Evolution of Bone Screws with special reference to AO screws

Part 2: Locked Plate Screws

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The goal of modern fracture treatment is early regaining function with optimal biology and induction of fracture healing *(1)*. Today the tool to reach this goal is the internal fixator.

While absolute stability of surgical fracture fixation allows early function and healing in mechanically neutral condition, it lacks proper **induction** of the repair process *(2)*.

Implant contact damages blood supply, results in early temporary bone loss *(3)* (Fig. 1) and possible sequestration. Minimizing or preventing **contact** at least of the main splint (plate, nail) *(4, 5)* is a biological goal. This goal is reached using locked plate screws.

Flexible fixation allowing limited mobility of the fracture should install deformation of the repair tissue to induce healing and still allow bone bridging. The strain theory gives guidelines for understanding and optimization. The strain theory addresses the critical tissue deformation which is not defined by the terms of mobility of fracture or lack of stability of fixation *(6)*.

The conventional plate fixation *(2)* couples bone and plate through **friction**. The internal fixator couples bone and plate through screws acting as bolts.

Reduced bone contact is achieved through undercuts as demonstrated *(7, 8)* and the data questioning the effect of undercuts *(9, 10)* is explained based on different contact area depending on the relation of the curvature of the under surface of the plate and surface of the bone *(7)*. Figures 2 to 5.

The disadvantage of contact necrosis is less the loss of bone itself but the reduced resistance to infection due to necrosis with possible sequestration. The minimal distance to allow blood supply between implant and bone is a fraction of a millimetre.

Shaping the plate to precisely fit the bone is not required when using locked screws. Locking is a prerequisite to using uni-cortical screws which may be self-threading or additional self-drilling. The length of uni-cortical screws is not critical as the tip of such screws may protrude more or less into the medullary cavity.

The Point Contact Fixateur (PC-Fix) was an innovative and simple to handle solution, proven by unique follow up in clinical tests demonstrating excellent infection resistance and safe healing. The PC-Fix is an internal fixator improving surgical application of earlier designs like Zespol *(11)* and Mast-Schuhli *(12)* and later LISS (Figures 6 and 7). The PC-Fix was not accepted by industry as its principle and solution demanded basic biological and biomechanical understanding (Figures 8 to 10). Thus, it remained prove of concept until recent rebirth Tepic pers com. The elevation of the PC-Fix under surface permits better blood supply but also allows for callus bridging of the near cortex. Tepic demonstrated solid healing within 10 weeks when clinical experience does, as a safety rule, wait for two years to remove conventionally applied implants *(13)*.

The LCP takes advantage of so called combiholes (Fig. 11), a combination of conventional fixed angle locked screw and the compression component of the spherical principle of the DCP *(14, 15)*. The LCP allows three different applications of plate screws:

- a locked screw applied in orthogonal position (Fig. 12 *ICUC® ID: 22-OB-019* image 67 out of 105) *(16,17)*
- a conventional screw for compression (Fig. 13 ICUC® ID: 22-GA-955 image 52-55 out of 106) and
- a conventional screw in neutral position (Fig. 14 ICUC® ID: 42-SI-754 image 55-57 out of 192), a mechanical advantage and a biological shortcoming.

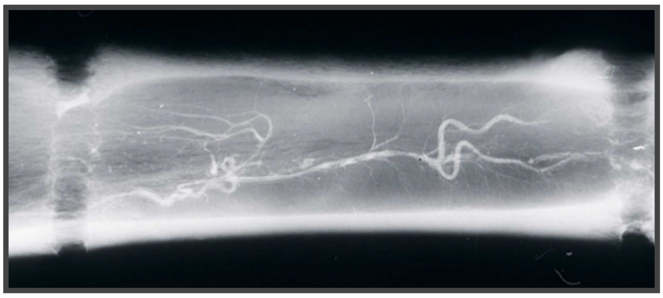

***Fig. 1:* Early temporary porosity in the near cortex in plated bone** segment of sheep about 2 months after plate fixation (courtesy of R. Ganz).

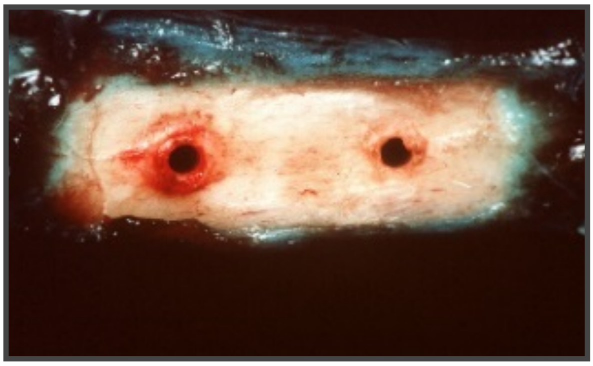

***Fig. 2:* Large contact damage to periosteal blood supply,** DCP, fitting radii of plate and bone *(7)*.

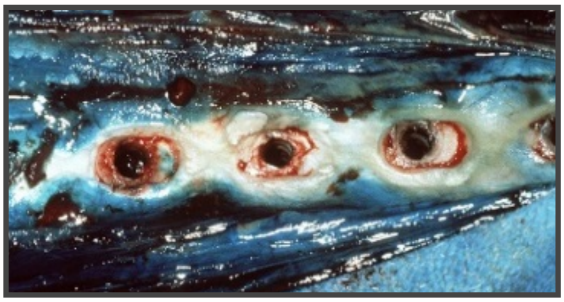

***Fig. 3:* Limited contact damage,** LCDCP, radius of plate under surface curvature larger than radius of bone surface. The under cuts have a small effect *(7)*.

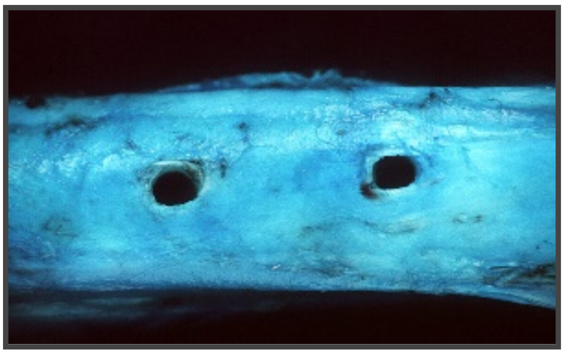

***Fig. 4:* No contact,** elevated plate, fixator interne, no damage to periosteal blood supply *(7)*.

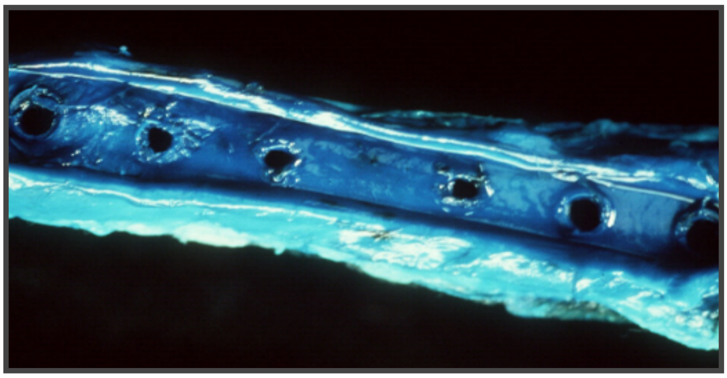

***Fig. 5:* Undisturbed blood supply** beneath the elevated plate *(7)*.

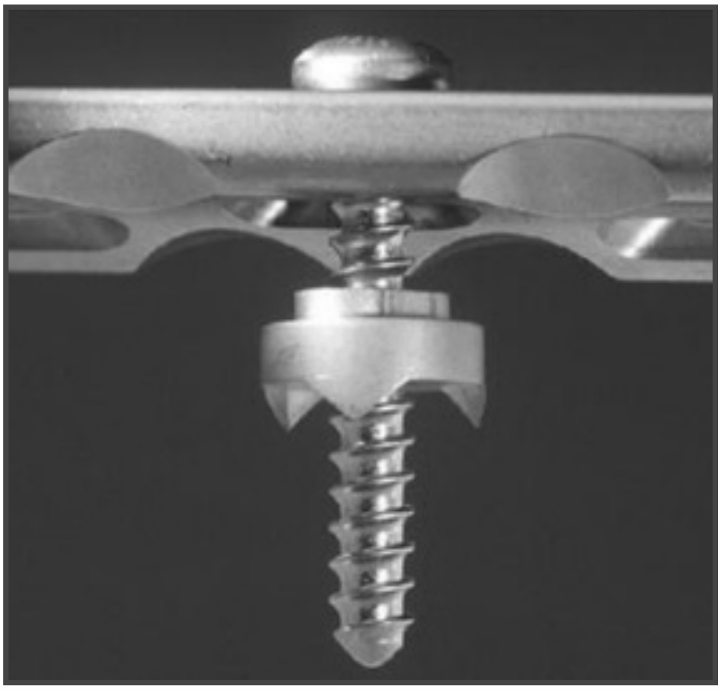

***Fig. 6:* Schuhli** (Mast) (Kolodziej et al. 1998).

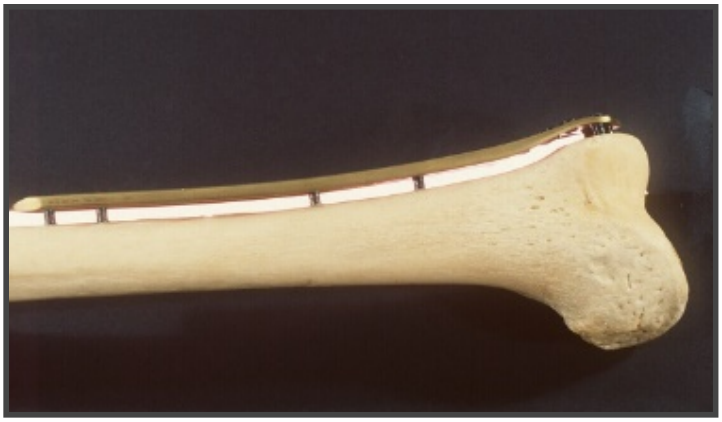

***Fig. 7:* LISS Locked screws** allow fixation in elevated position.

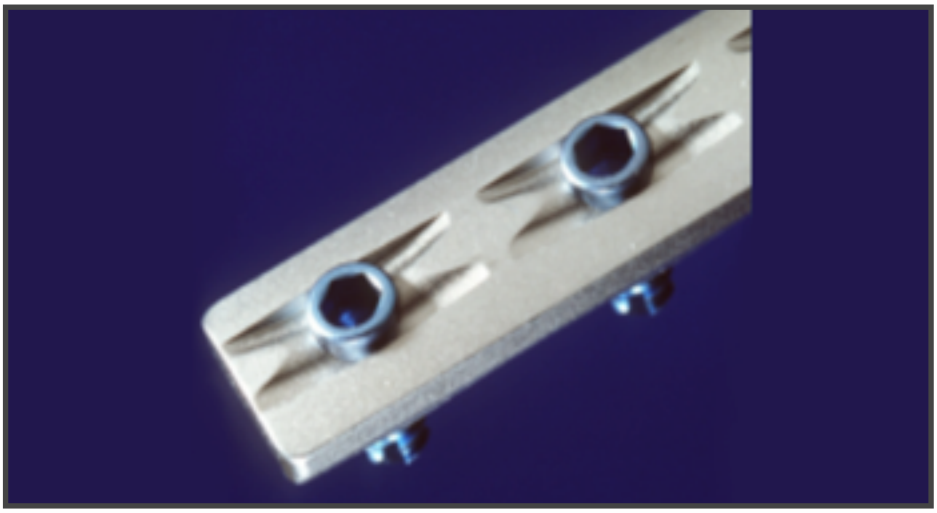

Fig. 8: **PC Fix.** The plate acting as an internal fixator is undercut on both surfaces (Fig. 9 and Fig. 10).

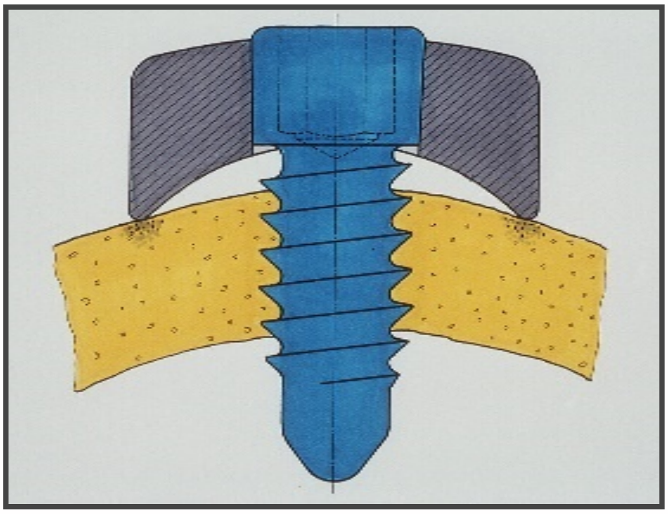

Fig. 9: **PC-Fix** schematic cross-section showing the minimal contact points, which serve to hold position during tightening.

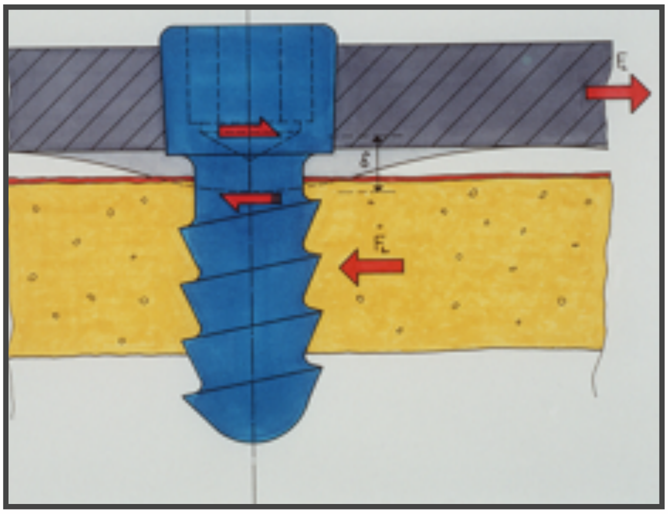

Fig. 10: **PC Fix.** schematic longitudinal cut.

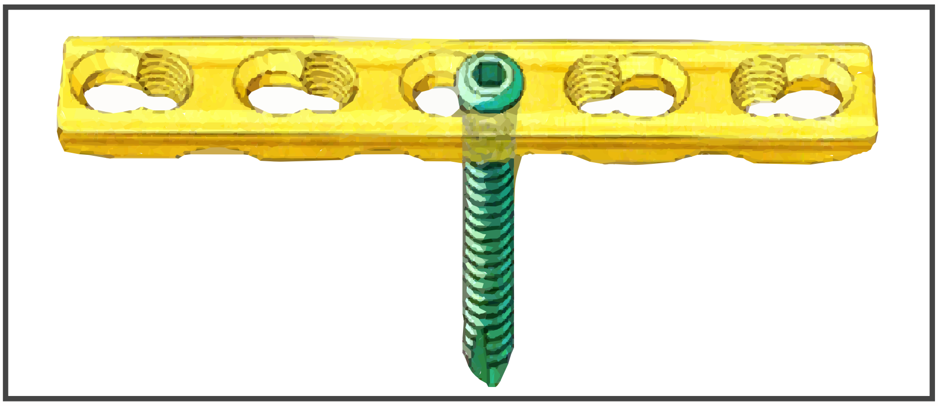

Fig. 11: **LCP with screw** in locked position.

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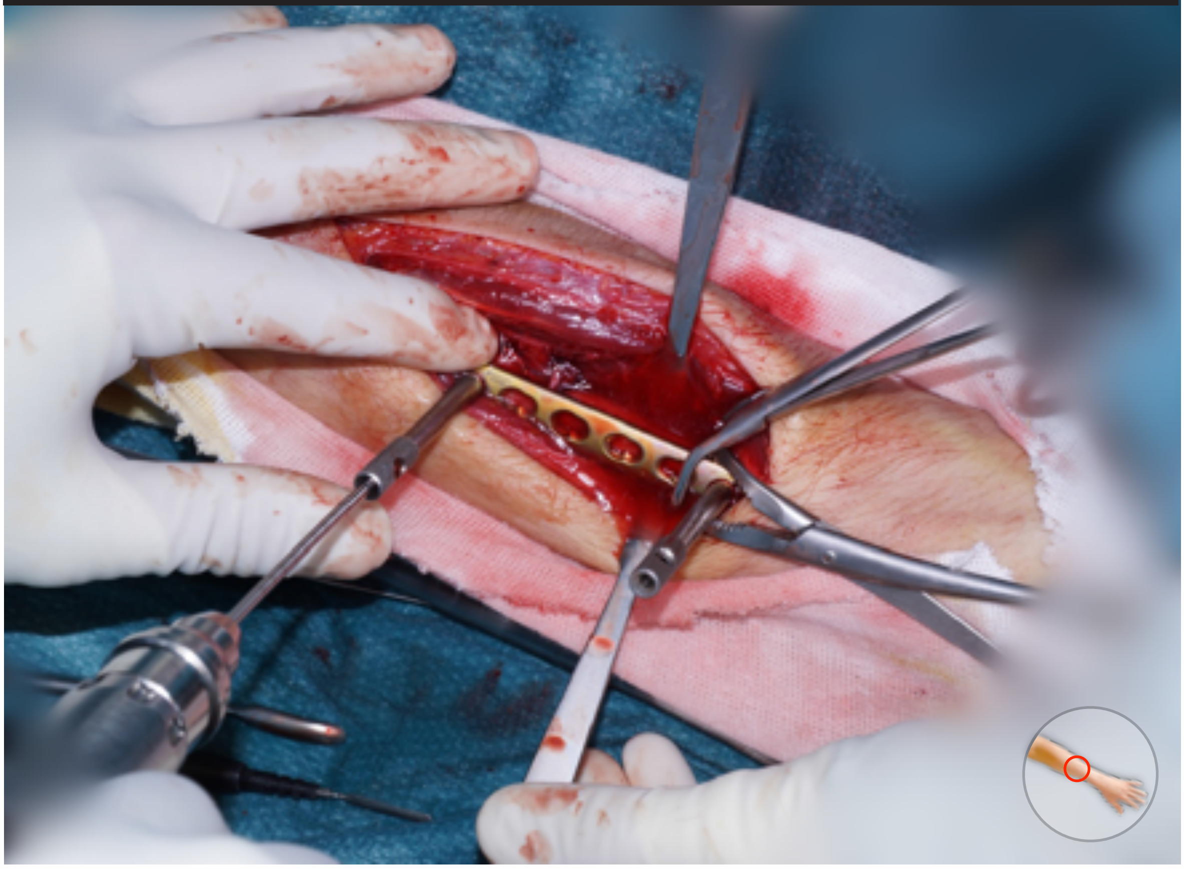

Fig. 12: **A locked screw applied in orthogonal position.** Picture 67 out of 105, *ICUC App® case ID: 22-OB-019.*

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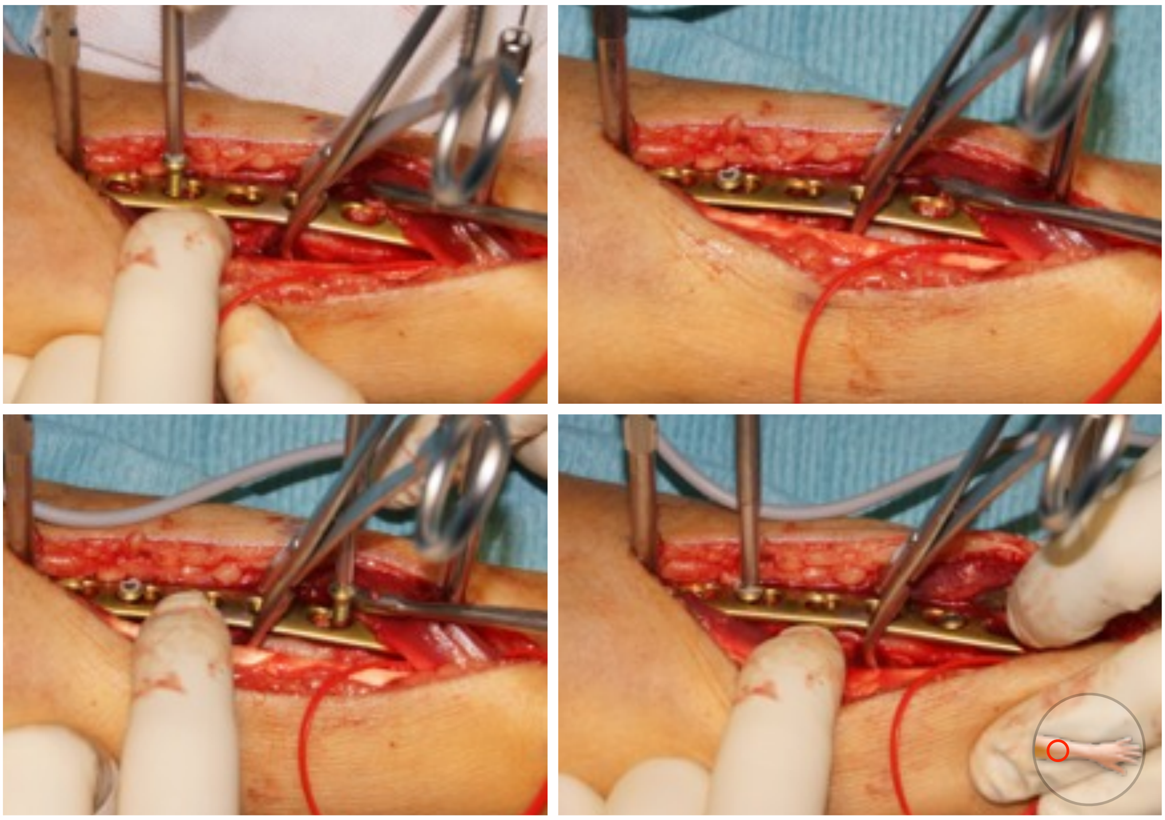

Fig. 13: **A conventional screw for compression.** Pictures 52-57 out of 106, *ICUC App® case ID: 22-GA-955.*

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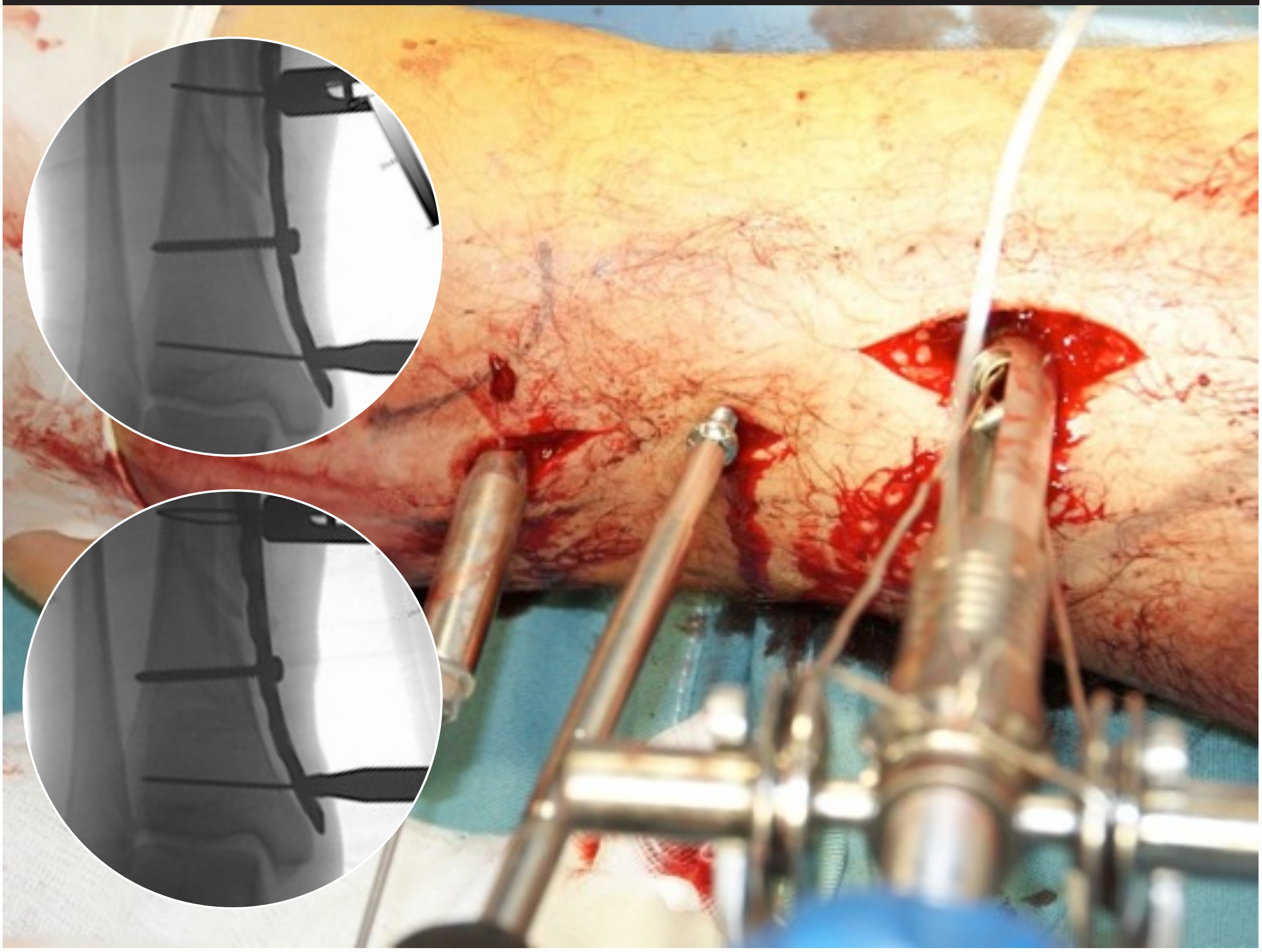

Fig. 14: **A conventional screw in neutral position,** a mechanical advantage and a biological shortcoming.
Pictures 55 to 57 out of 192, *ICUC App® case ID: 42-SI-754*.

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