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Application of non Invasive Imaging in Relation to Hinge Type Synovial Joint of Maxillofacial Apparatus

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ABSTRACT

Internal derangement of the temporomandibular joint (TMJ) results in anterior disc displacement with reduction (ADDR), the disc is anteriorly displaced in the closed position whereas in the opened position the disc returns to its normal location. In anterior disc displacement without reduction (ADDWR), the disc is anteriorly displaced in the closed position but does not return to its original location in the opened position. Here we studied and compared the effects of the ADDR and the ADDWR on the components of the TMJ by using the magnetic resonance imaging technique (MRI). From the archival MRI records, 214 joints from 107 patients were included. The selection criteria for the patients complaints as TMJ pain, clicking, limited mouth opening, headache, jaw tenderness and difficulty in eating. MRI records with sequences Proton Density (PD), PD FAT SAT and T2 gradient in the closed position and T2 gradient echo in the opened position. Data analysis and frequency distribution of explanatory variables by disc position in the open state was performed using chi-square test. Statistically significant differences were observed between the variables such as the joint space (closed position), disc morphology (closed position) and range of movement (opened position) among the ADDR and the ADDWR. In ADDWR, 20.3% demonstrated narrowed joint space and 1.6% with widened joint space, while in ADDR, 2.5% of joints had narrowed joint space and 0% widened joint space. Same was observed with abnormal disc morphology and rang of movement. The disc deformity is more in ADDWR compared to ADDR which can be seen as an alteration in the signal intensity. The malaligned disc could lead to the narrowing of the joint space and decreased range of movement in the ADDWR affected individuals.

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Key Words
Temporomandibular joint, MRI, ADDR, ADDWR, diagnostic imaging, articular disk

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INTRODUCTION

The temporomandibular joint (TMJ) possess a unique anatomical feature as the only joint without the hyaline cartilage on its articular surface[1]. The TMJ and its associated structures play an essential role in guiding mandibular motion and distributing stresses produced by activities such as mastication, deglutition and speech. TMJ disorders (TMD) are a group of degenerative musculoskeletal conditions associated with morphological and functional deformities[2,3]. TMD include abnormalities of the intra-articular disc position and structure as well as dysfunction of the associated ligaments and musculature[4]. The Symptoms and signs associated with TMD include painful joint sounds, restricted or deviating range of motion, and cranial and/or muscular pain known as orofacial pain. 25% of the population with TMD experience symptoms but 4% seek treatment[5]. The most common TMJ conditions being pain-related and intra-articular disorders. Intra-articular disorders of the TMJ have been defined as an abnormal positional relationship between the disc and the condyle, articular eminence and articular fossa[6]. Internal derangement are often occurs as a change in the normal course of the articular disc in relation to the articular eminence and the mandibular condyle, including the function of the articular disc. It is often asymptomatic and the most common pathology in TMJ[6]. There are two types namely, the disc displacement with and without reduction. Disc displacement with reduction (DDWR) corresponds to 41% of TMD clinical diagnoses[7]. Also, DDWR can occur in 33% of asymptomatic individuals. These may occur in the anterior, posterior and mediolateral directions. Although the clinical examination is quintessential in the diagnosis of TMD, radiological imaging plays a vital role in the diagnosis of TMD to view the complex anatomy and pathology. Appropriate imaging techniques should be chosen depending on the clinical examination and individual selection criteria. The joint function of the TMJ can be accomplished by comparing the condyle in the closed and opened mouth position. Though, clinical examination has its part in diagnosis, There is cogent evidence that conventional radiographs and tomography have limited role in the assessment of TMD. Precise and accurate location of the articular disk using sagittal and coronal MR images have become a standard for the diagnosis of internal derangement of the TMJ along with diagnosing disc displacements and intra-articular disorders as it predominantly highlights the soft tissue components of the TMJ (articular disc, synovial membrane, lateral pterygoid muscle)[8-11]. The study mainly focussed on the comparision of the effects of the ADDR and the ADDWR on the components of the TMJ by using the magnetic resonance imaging technique (MRI).

MATERIALS AND METHODS

For this retrospective study, Archival MRI records with detailed history of a total number of 107 patients between the ages 16-83 years (214 TMJs-left and right) from the Department of Oral and Maxillofacial Surgery (OMFS) at the Royal London Hospital. The MRI scans of patients who complained of one or more of the following symptoms:

- TMJ pain
- TMJ clicking
- Limited mouth opening
- Headache
- Jaw tenderness
- Difficulty in eating

The clinical examination was carried out by a consultant in OMFS with special interest in TMJ disorders. MRI findings were reported by a consultant in Oral and Maxillofacial Radiology (OMFR).

MRI: The MRI images that were taken with the following parameters were used:

- Sequences in the closed position included-proton density (PD), PD Fat
- Saturation (PD FAT SAT)-T2* gradient

The term 'FAT SAT' refers to the suppression of the unwanted signal emitted by the fatty tissues which is mainly implemented to reduce inhomogeneity between the tissues. The main significance of the T2 scan is its shorter duration of scan than the T2.

- Sequences in the opened position included-T2 gradient echo

Average duration of the scan was 30 minutes (mins). Oblique slices were obtained perpendicular to the long axis of the condyle. Since pathology in any tissue is often associated with edema/fluid, the characteristic of a T2 weighted image is the high signal intensity of water. Hence, T2 sequence is very suitable to detect pathological conditions[12]. From the images, the following variables and information were recorded with regard to the articular surfaces the variables were divided as follows,

- Normal
- Abnormal
- Osteophyte
- Flattening
- Erosion

With regard to the joint space, the variables were divided as follows:

- Normal
- Narrowed
- Widened

With regard to the disc morphology, the variables were divided as follows:

- Normal
- Abnormal

With regard to the disc position (closed state), the variables were divided as follows:

- Normal
- Anterior disc displacement
- Posterior disc displacement
- Mediolateral displacement

With regard to the range of movement (opened state), the variables were divided as follows:

- Normal
- Abnormal

With regard to the disc position (opened state), the variables were divided as follows:

- Normal
- Anterior disc displacement with reduction
- Anterior disc displacement without reduction
- Mediolateral displacements with reduction
- Posterior disc displacement without reduction
- Posterior disc displacement with reduction

Statistical Analysis: Descriptive statistics including frequencies and proportions were obtained by chi square test. Analytical statistics using logistic regression model were employed in the study to extrapolate the role of closed position (condyle, glenoid fossa, articular eminence, joint space, disc morphology and disc position) and the opened position (range of movement) of the TMJ on the ADDR and ADDWR using the Statistical Package for Social Sciences (SPSS version 13.0.1 Inc. Chicago, USA). The level of statistical significance was set at 0.05.

RESULTS AND DISCUSSIONS

The mean age of the patients was 40.20±15.55. Only 2.5% of joints in ADDR group were found with narrowed joint space and 0% with widened joint space whereas in ADDWR group 20.3% demonstrated narrowed joint space and 1.6% with widened joint space. 39 joints (97.50%) in the ADDR group were found to have normal joint space when compared to 78.1% in the ADDWR group. One joint (2.50%) in the ADDR group was found to have narrowed joint space when compared to 20.30% in the ADDWR group. None of joint in the ADDR group was found to have widened joint space when compared to 1.60% in the ADDWR group. The association between the disc position in the opened position and the joint space in the closed position was found to be statistically significant (P 0.023). Significant association between the disc morphology in the closed position and the joint space in the closed position was observed (P 0.005). 25 joints (62.50%) in the ADDR group were found to have normal disc morphology compared to 34.40% in the ADDWR group. 15 joints (37.50%) in the ADDR group were found to have abnormal disc morphology when compared to 65.60% in the ADDR group. 33 joints (82.50%) in the ADDR group had anterior disc displacement when compared to 84.40% in the ADDWR group. The 5 joints (12.50%) in the ADDR group had normal disc position compared to 15.60% in the ADDWR group. Only two joints (5.00%) in the ADDR group were found to have mediolateral displacement. However, this difference was not of statistical insignificance (P = 0.185).Statistical significance was comparing the range of movements among ADDWR and ADDR group. 34 joints (85.00%) in the ADDR group were found to have normal range of movement when compared to 65.60% in the ADDWR group. 6 joints (15.00%) in the ADDR group were found to have abnormal range of movement when compared to 34.40% in the ADDWR group (P = 0.030). Logistic regression analysis was performed in order to elucidate the prognosis of these factors in ADDR and ADDWR. P values for the normal, narrowed and the widened joint space were 0.092, 0.029 and 1.00 respectively. The OR suggested that the TMJs with the narrowed joint space were found to be 10 times more likely in ADDWR rather than in ADDR. The P value of 0.006 was observed in the abnormal disc morphology. TMJs with the abnormal disc morphology were found to be 3 times more likely in ADDWR than in ADDR. The difference observed in the C.I was of acceptable limit.

TMD is defined by the American Academy of Orofacial Pain (AAOP) as a complex term covering a number of clinical problems involving the masticatory muscles, the joint and the associated structures. TMD is classified into two groups: muscular and articular with common clinical signs represented by pain, limited mouth opening and joint sounds (clicking, crepitation)[13]. The changes observed in the articular surfaces and the surrounding tissues in relation to the ADDR and ADDWR are as follows,

Closed position:

- Condyle-normal, abnormal, osteophyte, flattening.
- Glenoid fossa-normal
- Articular eminence-normal and abnormal

- Joint space-normal, narrowed and widened
- Disc morphology-normal and abnormal
- Disc position-normal, anterior displacement and mediolateral displacements

Opened position:

- Range of movement-normal and abnormal

In this study, the factors which are likely to be of more significant in internal derangements of the TMJ are highlighted. The use of MRI in the diagnosis of the internal derangements prove to be successful based on the study with a sample size of 100 subjects by Sener and Akgunlu[14]. They concluded that the degenerative changes such as the osteophyte, flattening and erosion and the joint effusion does not play an important role in the early assessment of ADDR and ADDWR. Also they added that the mediolateral displacements, morphology and the signal intensity of the disc, scar tissue and the presence of osteonecrosis were more prevalent in ADDWR than in ADDR. T2-weighted images are produced by using longer TE and TR times. In these images, the contrast and brightness are predominately determined by the T2 properties of tissue which appear bright on imaging.T2-weighted and proton density-weighted images were found to be more useful than T1-weighted images in the diagnoses of articular disc pathoses. Sano and Westesson found the T2 signal from the retrodiscal TMJ tissues to be correlated to the degree of pain. They suggested increased vascularity in those tissues as a possible explanation. Also by employing double echo technique, two types of images can be taken simultaneously which is crucial importance when assessing disc status[15,16]. When having to choose between several variations of MRI techniques and each imaging is expensive. T2 has proven to be superior to other types of static MR images in revealing the boundary of complex anatomical structures by increasing the signal intensity of the posterior band of the disc on MR images[17,18]. Joint effusion can also be visualized to a greater detail in T2 images as typical bright signals in joint space of patients with TMJ pain and dysfunction[12]. On comparision, the results from this study demonstrated that the factors such as joint space, disc morphology and range of movement were more prevalent in ADDWR than in ADDR suggesting that these may act as indicators for the detection of the transition of the early ADDR to late ADDWR stages. Also added that the articular disc may be the epicentre for the ADDWR along with the joint space and the range of movement as its subsidaries. The clinical symptoms of ADDR and ADDWR are mentioned as follows.

ADDR-This condition is characterized by an anteriorly displaced disc in the closed position which recaptures during the opened position. This can occur due to the thinning of the posterior disc border and elongation of the inferior retrodiscal lamina and discal collateral ligaments which may lead to displacement of the disc from the joint space. Clinically, the patient is asymptomatic. The deviation of the mandible during the disc reduction is noted. A click of intermittent nature is observed during the disc reduction. The range of movement is limited at this point and then the normal range of movement continues. The interincisal distance is reduced[19].

ADDWR-This condition is characterized by an anteriorly displaced disc in the closed position which does not recapture during the opened position. This can occur due to loss of elastic nature of the superior retrodiscal lamina so that the forward movement of the condyle can push the disc to the anterior direction. Clinically, the patient is sympotmatic. The click observed is of continuous nature. The deviation of the mandible is noted towards the involved joint during the termination of the movement. The pain is aggravated by the movement beyond the restricted point due to the position of the condyle on the retrodiscal tissues. The interincisal distance is reduced. The limited range of movement is observed throughout the condition[20,21]. The morbidity is likely to be more in ADDWR rather than in ADDR. The disc morphology which is usually of biconcave shape, is altered in ADDWR. Due to this change, the signal intensity is low. When the disc is anteriorly displaced, the condyle is forced into a posterior portion leaving the joint space size to be narrowed and close contact of the articulating surfaces of the bony components can lead to restriction of the mandibular movement. The disc morphology would be altered from the anatomical biconcave shape into any other abnormal shapes. Due to this change, there would be a signal intensity of low level. When the disc is moved out of its place, then there is chance for the joint space to be reduced in dimension. As the joint space is reduced the normal mandibular movement is restricted due to the close contact of the articulating surfaces of the two bony components namely the mandibular condyle and the articular eminence. This may lead to the production of friction resulting in the occurence of the pain, leading to the advanced stage known as the ADDWR[22]. The consequences of the ADDWR condition experienced by the patient are inability to chew the solid diet, difficulty in speech, inability to brush the teeth leading to a compromised dental health status, lack of movement of oral musculature which may lead to muscle atrophy, restricted social behaviour and occasionally radiating pain may be felt in the adjacent anatomical regions such as ear, temporal area, back of the neck and shoulder. Inspite of the well delineated clinical symptoms of the internal derangements of

TMJ, the pathogenesis remains to be unclear. Previous studies by Sato *et al* demonstrated that the Interleukin-8 (IL-8) and Substance P may be involved in the pathogenesis[23]. With respect to the radiological investigations for the internal derangements of TMJ, Rudisch *et al*. concluded that in order to support the clinical findings, MRI needs to be included[24]. On comparision to the traditional radiographic techniques, MRI helps in the demonstration of the soft tisssue, articular disc, which plays an important role in the mechanism of the internal derangements of TMJ. Whereas, the traditional radiographic techniques and CT demonstrate only the osseous structures. The principle of MRI is based on the magnetic field which helps in the alignment of the protons in the human body to produce an image of the area of interest[25]. The safety of the patient is improved by the absence of ionising radiation. Comparing CT and MRI, the sagittal slices are obtained in the same manner. The coronal slices are obtained without the patient reorientation in MRI whereas in CT the patient is advised to maintain prone position. If the transition from ADDR into ADDWR is diagnosed at an early stage then the treatment approach may be modified. The study also demonstrated that the mean age of the patients with ADDWR was 40.20±15.55. At this particular age, nonsurgical therapy would be more beneficial to the patients thereby minimising the post surgical complications[26]. There was no difference observed between the right and left TMJs in relation to ADDR and ADDWR. The ADDR and ADDWR in this study were found to be more prevalent in females than in males. Previous study by Ichiro Ogura 2006 also demonstrated a higher prevalance of the internal derangements in females rather than in males[27]. The statistical significance was observed in the variables such as joint space (closed position), disc morphology (closed position) and range of movement (opened position). However, statistical insignificance was observed in the variables such as condyle (closed position), glenoid fossa (closed position), articular eminence (closed position) and disc position (opened position). Logistic regression analysis demonstrated that the prevalence of the abnormalities of the joint space, disc morphology and range of movement would be more likely 10, 3 and 3 times in ADDWR compared to ADDR. In summary, internal derangements of TMJ, as it involves articular disc as the main component, which is a soft tissue can be viewed in a detailed manner with the help of MRI rather than the other radiological investigations thereby improving the prognosis and restoring the health status of the patient. The wide C.I in the joint space could have been minimized with the help of a large sample size. This study lead to some exploring areas in relation to the internal derangements of the TMJ.

CONCLUSION

MRI provides a detailed and precise information regarding the position and the structure of the articular disc in the TMJ region which cannot be visualized in any other radiographic modalities. The disc deformity is more compared in ADDWR and can be visualized as an alteration in the signal intensity. The malaligned disc leads to the narrowing of the joint space thereby decreasing the range of movement in the ADDWR affected individuals.

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