INTRODUCTION

The temporomandibular joint (TMJ) of the jaw is a unique and complex structure composed of a concave articular surface (fossa) on the temporal bone, a convex articular surface (condylar head) on the mandible and a bi-concave fibrocartilaginous articular disc inter-positioned between the two bony structures. Motion of the articulating disc is constrained by surrounding ligaments. Interruption of normal articular disc motion causes temporomandibular joint disorders (TMDs). TMDs are characterized by altered disc displacement and osteoarthritis of the joint.

Surgical intervention provides relief of pain and improvement in quality of life for patients, especially in end-stage advanced TMJ osteoarthritis (OA), when bone-on-bone contact and/or fibroosseous ankylosis cause unbearable conditions for patients. Therefore, understanding joint mechanics and kinematics of the TMJ is essential for determining proper treatment of the TMJ during OA.

Previous studies have typically assessed TMJ function and surgical outcomes subjectively by patient response questionnaires and objectively by measuring the borderline movement of the incisors (Mercuri, 2004; Wolford et al., 2003; Nitzan et al., 2001). However, more recently, investigators (Gallo, 2005) have suggested the combination of medical imaging and kinematic data acquisition methods represent and quantify the motion of the condyles and incisors with greater accuracy.

The purpose of this study was to quantify movement of the mandibular condyles and the incisors in TMJ OA patients before and after TMJ metal fossa-eminence hemi-joint replacement surgery. These motions were quantified using an electromagnetic motion tracking system combined with patient-specific CT images.

METHODS

Fourteen patients with TMJ OA were enrolled in the study according to IRB guidelines prior to receiving a hemi-joint implant. Subjects were fit with custom plastic dental stents. Six 0.8 mm diameter metal beads were embedded in the stents on the vestibular surface of all four first molars and both upper and lower central incisors. The stents were form fitted and no adhesive materials were required to fix them to the teeth.

The subjects wore the dental stents on their upper and lower teeth during both the CT imaging and the kinematic recording sessions. CT scans were obtained on a 64-slice MDCT system (Sensation 64, Siemens, Forchheim, Germany). Locations of the metal beads and the volumetric centroids of the condyles were obtained in the CT coordinate system using Analyze image analysis software (Robb et al., 1989).
Pre-and post-operatively, an electromagnetic tracking device (Polhemus, Inc.) and accompanying software (The Motion Monitor, Innovative Sports Training, Inc., Chicago, IL) were used to record the three-dimensional kinematics of the mandible relative to the temporal bone in the in-vivo coordinate system. A calibrated Plexiglas digitizing probe was used to locate the metal bead locations within the in-vivo coordinate system. Four trials of maximal opening-closing movements were performed starting and ending in the maximum intercuspal position.

The transformation between the two coordinate systems (in-vivo and CT) was determined using the 3D positions of the metal beads (Fig. 1). The CT image data (including the condyle centers and incisor locations) were then transformed to the in-vivo coordinate system for analysis and animation.

Figure 1: Kinematic data and CT images were aligned using markers on the upper and lower custom dental stents.

Three opening portions of the mandibular movements were selected from the trial with the greatest mouth opening. Condylar and incisor linear distances (LD, 3D distance), and curvilinear distance (CP, length along 3D path) were calculated for incisor and condylar points defined from the CT images during jaw opening and closing. Rotation of the mandible was evaluated using helical axis parameters.

RESULTS AND DISCUSSION

The mean calculated LD and CP traveled by the incisors increased significantly from 30.36 mm ± 6.87 mm and 31.53 mm ± 7.03 mm pre-operatively, to 35.52 mm ± 5.28 mm and 36.58 mm ± 5.52 mm post-operatively (p<0.05), respectively. The mandibular rotation significantly increased from 19.30°±4.92° pre surgically to 24.81°±3.86° degrees post surgically. Condylar LD and CP values did not change significantly from pre- to post-implant surgery.

SUMMARY/CONCLUSIONS

This kinematic method documented preservation of operated and unoperated condyle motion, improved incisal opening and increased mandibular body rotation and allowed for objective measures of surgical outcome. More advanced analysis methods including helical axis locations and orientations, and inter-boney (joint space) distances will highlight the benefits and applicability of TMJ kinematic analysis in a clinical setting.

REFERENCES


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