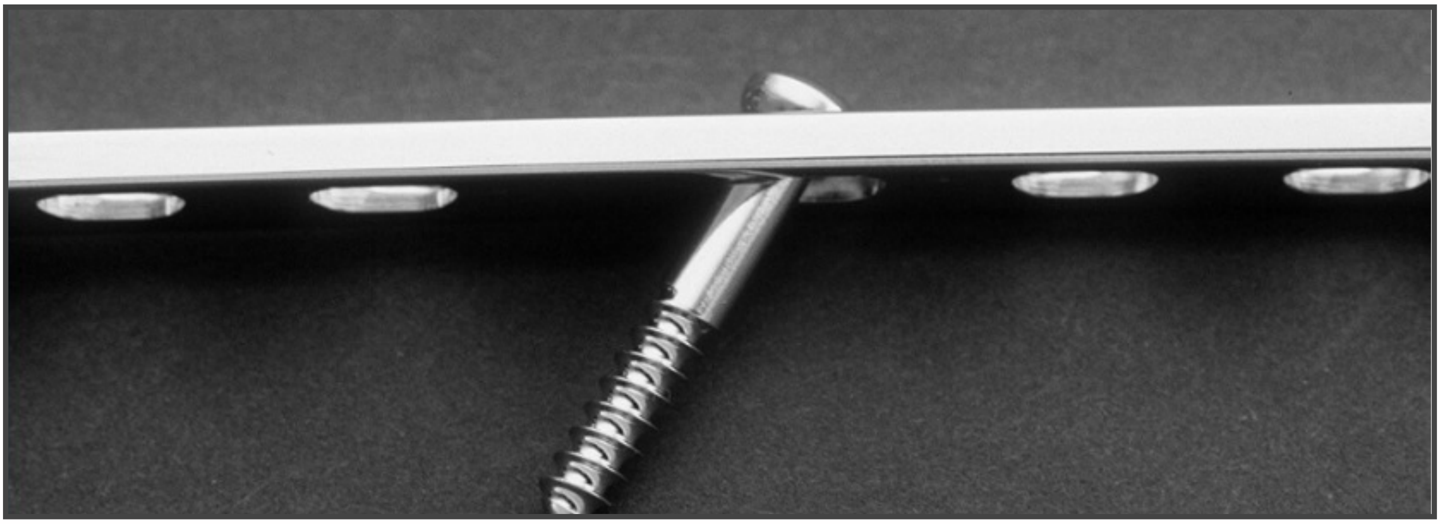

Fig. 14: **DCP with inclined lagged plate screw.** A large amount of inclination allows interfragmentary compression of an oblique fracture plane.

References

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