Evaluation of Total Ankle Arthroplasty Design considered Motion Characteristics of Ankle Joint for responding to Sudden Tilting Perturbation

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Disclosure

NO CONFLICT TO DISCLOSE

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*Introduction/Purpose*

- The anatomical geometry and motion characteristics are important factors for TAA designs.

- However, traditional TAA designs do not well consider the anatomical geometry and motion characteristics for responding to a sudden perturbation although the ankle joint contributes partially to human balance to prevent falling induced by a sudden perturbation.

- The aims of the current study were to identify the anatomical geometry and motion characteristics of the ankle joint during sudden tilting perturbations, to reflect the motion characteristics in the design of TAA, and to evaluate the design.
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*Method – Range of Motion (ROM) Measure

- Subjects

7 healthy males participated

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Weight (kg)</th>
<th>Height (cm)</th>
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<td>25.5±1.7</td>
<td>71.3±6.5</td>
<td>173.9±6.4</td>
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<General characteristic of subjects>

- All subjects who had no past history of musculoskeletal pathologies
- The risks of the test explained to the subjects
- This study approved by Sejong University Institutional Review Board
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*Method – Range of Motion (ROM) Measure

- Tiling of Base Plate to induce Dynamic Tiling of User
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*Method – Range of Motion (ROM) Measure*

- Experiment Environment (3D motion capture system)
  - Trials: 5 times tilting, 3 trials with 10 minutes rest time
  - Measure joint angles
    - 8 infrared camera (VICON, T10s)
    - Sampling rate: 100 hz
    - Measure changes of ankle joint angle
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*Results*

(a) In tilting perturbation around coronal axis (Left: Left Ankle, Right: Right Ankle)

(b) In tilting perturbation around 45° clockwise rotated sagittal axis (Left: Left Ankle, Right: Right Ankle)

(c) In tilting perturbation around sagittal axis (Left: Left Ankle, Right: Right Ankle)

(d) In tilting perturbation around 45° clockwise rotated coronal axis (Left: Left Ankle, Right: Right Ankle)

P<0.05
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*Results*

- Dorsi/Plantar flexion, Inversion/Eversion and Abduction/Adduction were ranged from $11.3\pm1.6^\circ$ to $-9.4\pm3.5^\circ$, $8.5\pm5.0^\circ$ to $-10.1\pm6.3^\circ$, and $0.7\pm0.2^\circ$ to $-1.0\pm0.2^\circ$, respectively, for the sudden tilting perturbations.

- Dorsi/Plantar flexion of TAA designed newly were 1.5 times larger than that measured from the experiment above, with no interference.
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* Results

Maximum von mises stresses predicted from FE analysis with the international test conditions were not exceed a yielding strength of the material used for TAA designed newly and no dislocations among the TAA components were identified.

Dorsi-flexion  Plantar-flexion
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*Discussion*

- The results indicated that a realization of the natural ankle joint motion trajectory should be improved although TAA design suggested in the current study might well present ROMs for responding to sudden tilting perturbations and have a proper structural stability corresponded to the standard criterion recommended from the international testing standard.

- The TAA design will be modified more considering advanced anatomical and biomechanical parameters, particular in the characteristics of the ankle joint motion trajectory, in our ongoing study. The current study may be, however, valuable to suggesting new TAA design for responding to a sudden perturbation to prevent falling. And the evaluation of the structure of the developed implant is proceeding.
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*Reference*

- Standard Specification for Cobalt-28 Chromium-6 Molybdenum Alloy Castings and Casting Alloy for Surgical Implants (UNS R30075)-(This specification is under the jurisdiction of ASTM Committee F04 on...