Introduction:
Anterior spinal instrumentation of the thoracic and lumbar spine has gained in popularity since Dwyer et al [1] developed the cable system in 1964. However, implant loosening, screw breakage and cut-throughs have been noted clinically when using Dwyer or Zielke's Ventrale Derotations Spondylodes (VDS) instrumentations [2,3]. To avoid these complications and pseudarthrosis, one may use an anterior vertebral screw to penetrate the second cortex, or even a double-screw instrumentation using two parallel and penetrated screws to provide a stronger fixation. Bi-cortical screw purchase of vertebral body in anterior spinal fixation is well recognized to achieve optimal stabilization of implants [4]. However, the potential hazards of penetration of anterior vertebral cortex screws that might cause neurovascular or organs injuries.

Methods:
In the current biomechanical study, single-screw with bi-cortical purchase and various modes of double-screw fixation in anterior vertebral bodies were done using Trifix vertebral screws (San Andrio, CA, USA, Fig. 1.A) to assess the biomechanical stability of each fixation mode. The pullout forces of two parallel or triangulated anterior double-screw fixation with uni-cortical or bi-cortical purchase, were compared with that of single-screw with bi-cortical purchase. Four porcine spines were used for biomechanical analysis and bone mineral density was measured on each individual specimen before test. Single-screw with bi-cortical purchase and double-screws with 4 different modes of fixation which includes group A: triangulated with one screw penetration; group B: triangulated with no screw penetration; group C: two parallel with two screws penetration; and group D: two parallel with no screw penetration, were sequentially allocated into T11-L6 (totally 31 vertebrae) vertebrae. The experimental set-up were shown in Fig. 1.B and Fig. 2.

Results:
As shown in Fig. 3, the mean maximum pull-out forces for Groups A to D of the double-screw fixations and the single-screw with bi-cortical purchase were 3,283 ± 553 N, 2,717 ± 250 N, 2,450 ± 327 N, 2,067 ± 211 N and 1,700 ± 490 N, respectively. The results demonstrate that the magnitudes of pullout force for various double-screw fixation modes are significantly higher as compared to the mode of single-screw bi-cortical purchase (p<0.05). However, in pullout tests of double-screw fixation, there is no statistically significance between group B and group C (p=0.144).

Discussion:
In anterior vertebral double-screw fixation, the triangulated with no screw penetration mode can achieve ideal stability as those of two parallel with two screws penetration mode that is commonly advocated clinically. Therefore, the risks of placing anterior vertebral screws with cortical penetration can be avoided.

References

Fig. 1(A) The implanted vertebral screw and (B) of single-screw fixation mode.
Fig. 2. The pullout test vertebral screw and (B) of single-screw fixation Experimental set-up for triangulated implantation.

Fig. 3. The pullout forces of the single-screw with bi-cortical purchase and double-screw with four modes of fixation.

**Department of Biomedical Engineering, Chung Yuan Christian University, Chung-Li, Taiwan.