

Performance characteristics of the headless screws and HOLLYX® screws used in arthroscopic ankle arthrodesis

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INTRODUCTION

In arthroscopic ankle arthrodesis, screws are generally used for initial fixation. Proper synostosis depends on the appropriate alignment and inter-talocrural joint pressure force.

Different screws, including headless screws, can be used when applying this technique. Here, we report our experience of comparatively examining the results of a pull-out test (PO-T) and those of a compression test (CP-T) using simulated bones for five types of screws (two types of headless screws and three types of HOLLYX® screws used for the same procedure).

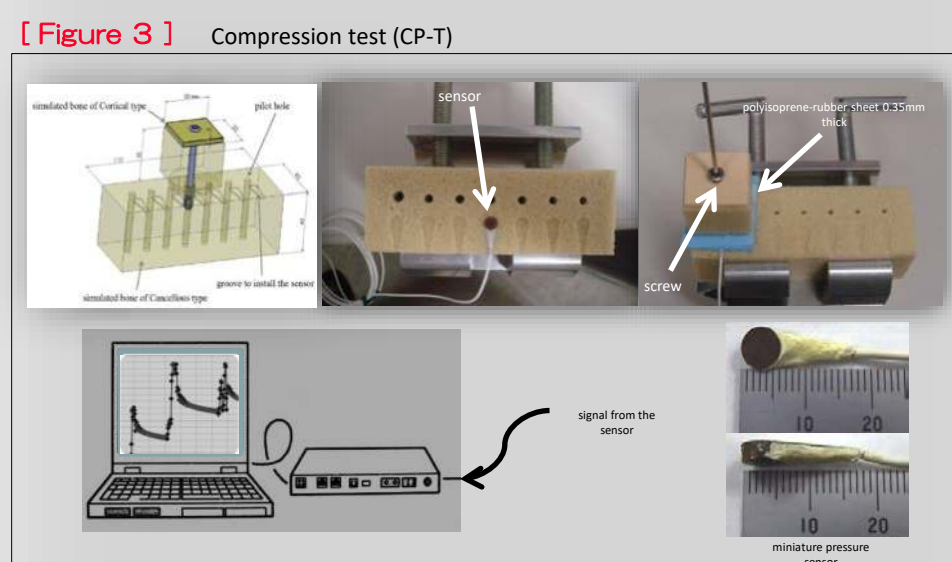
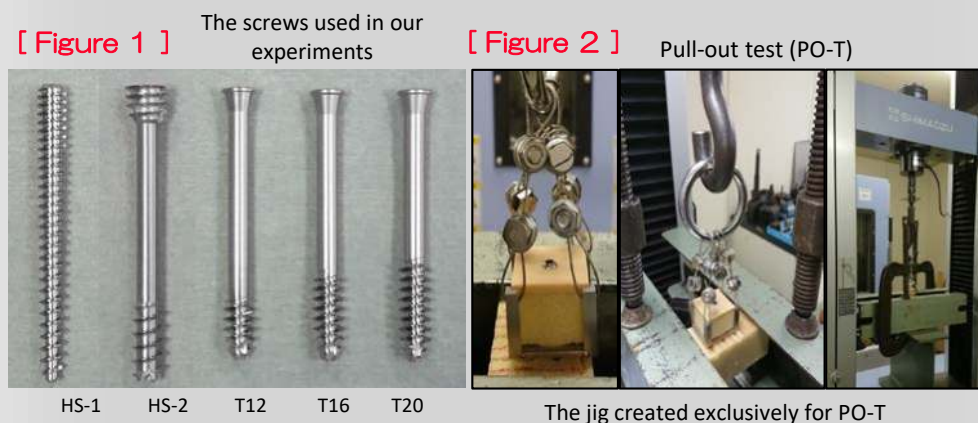
MATERIAL & METHODS

We used two types of headless screws (HS-1, HS-2) and three HOLLYX® screws [12-, 16-, and 20-mm threads (T12, T16, and T20, respectively)] (Fig.1). We used simulated bones processed similarly for PO-T and CP-T. After attaching the jig created exclusively for PO-T to the simulated bones, we inserted the screws and took measurements using a universal testing machine equipped with a 5 kN load cell (Fig.2). For CP-T, we used the same method as the poster presentation at the ORS 2015 and 2016 Annual Meeting (Fig.3). We performed three sets of PO-T and CP-T and compared the results.

Differences between screws were identified using one-way analysis of variance and Holm's multicomparison test. All tests were two-tailed. These data are presented as P values; P values of <0.05 were considered to be statistically significant.

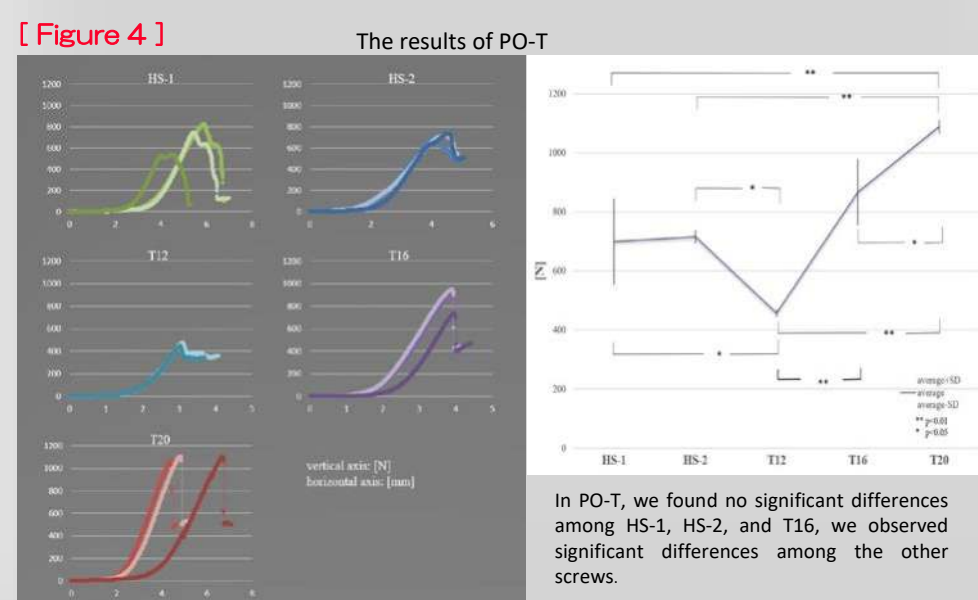
RESULTS

In PO-T, the mean values of HS-1, HS-2, T12, T16, and T20 were 699.760, 715.324, 457.745, 867.387, and 1087.947 N, respectively; although we found no significant differences among HS-1, HS-2, and T16, we observed significant differences among the other screws (Fig.4). In CP-T, the mean maximum pressures with HS-1, HS-2, T12, T16, and T20 were 0.545, 0.244,



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0.592, 1.320, and 1.729 MPa, respectively, and we observed significant differences among all the screws. The mean angles at which maximum pressure was reached with HS-1, HS-2, T12, T16, and T20 were 405, 225, 180, 210, and 225 degrees, respectively, with significant differences between HS-1 and the other screws but no significant differences among the other screws (Fig.5-1). Regarding the characteristics of the graph obtained, in the case of three HOLLYX® screws, the pressure suddenly dropped to 0 after the peak, but for both HS-1 and HS-2, the pressure did not decrease to 0 despite falling after the peak. Moreover, in the case of HS-1, the pressure tended to increase after the initial decrease (Fig.5-2).



In PO-T, we found no significant differences among HS-1, HS-2, and T16, we observed significant differences among the other screws.

DISCUSSION

Generally, the results of PO-Ts are used for screw performance evaluation, but the rank orders of screws were inconsistent between PO-T and CP-T. Therefore, it seems difficult to substitute the results of PO-T at least with respect to pressure force. However, substitution may be possible when threads of the same type differing only in thread length are to be compared.

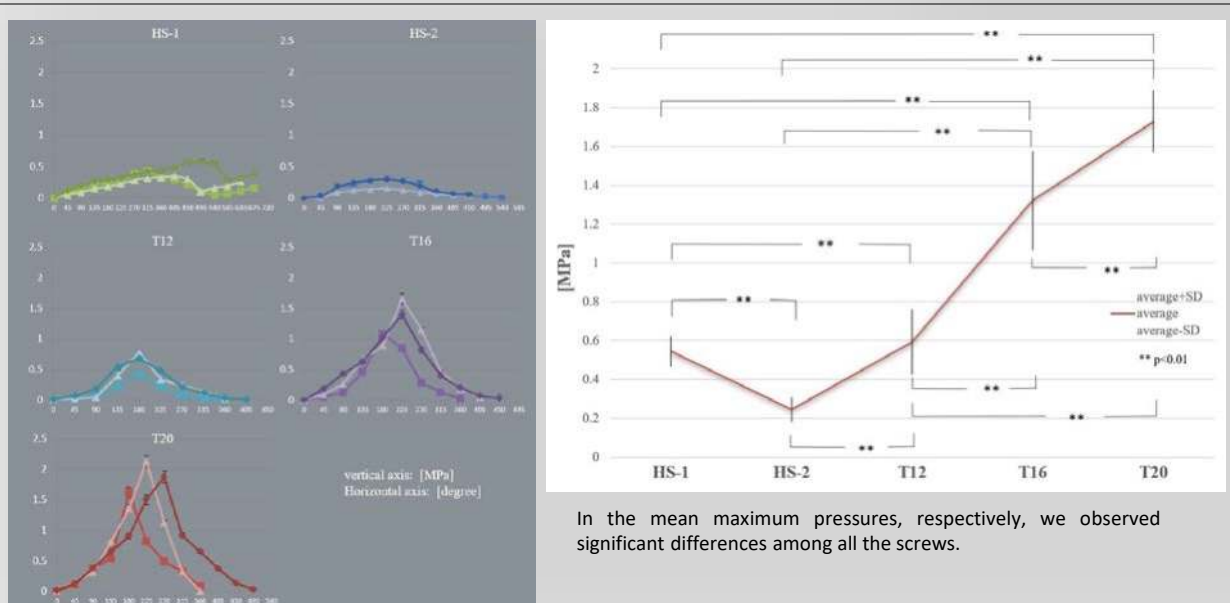
For initial fixation, it appears preferable to use T16 or T20 screws with high pressure force. However, considering that the pressure suddenly decreases after reaching the maximum pressure, the surgeon needs to estimate the approximate angle reaching the maximum pressure beforehand and pay attention to the excessive rotation of the screw. In contrast, when using HS-1 and HS-2 screws, according to our results, constant pressures can be expected even after excessive rotation, which appears to be an advantage, although the pressure forces were lower than those of HOLLYX® screws. Therefore, care should be taken after treatment by making adjustments by increasing the number of screws at the time of insertion or prolonging the duration of the nonweight-bearing period.

Limitations of this study include that our experiments allowed us to make comparisons wherein each screw was individually inserted vertically in the same way, but during actual surgical procedures, multiple screws are inserted obliquely. Therefore, clinical results should be examined to confirm that screws are actually beneficial for bone union.

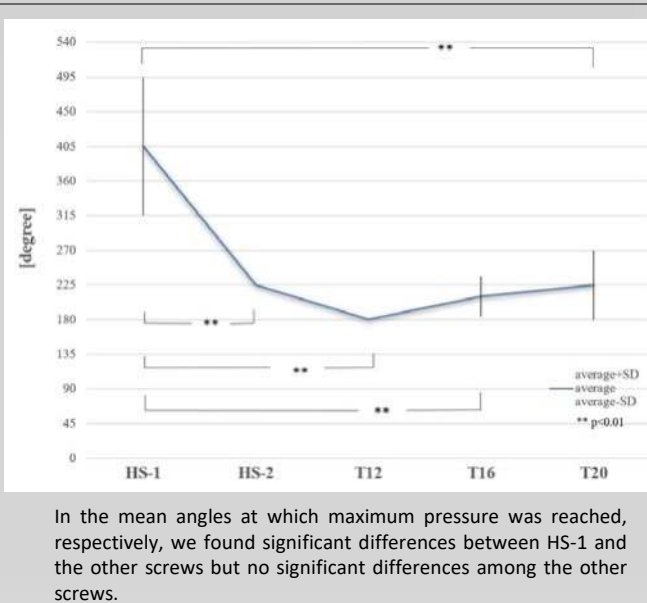
SIGNIFICANCE

The results of our PO-T and CP-T suggest that they cannot be regarded simply as being equivalent. For initial fixation, T16 or T20 screws may be appropriate, but with HS-1 and HS-2 screws, a constant pressure (albeit lower than that generated by HOLLYX® screws) can be expected even after excessive rotation.

[Figure 5-1] The results of CP-T #1

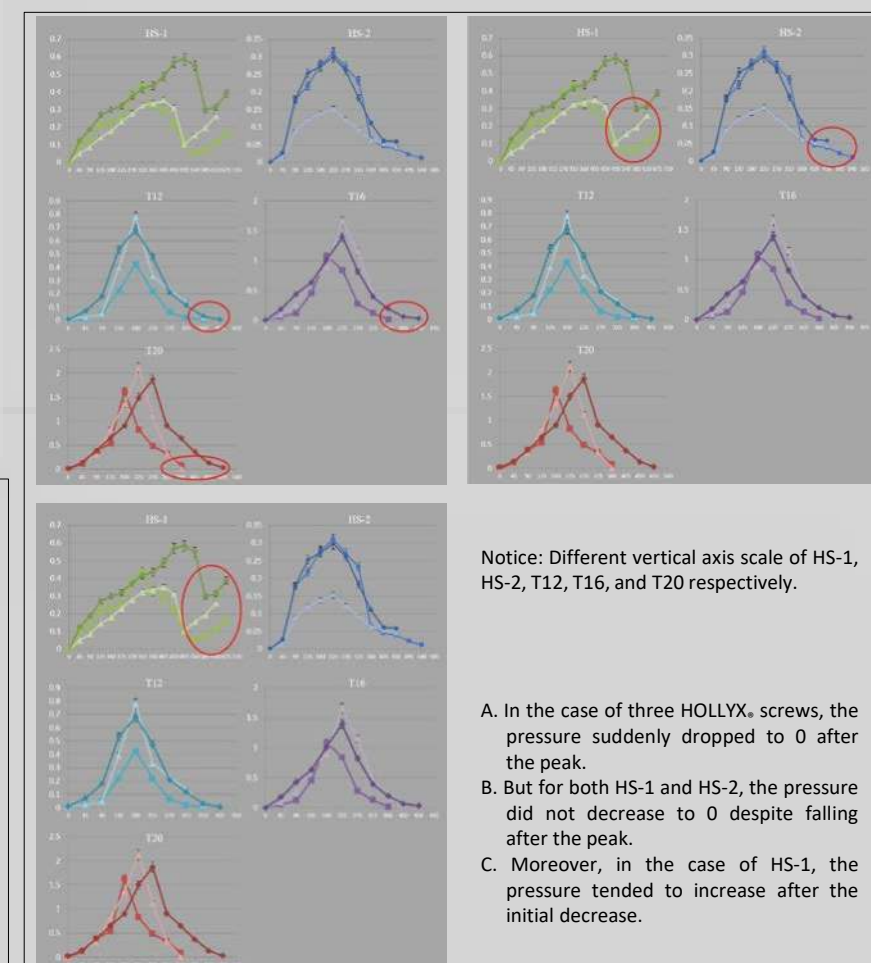


In the mean maximum pressures, respectively, we observed significant differences among all the screws.



In the mean angles at which maximum pressure was reached, respectively, we found significant differences between HS-1 and the other screws but no significant differences among the other screws.

[Figure 5-2] The results of CP-T #2



Notice: Different vertical axis scale of HS-1, HS-2, T12, T16, and T20 respectively.

- A. In the case of three HOLLYX® screws, the pressure suddenly dropped to 0 after the peak.
- B. But for both HS-1 and HS-2, the pressure did not decrease to 0 despite falling after the peak.
- C. Moreover, in the case of HS-1, the pressure tended to increase after the initial decrease.

Conflict of interest statement

The authors have no conflicts of interest associated with this study.