Variable Angle Locked Screw (VAL): from concept to application

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Problem: Locked plate-screw constructs, a technology that improves biology of internal fixation, is widely accepted. Understanding of biology and biomechanics is a prerequisite to obtain optimal results *(1–9)*. For reliable stabilization, locked screws need to provide solid and maintained anchorage to plate and to bone and their application needs to be forgiving. Fixed Angle Locked screws (FAL) do function only when perfectly aligned with the axis of the screw hole[1] (Fig. 1). The fixed angle does not allow to avoid areas of bone that lack providing good anchorage like fracture planes, or fragmented bone (Fig. 2). Furthermore, when stabilization of a small articular fragment is required fixed angle locked screws do not allow ideal inclination and screw positioning which provides good anchorage in the small fragment (Fig. 3) and avoids tip penetration into the joint (Fig. 4). The FAL in the PHILOS plate may even obstruct application of the calcar screw (Fig. 5).

Solution: The conical outline of the threaded connection between screw head under surface and plate hole of the fixed angle locked screw (FAL) does allow inclined insertion but it loses solid coupling when the mismatch *(10)* is greater than only 2 degrees (Fig. 6) *(11)*. Application avoiding such mismatch even with proper instruments and experienced surgeons is rather the exception than the rule ("inadvertent tilt"). With an outline of the threaded connection that is rather spherical than conical (Fig. 7), like in the Variable Angle Locked screw (VAL), the range of inclination providing solid coupling is extended to about 15 degrees (Fig. 8) *(12)* which makes the technique more forgiving.

Advantages and disadvantages: With a range of solidly connecting inclination of 15 degrees it is possible to avoid with the tip of the screw fragmented bone areas, improving fixation (Fig. 9). Furthermore, the mentioned inclination allows to establish solid anchorage in small articular fragments while avoiding penetration into the joint with its deleterious consequences (Fig. 10).
At exactly neutral[2] inclination, the VAL screw provides only a slightly smaller locking quality when compared to the FAL screw.

A subjective disadvantage of the VAL vs. the FAL has been voiced ("I want to keep the info of the ideal screw position as a guide to judge how good was my fracture reduction and plate position"), according to which the surgeon knows better the final position of the screw tip when the inclination is limited to the neutral position. The latter "feeling" can be obtained when using the VAL together with the neutral drill guide (Fig. 11).

Construction of the VAL: The outline of the threaded part of the screw head undersurface is spherical and lends itself to allow inclined application (Fig. 7). The screw hole with its spherically outlined threads is divided into four parts whereby the cut-outs are aligned along the long axis of the screw hole. The latter improves the solid locking at inclined position while it reduces slightly the locking quality in perfectly aligned orientation of the screw axis to the screw hole axis *(12)*.

Conclusion: VAL allows to optimize locked screw tilting according to surgeon's needs and the range of safe inclination, as allowed by the outline of the plate hole, makes the technique more forgiving and even allows free-hand application of the VAL screw. If such application is considered, the next step could well be to replace the FAL throughout by VAL.

1 The plate hole may be inclined in relation to the plate therefore, the inclination of the screw should always relate to the plate hole axis and not to the plate.
2 The expression «neutral» is used here to indicate that the long axis of the screw is perfectly aligned with the axis of the plate hole.

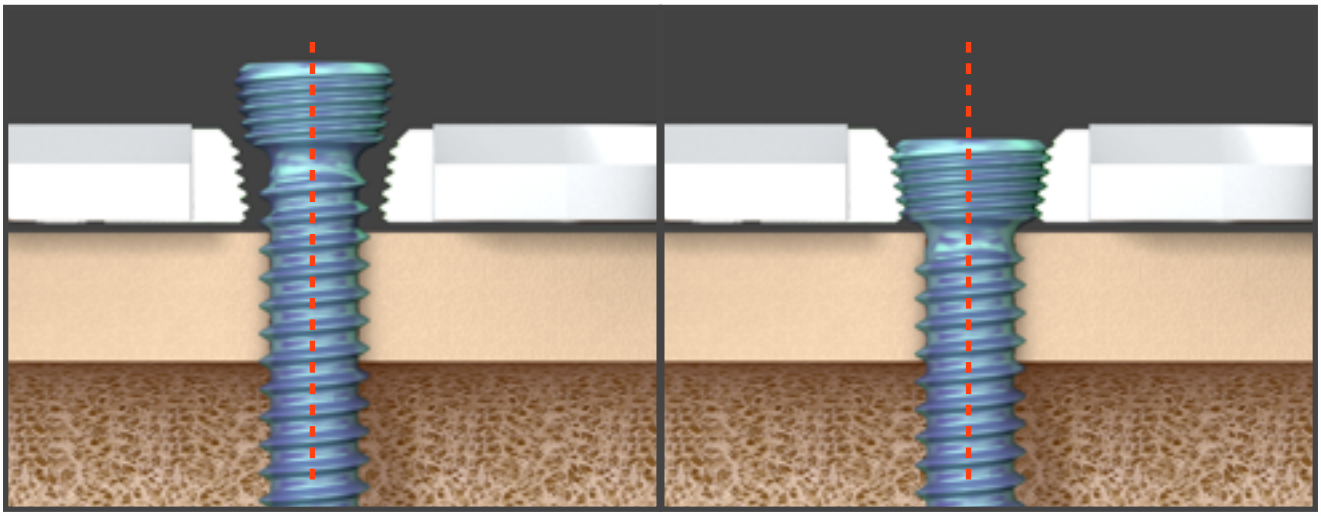

Fig. 1: Fixed angle locked screw perfectly aligned with the axis of the plate hole. This is the only position which provides solid locking of the FAL.

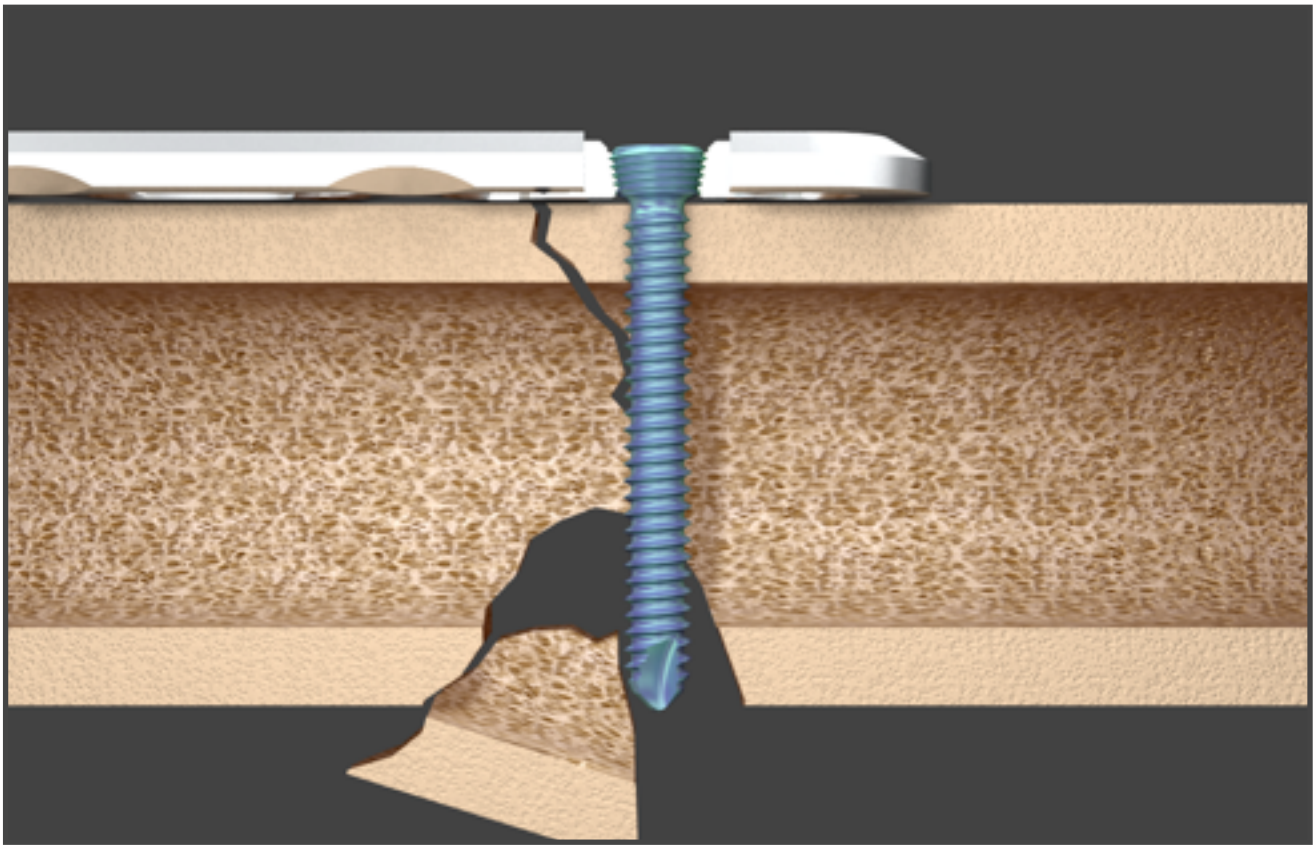

Fig. 2: The tip of the FAL screw is positioned in an area of bone which does not provide solid anchorage.

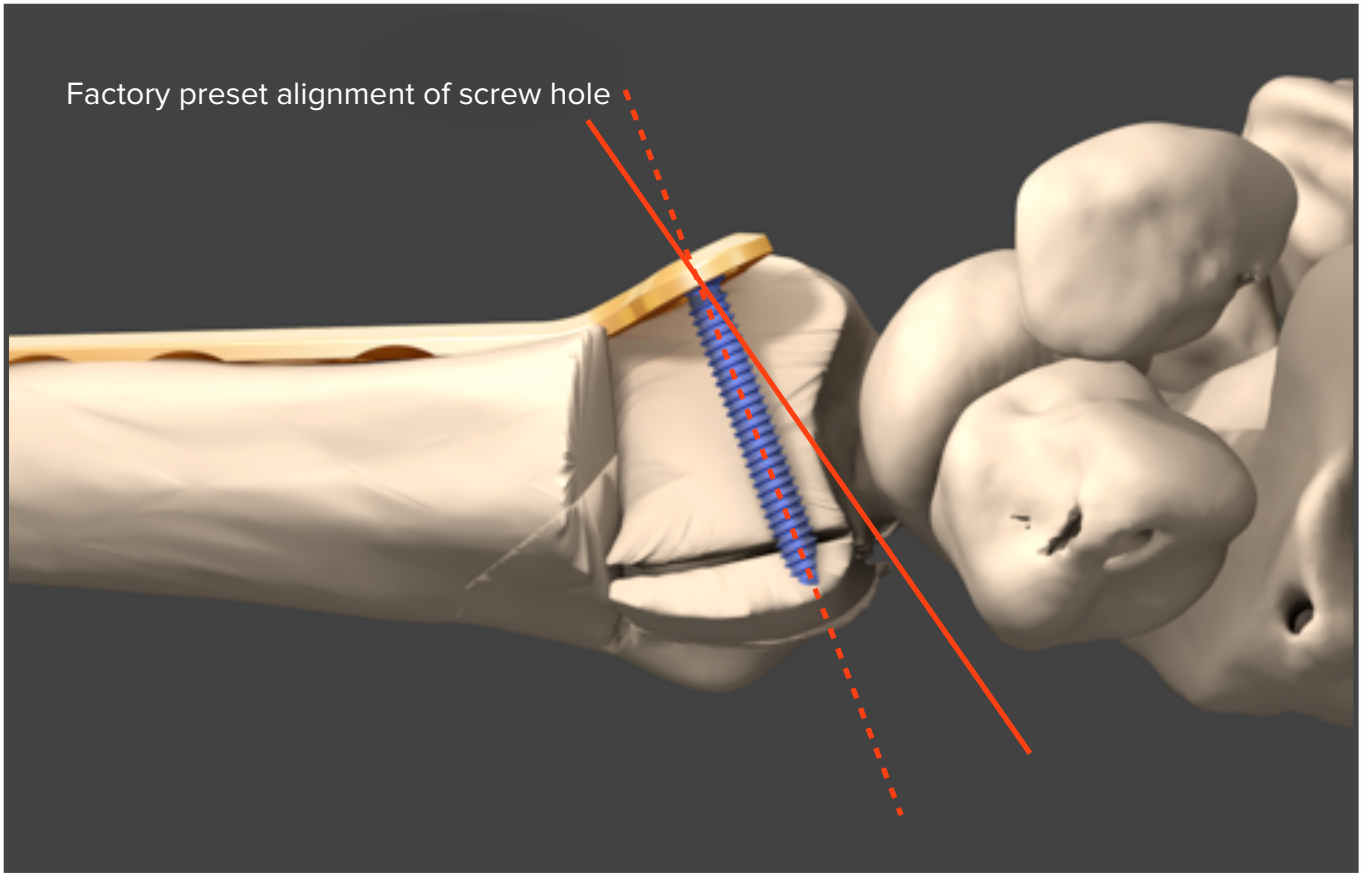

Fig. 3: For optimal anchorage the tip of the screw needs to be positioned well within the small fragment (dashed red line). The fixed angle screw (continuos red line) may not allow to reach this position.

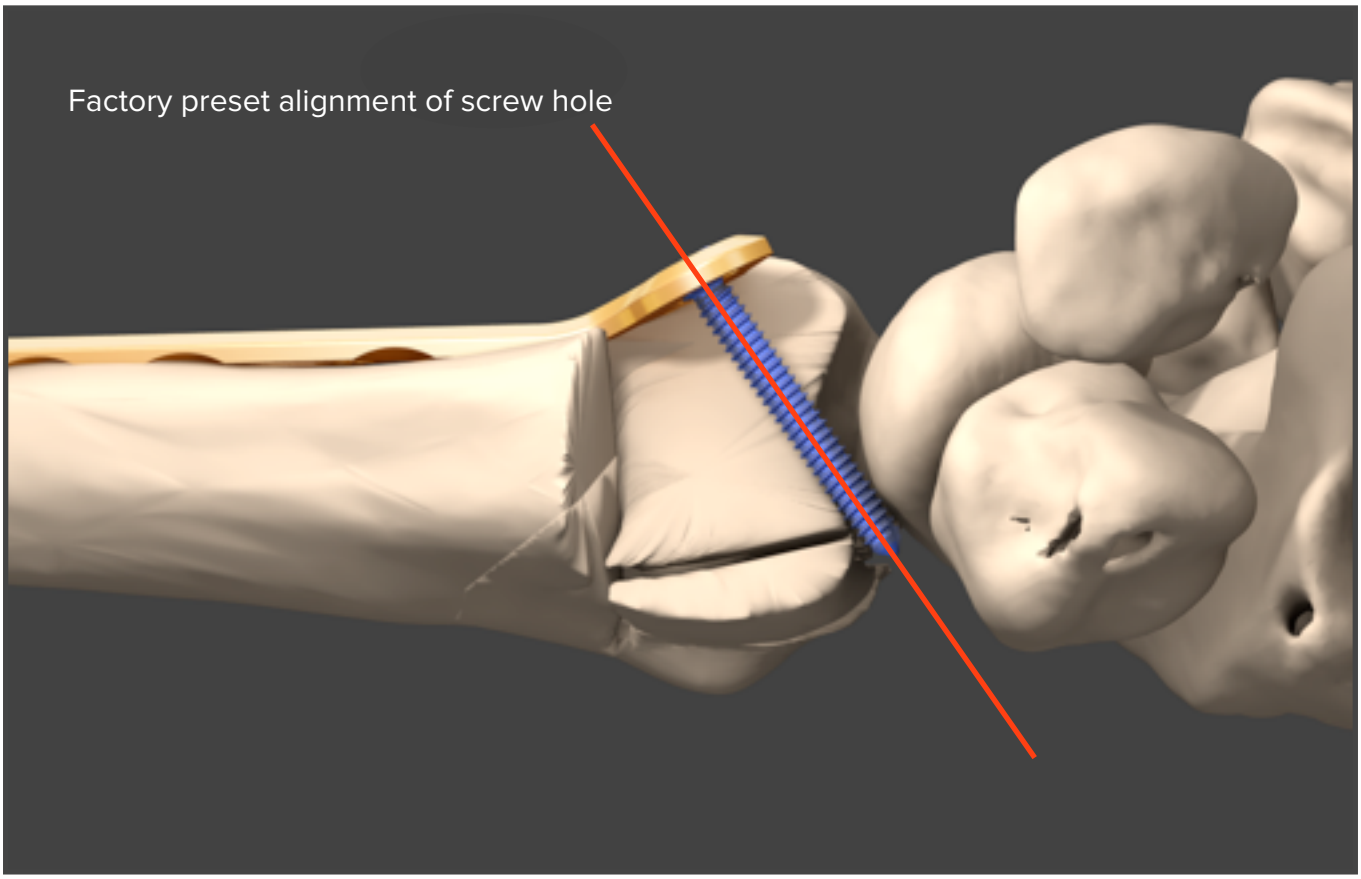

Fig. 4: The tip of the screw is penetrating into the joint. The fixed angle screw may no allow to prevent this.

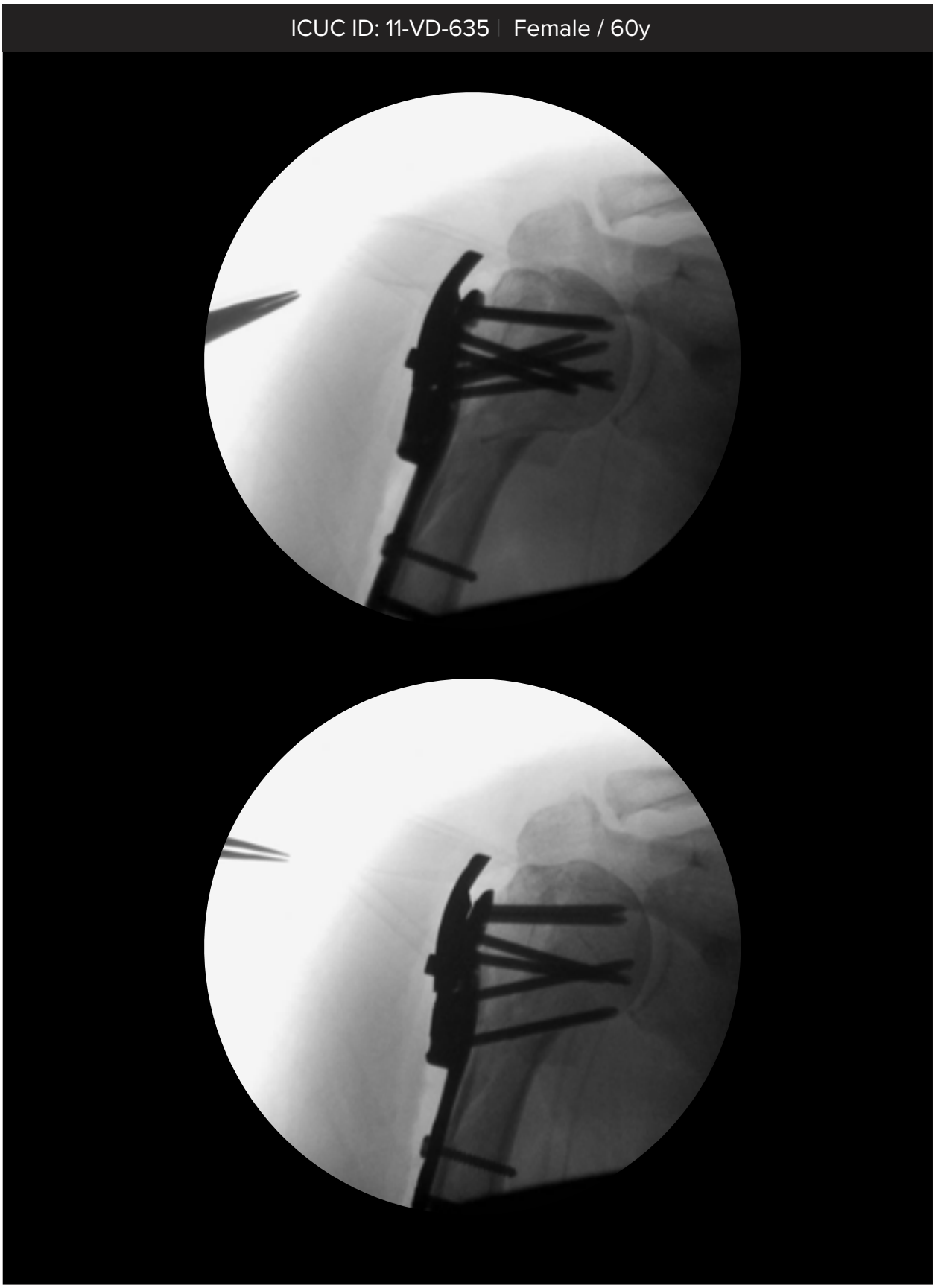

Fig. 5: The PHILOS holes are FAL and could not be inserted. If the plate is positioned too high or too low, or in specially tall or short individuals, the FAL calcar screw cannot be correctly placed.

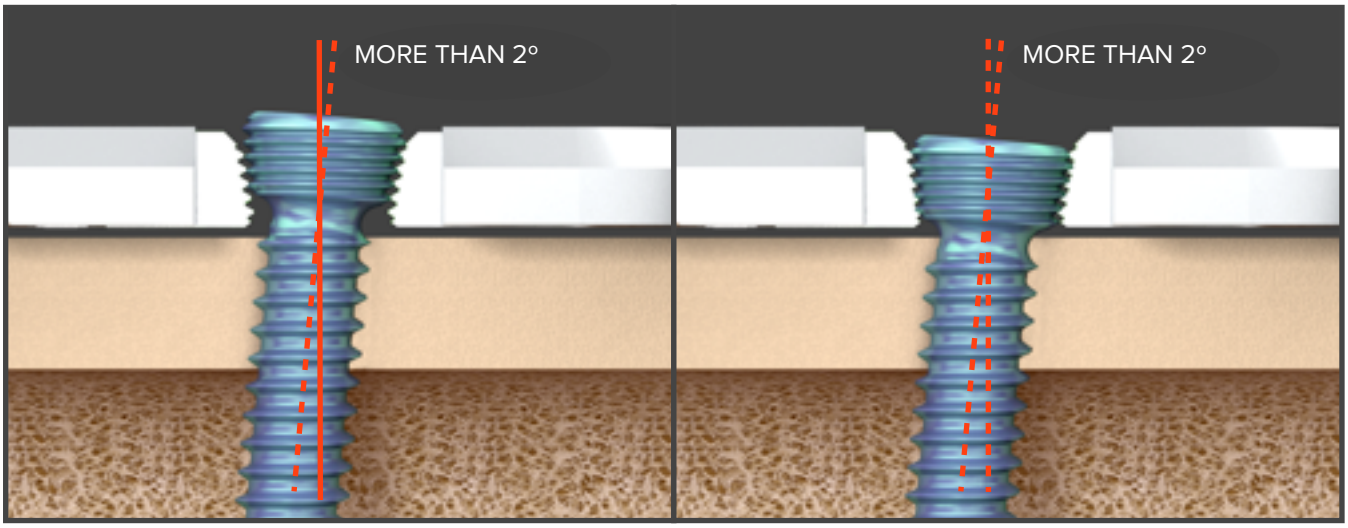

Fig. 6: Slightly inclined position of the FAL; with a mismatch of more than 2 degrees off the neutral position the FAL loses solid coupling, i.e. does not function properly.

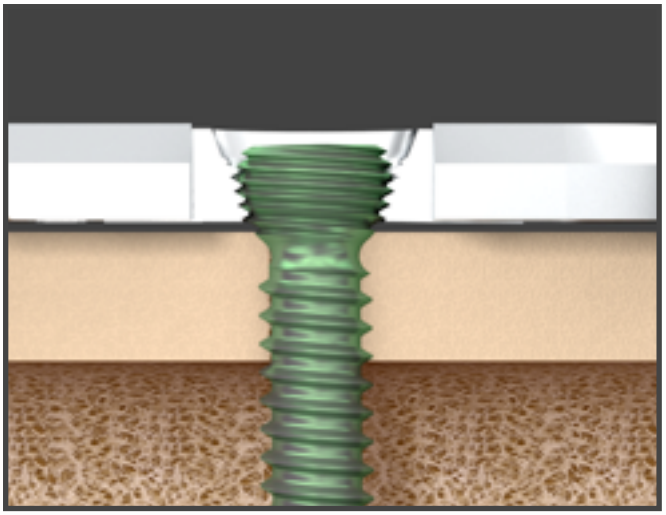

Fig. 7: The spherical outline of the screw head undersurface is the basis of solid coupling when inclined.

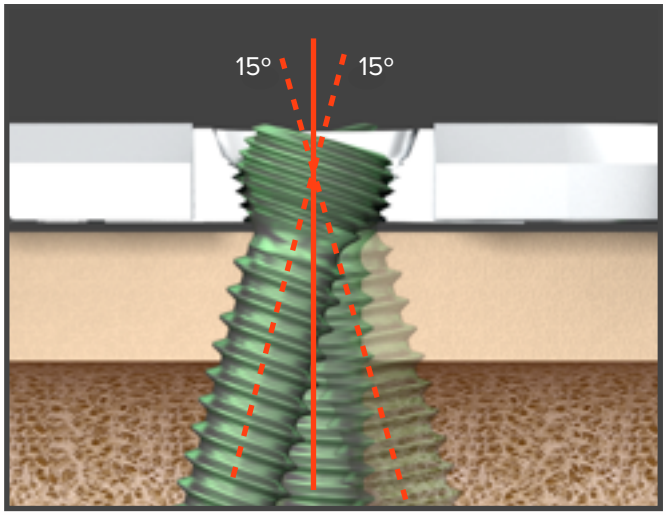

Fig. 8: The spherical outline of the VAL allows tilting to +/- 15 degrees maintaining solid coupling.

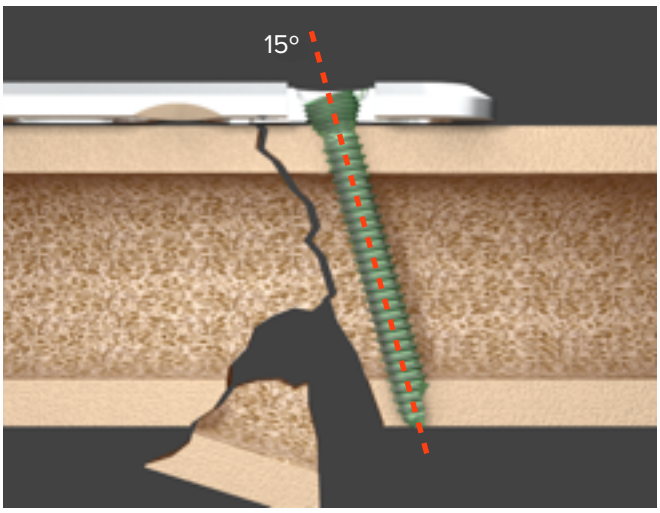

Fig. 9: The allowed tilting of the VAL screw allows improved anchorage avoiding the fragmented bone area.

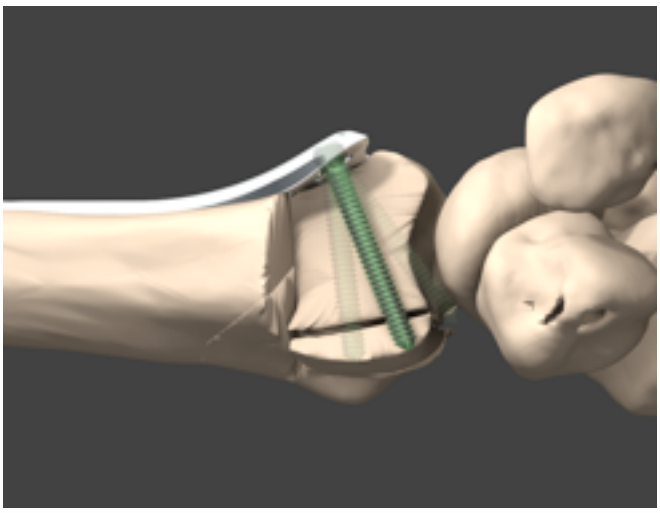

Fig. 10: Tilting allowed by the VAL allows to prevent penetration into the joint.

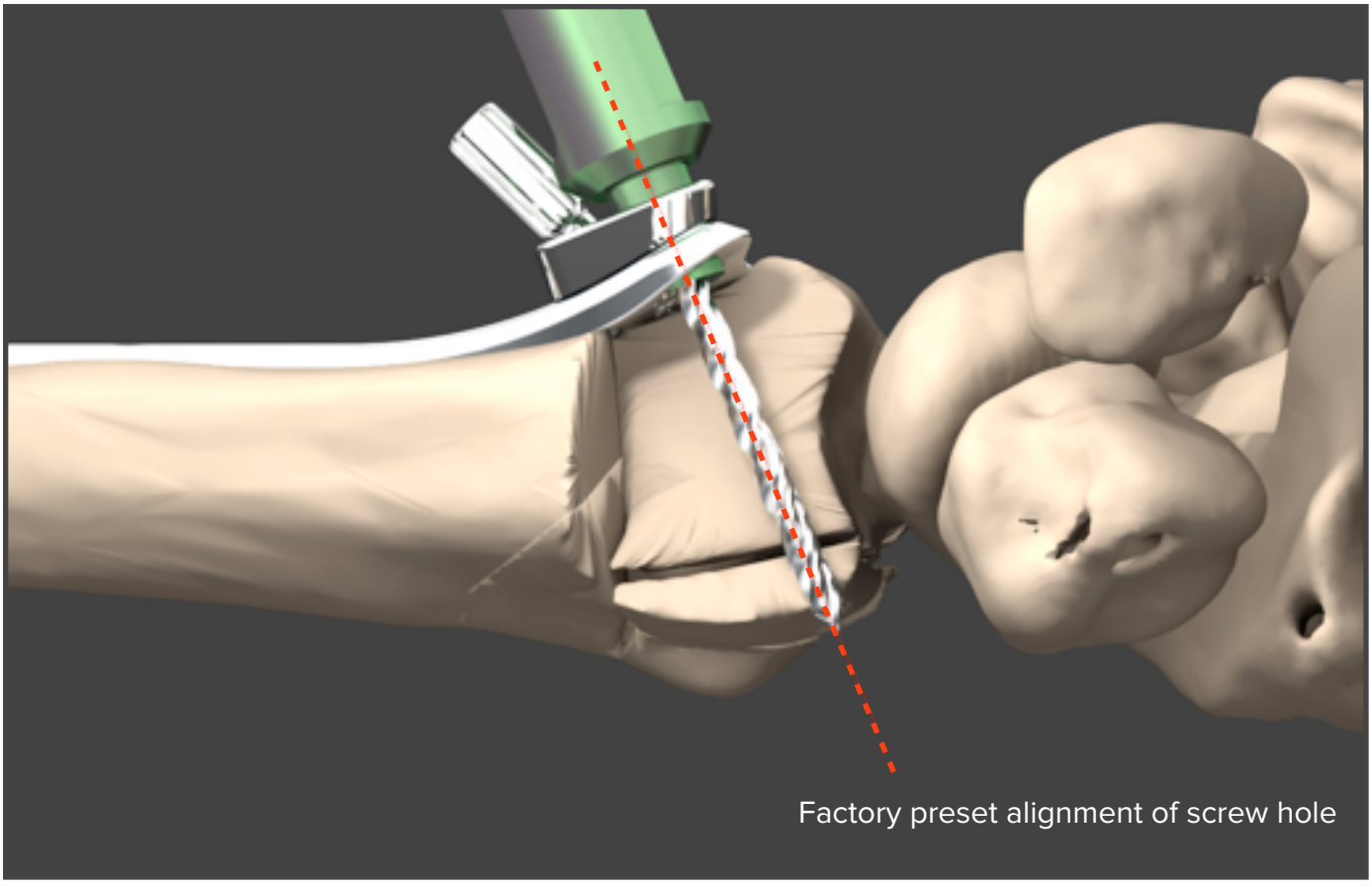

Fig. 11: The perfect neutral position of the VAL can be easily obtained using the guiding block.

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