DOES TOTAL DISC ARTHROPLASTY CHANGE KINEMATIC FEATURES OF CERVICAL SEGMENTS IN AXIAL ROTATION?

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1. Introduction

The number of total disc arthroplasties (TDA) is increasing. Avoiding of adjacent level disease (ALD) is supposed to be the advantage compared to the standard procedure of fusion. The intervertebral disc mechanically represents a deformable synarthrosis following 6 degrees of freedom (DOF): Thus, the disc does not reduce the number of DOF of the relative motion between the adjoining vertebral bodies. The segmental DOFs are only restricted by the number of simultaneously guiding joints [1]. Cervical segments have two uncovertebral (Fig. 1) and two vertebral joints (Fig. 2).

Working hypotheses:
a. Since Bryan TDA does not restrict the number of DOFs of segmental motion it should not alter direction and position of the instantaneous helical axis (IHA). b. The influence of Prestige TDA to kinematic features should be small.

2. Material and methods

A cyclic triangular time function of axially directed pure torque \( \bar{T}_z(t) \) (amplitude: 224 Ncm, freq.: 1 min\(^{-1} \)) was mono-segmentally applied to the C3/C4-segments of 8 human spines (68.7 ± 13.5 yrs). Each segment was axially loaded by 10N. A custom-made 6D measuring apparatus was used (resolutions: <2.4µm for translation; <0.001° for rotation). More then 400 snapshots of segment positions per cycle were taken: By that the position of the instantaneous helical axis (IHA) as function of the rotational angle \( \alpha \) and the respective rotational angle-torque characteristics \( \alpha(T_z) \) were recorded for the intact segments and then after implantation of firstly Prestige and secondly Bryan. The upper and lower vertebra were fixed in Combipress® Plastic and bolted to the apparatus (Fig. 1). The TDAs were implanted under manufacturers’ instructions. Prestige-TDA was implanted first because it needs less bone resection. Correct implantation was controlled by X-rays in multiple projections.

3. Results

Figs. 2 illustrates the position of the IHA at rotational angle \( \alpha = 0 \) in the intact C3/C4-segment D. Torque vector \( \bar{T}_z(t) \) and IHA draw...
the angle $\beta = 32.7^\circ$. Hence $\dot{T}_z(t)$ also produced lateral flexion. IHA met the anterior part of the intervertebral disc and intersected the reference plane at $x = +6.1\text{mm}$.

TDA-Implantations did hardly alter the IHA-direction (Fig. 3). Mean data: $68.2^\circ$ (intact seg.), $69.6^\circ$ (prestige), $69.5^\circ$ (bryan).

But the IHA position was dorsally shifted by $\Delta x = 8\text{mm}$ for prestige and $\Delta x = 9\text{mm}$ for bryan (compare fig.2, fig.3, and fig.4).

Fig. 4: Centrodes of seg. D: IHA-intersections with the x-y-plane for the rotation range -$0.8^\circ$ to $+0.8^\circ$.

For the Bryan Disc of segment D the cent rode was additionally shifted to the right side.

But lateral shifts were statistically not significant as figure 5 demonstrates. Altogether the mean shifts (for $\alpha = 0$) of the IHA-positions amount to:

Bryan: $\Delta x = -8.15\text{mm}$, SD = 3.93mm, $p<0.1\%$; $\Delta y = -1.87\text{mm}$, SD = 4.08mm, n.s..<br>

Prestige: $\Delta x = -5.39\text{mm}$, SD = 4.99mm, $p<1\%$; $\Delta y = -0.42\text{mm}$, SD = 4.64mm, n.s., see fig. 5.

Fig. 5: Displacements ($\Delta y, \Delta x$) of IHA-positions after TDA-implantations for 8 C3/C4 cervical segments. Rotational angle $\alpha = 0$. Pr, Br = mean values with standard errors for Prestige and Bryan.

4. Discussion

The working hypotheses concerning segment kinematics were rejected by the measurements: Though for all implantations the IHA-direction remained unaltered the IHA-position was dorsally shifted after Bryan TDA significantly more than after Prestige TDA.

By one fresh C3/C4 Wachowski [2] have measured that resection of both UCJs did not alter IHA-direction but did shift IHA-position dorsally by 4.7mm. Because guiding function of both UCJs is most likely deactivated by TDA the dorsal IHA-shift of 5.3mm after Prestige-TDA may be attributed to UCJ deactivation. In Bryan-TDA the anterior ligaments of the segments must be tensed for initial mechanical stability of the Bryan shells in the vertebral bodies yielding probably a certain degree of extension of the segment which would shift the IHA-positions of axial rotation further dorsally as additional measurements suggested which are also to be shown.

Conclusion: Segment kinematics after TDA additionally depends on implantation method.

5. References