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Virtual Arthroscopic QuickTime and QuickTime VR Movies of the Visible Human Temporomandibular Joint

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Abstract The purpose of this study was to make a simulation of performing arthroscopy of the temporomandibular joint (TMJ) using two kinds of movies of computed arthroscopic simulation (virtual arthroscopy). One movie using QuickTime (QT) was made for navigating through the joint space. The other one using QuickTime VR (QTVR) was for interactive observation of the space. Volume-rendering the TMJ from the cryosections of Visible Human female on the Internet and "fly-through" into the simulated TMJ were conducted with the three dimensional visualization software of Analyze$_{AVW}$ on the Silicon Graphics O2 workstation. Virtual arthroscopic images obtained by "fly-through" simulation were combined to make a QT movie and QTVR movies on the Macintosh computer. The QT movie was similar to the video of the joint space made during real TMJ arthroscopy. The QTVR movies mimicked the performance of a real arthroscopy because it was possible to watch the desired intra-parenchymal surfaces of the soft tissues by panning and zooming on the monitor. These results indicated that virtual arthroscopic QT and QTVR movies would be a new diagnostic procedure to depict TMJ pathology.

Introduction

In the management of temporomandibular disorders, one of ongoing concerns is how to know what pathological changes are happening in the joint space. Masatoshi Ohnishi is the pioneer in the usage of arthroscopy of the temporomandibular joint (TMJ)[1]. The technique has been accepted worldwide. It is however invasive and therefore uncomfortable for the patients. If the joint space could be seen with a noninvasive technique, it would be comfortable for the patients.

Nowadays, sophisticated three-dimensional (3D) visualization software and powerful computer have enabled virtual representation of anatomy possible[2-4]. We reported virtual arthroscopy (computed arthroscopic simulation) of the TMJ[5]. The purpose of this study was to make a simulation of arthroscopy of the TMJ by the use of two kinds of movies. One movie using QuickTime (QT) was conducted for navigating through the joint space of the TMJ. The other again using QuickTime VR (QTVR) was made for interactive observation

of the intra-parenchymal surfaces of the TMJ.

Technical terms of computer language are defined as follows[6]. "Virtual reality" means a simulated model, in which a user can make a tour of the space that looks like the real world. "Fly-through" means to enter and explore the simulated space. QT is a format to watch a movie on the computer. QTVR is a format to see an interactive movie on the computer. In a QTVR movie, the user can watch the desired object by panning and zooming on the monitor using a computer mouse. "Click" means to press the computer mouse button once. "Drag" means to move the mouse with pressing the button.

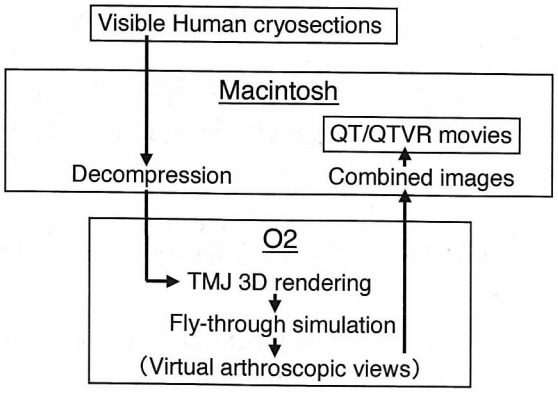

Fig. 1. Schematic illustration how to make QT and QTVR movies.

Materials and Methods

The method of making the movies is illustrated (Fig. 1). Visible Human female on the Internet was used as original data under the permission of National Library of Medicine of the United States of America. The cryosections were read with Adobe Photoshop™ 3.0.5 (Adobe Systems Incorporated, Seattle, Washington, USA) on the Macintosh computer (Apple Computer, Inc., Cupertino, California, USA). The images were processed with the 3D image processing software of Analyze$_{AVW}$ 1.0 (Biomedical Imaging Resource, Mayo Foundation, Rochester, Minnesota, USA) on the O2 workstation (Silicon Graphics Incorporation, Mountain View, California, USA) to volume-render the TMJ and to fly-through into the simulated TMJ. Virtual arthroscopic views obtained by fly-through simulation were combined to make a QT movie with Strata VideoShop 3.0 (Strata Software, Saint George, Utah, USA) and a QTVR movie with the QuickTime VR Authoring Studio™ 1.0 (Apple Computer) on the Macintosh computer.

The QT movie was made to visualize the in

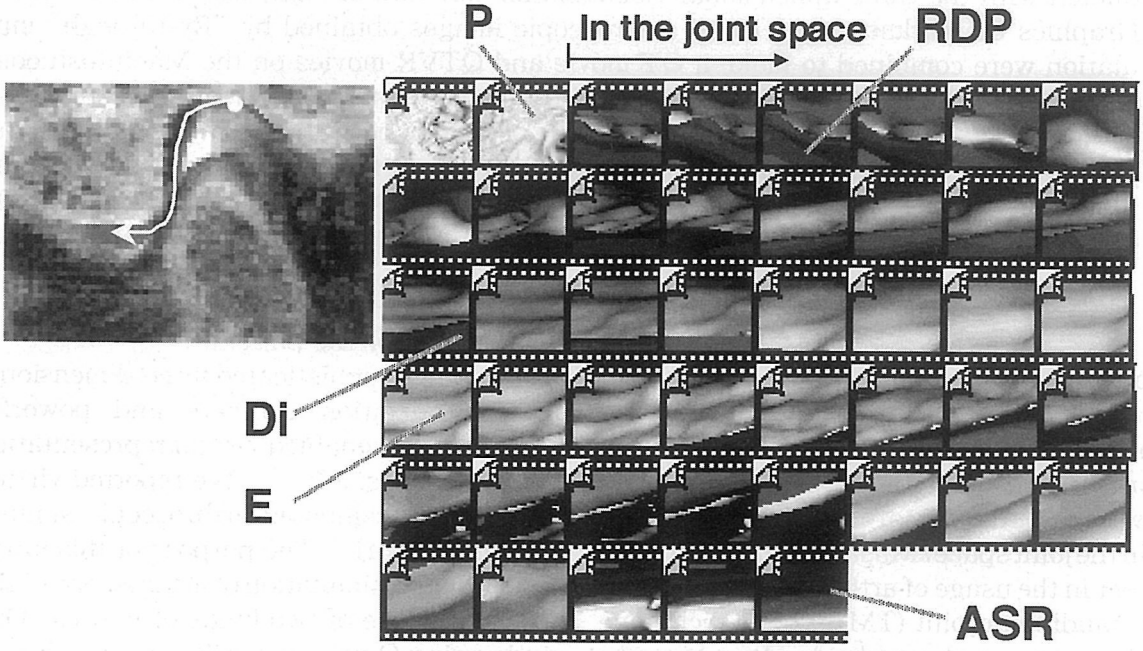

Fig. 2. QT movie of virtual arthroscopy. The arrow in the left picture shows the path which virtual arthroscope moved in the joint space. ASR: anterior synovial recess, Di: articular disc, E: articular eminence, P: penetrated point, RDP: retrodiscal pad.

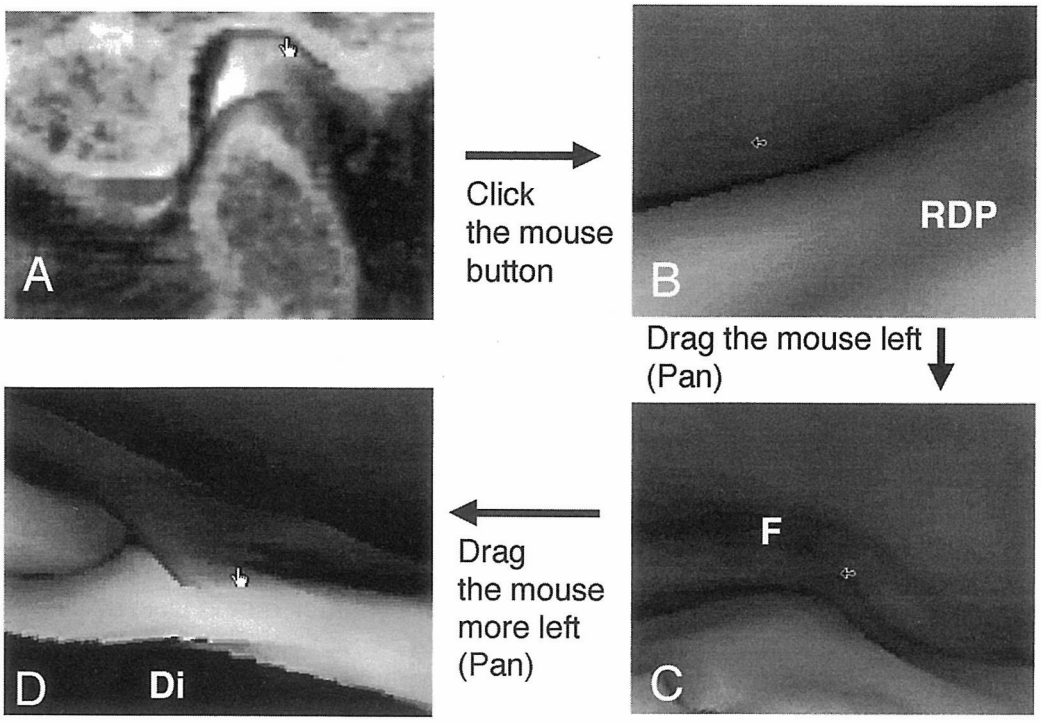

Fig. 3. QTVR movie on the retrodiscal pad. The concept of panning is represented. Picture A: sagittal plane picture map, picture B, C, and D : different views of the QTVR movie, Di: articular disc, F: articular fossa, RDP: retrodiscal pad.

terior of the joint from the lateral side. The QTVR movies were intended to perform interactive observation of the panoramic interior from the four distinct points in the joint. These consisted of the retrodiscal pad, distal thicker portion of the articular disc, the intermediate thinner portion of the articular disc, and the anterior portion of the articular disc.

Results

QT movie was similar to watching a video of the joint space (Fig. 2). In the left picture map, an arrow indicates the path of the tip of virtual arthroscope. Right film pictures depict the movie. After having penetrated the skin (Point P), the tip on the disc moves from the posterior pouch to the anterior recess. The user flies through into the skin, penetrates it, then observes the interior views of the joint space. S/he can see the retrodiscal pad, disc, eminence, and anterior synovial recess.

QTVR movies on the retrodiscal pad of the TMJ are represented (Fig. 3). Picture A is a picture map of the QTVR movies. When the user wants to explore the joint space on the retrodiscal pad, s/he can click the hand sign on it. Then s/he can watch the view of picture B as if s/he is in the joint space. Next, if s/he wants to see the disc, s/he can drag the mouse left and see an arrow sign in the direction of her/his eyes' moving. Immediately after that, the view moves, then s/he can see the fossa at the top shown in picture C, next s/he can see the disc at the bottom shown in picture D. S/he can observe the smooth surface of the disc and the fossa. Such panning technique enabled to see the panorama view of the joint space.

A concept of zooming in the QTVR movies is demonstrated (Fig. 4). When the user wants to see magnified view movies in picture A, s/he can get it by zooming in shown in picture B.

QTVR movies on the distal thicker portion of the disc are indicated (Fig. 5). The user can watch arthroscopic views by clicking and dragging the mouse in the same manner. It shows almost smooth surface of the disc and a little wrinkled posterior surface of the eminence.

Similarly, the OTVR movies on the intermediate thinner portion of the disc and the anterior portion of the disc were made. The user can watch similar movies. (The figures are not shown here.) Thus, the QTVR movies provided almost all the panoramic views in the joint space.

Discussion

In the real arthroscopic procedure, an operator can observe the real time view of joint space of the TMJ. The goal of this study was to make the same situation. It seemed to be mostly achieved.

Viewing the QT movie of the TMJ was similar to watching the video of the upper joint space made during real arthroscopy, although it provided no color definition. The QTVR movies of the TMJ mimicked the performance of a real arthroscopy, because the user could see the intra-parenchymal surfaces of the TMJ such as articular disc and fossa, where it was possible to watch the desired area to look by panning and zooming on the monitor through the use of the computer mouse. Panning and zooming of the QTVR movie made the same views as seen by arthroscopic sweeping and pistoning techniques, respectively. The QTVR movies on the multiple points enabled the observation of all areas of the joint.

QT movies of medical simulation are recently made, some of which are watched on the CD-ROM or Internet. Movies are clearly much better than photographs to understand anatomical structures. QT movie of the TMJ would be a good help to know the joint pathology.

QTVR movies such as mountains, sea, and buildings are seen on the Internet. World Wide Web sites are suitable for making presentation of such movies, because a user can watch desired parts on the computer monitors. However, there has been neither Web site nor literature to apply QTVR to medical imaging. Apple Computer Inc. released a user friendly application software of QuickTime VR Authoring Studio™ to make a QuickTime VR movie in 1997 (http : //www.apple.com/quicktime/qtvr/authoringstudio/index.html). Then this study was conducted. Medical QTVR movies may become widespread as a new diagnostic tool in the future.

Because the files of QT/QTVR movies are too large size, they are usually compressed[6,7]. Each file size in this study is under 1000 bytes. Several compression methods such as

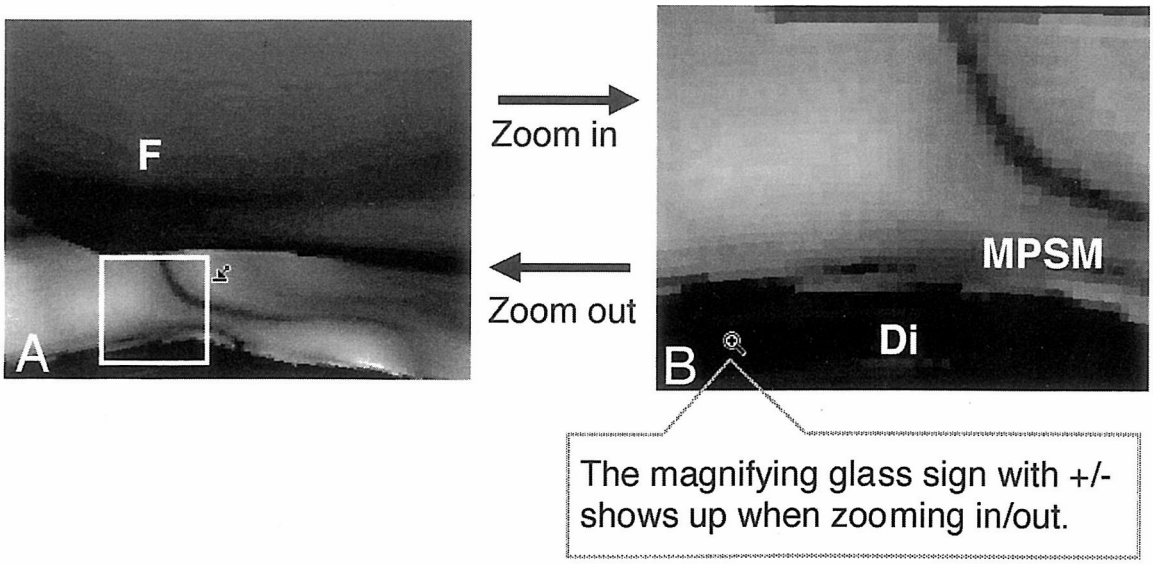

Fig. 4. QTVR movie on the retrodiscal pad. The concept of zooming is demonstrated. Picture A and B: different views of the QTVR movie, Di: articular disc, F: articular fossa, MPSM: medial portion of the synovial membrane.

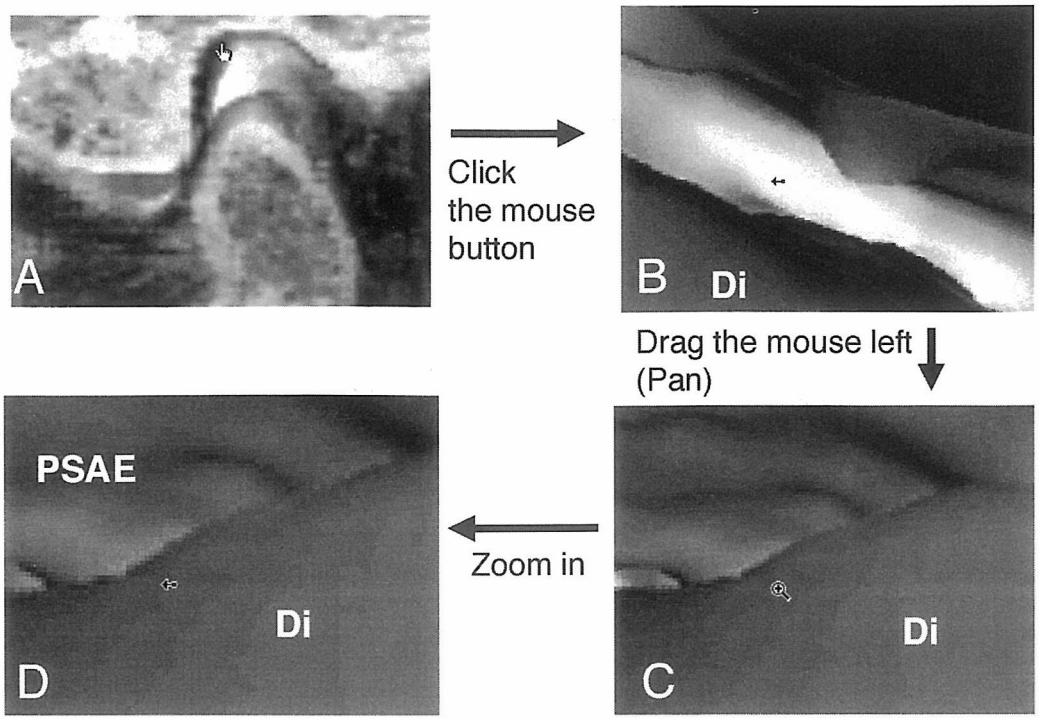

Fig. 5. QTVR movie on the distal thicker portion of the disc. Picture A: sagittal plane picture map, picture B, C, and D: different views of the QTVR movie, Di: articular disc, PSAE: posterior slope of the anterior eminence.

Cinepak and Photo JPEG (Joint Photographic Experts Group) are available, but all of them sacrifice the image quality[6,7]. In this study, however, smooth or wrinkled surface of the interior of the joint was identified shown in the Fig. 2, 3, 4, and 5. Current computer power and software are good enough to provide acceptable image quality.

Virtual arthroscopic QT/QTVR movies can never decrease the value of real arthroscopy, because they cannot perform surgery. The usefulness of arthroscopic surgery is not questionable for the TMJ disease patients[8,9]. Vir tual arthroscopic QT/QTVR movies might be diagnostic tools to know joint pathology, to help preoperative evaluation, and to be available for oral surgery residents training to learn arthroscopic views of the TMJ.

Unfortunately, to make virtual arthroscopic QT/QTVR movies in the current clinical setting is hard, because the ideal noninvasive original images for 3D reconstruction of the TMJ are unavailable. We consider that the best candidate may be double-contrast arthrographic spiral computed tomography at present. It is a minimum invasive procedure to depict clear TMJ images by the expansion of the space[10]. As its acquisition time is very short, patients are likely to tolerate it.

In conclusion, virtual arthroscopic QT/QTVR movies of the TMJ created almost the same views of real arthroscopy. They would be a new diagnostic procedure of the TMJ.

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