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Degree of disk displacement as a prognostic indicator in arthrocentesis outcomes: clinical and MRI correlation

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SCHOOL OF MEDICINE

Thesis

DEGREE OF DISK DISPLACEMENT AS A PROGNOSTIC INDICATOR IN ARTHROCENTESIS OUTCOMES: CLINICAL AND MRI CORRELATION

By

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ABSTRACT

Aims:

Multiple studies have shown that arthrocentesis is an effective treatment for internal derangement of the temporomandibular joint. However, it is not known which patient groups will respond to this procedure. It is often difficult for surgeons to preoperatively predict the outcome of arthrocentesis. This had led some researchers to analyze and evaluate specific variables which could possibly be used as prognostic factors to predict the outcome of arthrocentesis. None of those studies used the amount of disc displacement as a prognostic factor to assess the treatment outcome of arthrocentesis. Therefore, our study objective was to evaluate the amount of disc displacement as a prognostic factor for the outcome of arthrocentesis in patients with Internal derangement of the tempromandibular joint.

Materials and methods:

The study involved a retrospective review of the treatment records of 46 patients who underwent arthrocentesis of the TMJ by a single surgeon between 2010 and 2013.
A prognostic factor evaluated for its effect on the treatment outcome of TMJ arthrocentesis in this study was the degree of disc displacement. For study purposes, patients were divided into two groups: 1) Success group, and, 2) Failure group. Patients were categorized as successful if they met the success criteria prescribed by the American Association of Oral and Maxillofacial Surgeons in 1995.

MRI of TMJ was performed in two steps. Initially, oblique parasagittal sections were scanned with a 1.5 T MRI machine.

The amount of disc displacement was analyzed from sagittal oblique views of the MRI scans in closed mouth positions by measuring the angle between the posterior band of the articular disc and the center of the condylar head. The disc is considered to be in its normal position when the thicker portion of its posterior band lies within ±10° on the 12 o’clock position.

First, the condylar head was identified, and a circle was established to describe the outline of the anterior, posterior, and superior surfaces of the condylar head; this allowed separation of the condylar head from the neck region. Second, the center of the circle was identified and a vertical line was drawn from the center of the circle. The last step was to measure the degree of displacement from this vertical line to the posterior band of the disc.

Findings were compared for patients in the two groups for the following variables: age (continuous), disc displacement (continuous), and gender (female or male). P-value were calculated for differences in continuous or categorical variables using a T-test or Pearson's chi-squared test, respectively. The mean MMO, pain and diet scores were also
reported in the preoperative group and 12 months postoperative group by outcome status. Statistical significance was set at p < .05 based on a two-tailed test. SPSS was used for all statistical analyses (SPSS Inc, Chicago, IL, 1997).

**Results:**

46 patients with 46 joints were evaluated in the present study. Average age of patients was 31 years with arrange of 24 to 46 years. 35 cases (76.1%) were classified as successful and 11 cases (23.9%) were classified as unsuccessful based on the criteria described earlier. In the successful group, the mean MMO score was found to be greater at the 12 months postoperative interval when compared to the preoperative examination. In the unsuccessful group, the mean MMO score was also greater than preoperatively at the 12 months postoperative group but to a lesser extent than seen in the successful group. Pain level improved more in the successful group compared to the unsuccessful group. Diet scores showed improvement in chewing ability in the successful group but remain unchanged in the unsuccessful group There was a statistically significant difference between the two groups in the degree of anteriorly disc displacement.

**Conclusion:**

In summary, it has been shown that the degree of disc displacement, preoperative pain level, diet score, and MMO can be used as prognostic factors for the outcome of TMJ arthrocentesis. Future investigations should more carefully evaluate the validity of other variables. Identifying prognostic factors for the outcome on arthrocentesis will help with
guiding surgeons in the planned evaluation of TMJ cases. More specifically, clinicians will be able to create tailored treatment modalities based upon prognostic factors.
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LIST OF ABBREVIATIONS

ID .................................................................................................................. internal derangement
IRB ........................................................... Institutional Board Review
MMO ........................................................................................................ maximal mouth opening
MRI .......................................................................................................... magnetic resonance imaging
ROM ...................................................................................................... Range of mandibular movement
TMJ .......................................................................................................... temporomandibular joint
VAS .......................................................................................................... Visual analog scores
INTRODUCTION

Introduction

The temporomandibular joint (TMJ) is considered to be one of the most complex joints in the body. The non-articular surfaces in the human TMJ are lined with a synovial membrane which secretes synovial fluid. This fluid acts as a joint lubricant and helps with the metabolic and nutritional needs of the non-vascularized structures of the joint, including the disc. The four articulating surfaces in the TMJ are the articular surface facets of the temporal bone, mandibular condyle, and the superior and inferior surfaces of the articular disc.

Previous magnetic resonance imaging (MRI)-based studies have reported that the normal position of the articular disc is based on a clock-hands analogy in the closed mouth position. The disc is considered to be in its normal position when the thicker portion of its posterior band lies within ±10° of the twelve o’clock position. Discs in a position between 9 and 11 o’clock are considered displaced. However, some data suggests that the disc is in its normal position even if the angle goes up to 30° as this position correlates the degree of disk displacement more accurately with clinical symptoms of TMJ dysfunction.

MRI examination is the gold standard in evaluating the TMJ components, disc position and morphology. It provides clinicians with the ability to visualize soft tissue, joint fluid and joint structures in addition to evaluate the functional relationships.
between the condyle, articular disc, mandibular fossa, and articular eminence which allows for a better understanding of the sources of pain and its correlation with the clinical findings. MRI is the study of choice for evaluating soft tissue components of TMJ.

TMJ disc displacement has been defined as an abnormal relationship between the articular disc and the mandibular condyle, articular fossa, and eminence. Articular disc displacement is a type of internal derangement (ID) that may be present in asymptomatic and symptomatic patients. Anterior disc displacement is one of the most common types of internal derangements of TMJ. It occurs in patients of all ages, with a high prevalence in women aged 20 to 40 years. Studies indicate that up to 25% of the entire population has internal derangement of TMJ and are most often initially treated with nonsurgical methods such as diet modification, pain and muscle relaxant medications, physiotherapy, and occlusal splints. If nonsurgical methods are not successful, surgical intervention may be indicated. Historically speaking, open joint surgery was recommended for many years as the first surgical option. The goals of these surgical procedures was to change the morphology or position of the disc, or remove the disc, with or without replacement. Over time, it was shown that many of these open surgical procedures were not successful long-term, and were also associated with major complications. As a result, minimally invasive procedures gradually gained in popularity for the management of ID. Ohnishi described TMJ arthroscopy in 1975. Subsequently, many studies proved the value and success of arthroscopy in the management of symptomatic TMJs with internal derangements.
The physical action of lysis and lavage during the arthroscopic procedures in the superior joint space is believed to be responsible for the success of arthroscopic surgery. This has led to the use of TMJ arthrocentesis as a relatively less invasive procedure to reduce the inflammation in the superior joint space and restore normal range of motion. Multiple studies have shown that arthrocentesis is an effective treatment for internal derangement of the temporomandibular joint. However, it is not known which patient groups will respond to this procedure. It is often difficult for surgeons to preoperatively the outcome of arthrocentesis. This had led some researchers to analyze and evaluate specific variables which could possibly be used as prognostic factors to predict the outcome of arthrocentesis. For example, Nishimura et al. found that the following variables were significant prognostic factors: age, sex, duration of painful locking, preoperative and postoperative range of maximal mouth opening MMO, preoperative degree of pain, preoperative clicking on opening mouth before becoming locked, and MRI findings. In another investigation by Aktas et al., the researchers analyzed the following prognostic factors: age, sex, duration of locking, history of trauma, history of TMJ treatment, depression, bruxism, malocclusion and missing teeth. Emshoff investigated whether clinical variables such as age, gender, time since pain onset, pain level, and mandibular range of motion predict treatment outcomes of arthrocentesis and hydraulic distension of the TMJ. Alpaslan et al. evaluated if bruxism and the duration of symptoms act as prognostic factors affecting the outcome of arthrocentesis; they found that a history of clenching or bruxism and the duration of symptoms before arthrocentesis had no effect on treatment outcome.
None of those studies used the amount of disc displacement as a prognostic factor to assess the treatment outcome of arthrocentesis. Therefore, our study objective was to evaluate the amount of disc displacement as a novel prognostic factor for the outcome of arthrocentesis in patients with ID of the TMJ.
METHODS

The study involved a retrospective review of the treatment records of 46 patients who underwent arthrocentesis of the TMJ by a single surgeon between 2010 and 2013. This study was approved by the “Institutional Board Review” of Boston University/Medical Campus, (IRB #: H-32365) and informed consent was obtained from all patients.

Inclusion criteria were: 1) Clinically symptomatic internal disc derangement verified by MRI as “anterior disc displacement with and without reduction” 2) Failed conservative treatment including diet modification, physical therapy and occlusal splint treatment 3) Arthrocentesis performed with a two-needle standard technique as described originally by Nitzan et al.\textsuperscript{19}, and 4) Postoperative follow-up of at least 12 months. Patients were excluded if they met the following criteria: 1) Presence of TMJ bony involvement (Wilkes grade IV, V), 2) Patients with a history of previous TMJ surgery or trauma, and, 3) Poor quality MRIs.

All patients underwent monitored splint therapy for at least 6 months after surgery with occlusal adjustments made on each appointment as needed. Patients were instructed to be on a soft diet for 2 weeks after the surgery and start mouth-opening exercises immediately after surgery. Patients were clinically examined preoperatively and then at 3, 6 and 12 months postoperatively. A uniform subjective facial pain questionnaire (based on Visual analog scores (VAS)) and objective clinical TMJ examination protocol was used to standardize the assessment of the patients at each visit (Figure 1). Subjective examination included questions about the intensity of the joint pain, which was assessed
by using a visual analog scale (VAS; 0–10). Objective findings measured were MMO, and pain during range of motion mandibular movements before and after treatment. Diet scores were assessed by VAS on a scale of 1-10.

**Figure 1:** A TMJ examination form was used to standardize the assessment of the patients at each visit.
A prognostic factor evaluated for its effect on the treatment outcome of TMJ arthrocentesis in this study was the degree of disc displacement. For study purposes, patients were divided into two groups: 1) Success group, and, 2) Failure group. Patients were categorized as successful if they met the success criteria prescribed by the American Association of Oral and Maxillofacial Surgeons in 1995. These criteria were: a level of pain that is of little or no concern to the patient; MMO 35 mm or more; improvement in the ability to masticate a normal or nearly normal diet; functional and stable occlusion; limited period of disability and acceptable clinical appearance.

MRI of TMJ was performed in two steps. Initially, oblique parasagittal sections were scanned with a 1.5 T MRI machine. The data were collected on a 252 x 256 matrix with a field of view of 140 mm. Next, 3-mm-thick sagittal slices were placed during the close mouth position and self-maximal mouth opening to examine the configuration and position of the articular disc. T1 (TR/TE; 480/15 ms) pulse sequences were used to evaluate the disc position. MRIs were calibrated to the horizontal angulation of the condyle.

The amount of disc displacement was analyzed from sagittal oblique views of the MRI scans in closed mouth positions by measuring the angle between the posterior band of the articular disc and the center of the condylar head. The disc is considered to be in its normal position when the thicker portion of its posterior band lies within ±10° on the 12 o’clock position (Figure 2). First, the condylar head was identified, and a circle was
established to describe the outline of the anterior, posterior, and superior surfaces of the condylar head; this allowed separation of the condylar head from the neck region.

Second, the center of the circle was identified and a vertical line was drawn from the center of the circle as displayed in Figure 3. The last step was to measure the degree of displacement from this vertical line to the posterior band of the disc. All images were scanned to a computer and one single examiner assessed linear measurements of the condyles using a computer program (OsiriX v.4.1 32-bit and Adobe Photoshop CC 2014). The slice exhibiting the largest condyle diameter was selected to measure the amount of disc displacement.

![Figure 2](image)

Figure 2: The normal position of the disc in closed mouth position from the sagittal oblique view
Figure 3: Measuring the amount of disc displacement in 2 steps: 1) Determine the center of the condylar head by drawing a circle that outlines the anterior, posterior, and superior surfaces of the condylar head. 2) Draw a line from the center of the condyle to the posterior band of the disc. The angle formed between these two lines is the amount of disc displacement.

**Statistical Analyses**

Findings were compared for patients in the two groups for the following variables: Age (continuous), Preop pain score (continuous), Preop diet score (continuous), Preop MMO Score (continuous), Displacement (continuous), and Sex (Female or Male). P-value represents differences in continuous or categorical variables which was calculated using a T-test or Pearson's chi-squared test, respectively. Pain scores and Diet scores
were compared in the Success versus Failure groups preoperatively and at 3, 6, and 12 months postoperatively.

A multiple logistic regression analysis was conducted to evaluate each prognostic factor. Multiple logistic regression allows you to calculate the independent association between each prognostic factor and the outcome variable (success or failure) while holding constant the effects of the other prognostic factors. Age(continous), Preop pain score(continous), Preop diet score(continous), Preop MMO Score(continous), and Displacement(continous) were included in the logistic regression model.

Statistical significance was set at p < .05 based on a two-tailed test. SPSS was used for all statistical analyses (SPSS Inc, Chicago, IL, 1997).
RESULTS

46 patients with 46 joints were evaluated in the present study. Average age of patients was 31 years with range of 24 to 46 years. 35 cases (76.1%) were classified as successful and 11 cases (23.9%) were classified as unsuccessful based on the criteria described earlier. In the successful group, the mean range of MMO slightly increased within the first 3 months after surgery and continued to increase for 12 months postoperatively (Figure 4). However, in the unsuccessful group, the mean range of MMO slightly increased in the first 3 months and then remained constant from 3-6 months; there was a decrease from 6-12 months.

Pain level assessed based on VAS improved in both groups in the first 3 months postoperatively, however, the improvement was greater in the successful group (Figure 5). Results showed a relapse in the pain level in the unsuccessful group after the third month postoperatively. Pain constantly increased in the failure group and decreased in the successful group.

Diet scores showed improvement in the chewing ability in both groups in the first 3 months postoperatively. Those scores were assessed based on VAS. The improvement continued to improve in the success group. However, remain constant in the failure group for the rest of the follow up period (figure 6).

Analysis of the possible prognostic factors:
During the 12-month follow-up period after the procedure, there were statistically significant differences between successful and unsuccessful groups in pre-operative MMO score, degree of pain and diet score on the VAS preoperatively, and the degree of anteriorly disc displacement. There were no statistically significant differences in age and sex (Table 1).

Results from the logistic regression analysis indicate that the degree of anteriorly disc replacement was statistically significant (p<0.05) after adjustment for age, preop pain score, and preop MMO score (Table 2). The odds ratio (OR) was 0.88 (95% CI: 0.81-0.96) indicating that per unit increase in displacement, there is a 12% reduced odds of success. The finding that displacement remained statistically significant after adjustment for age, preop pain score and preop MMO score supports the hypothesis that displacement is a strong and novel prognostic factor for the outcome. Tables 1-3 summarizes these results.
Figure 4. Changes in mouth opening before the surgery, 3 months post op, 6 months post op and 12 months post op.

Figure 5. TMJ pain before arthrocentesis and 12 months post operative.
Figure 6. Diet scores before the procedure and 12 months post operative.
Table 1. Different variables evaluated as prognostic factors for the treatment outcome of arthrocentesis.

<table>
<thead>
<tr>
<th></th>
<th>Failure</th>
<th>Success</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total, n (%)</td>
<td>11 (23.9%)</td>
<td>35 (76.1%)</td>
<td></td>
</tr>
<tr>
<td>Age, y (SD)</td>
<td>31.68421 (5.45)</td>
<td>31.48387 (6.05)</td>
<td>0.91</td>
</tr>
<tr>
<td>Preop Pain score, score (†)</td>
<td>7.947368 (1.18)</td>
<td>6.903226 (1.04)</td>
<td>* &lt;0.05</td>
</tr>
<tr>
<td>Preop diet score, score (SD)</td>
<td>4.578947 (2.00)</td>
<td>2.709677 (2.55)</td>
<td>* &lt;0.05</td>
</tr>
<tr>
<td>Preop MMO score, score (†)</td>
<td>25.68421 (8.87)</td>
<td>34.19355 (7.69)</td>
<td>* &lt;0.05</td>
</tr>
<tr>
<td>Amount of disc Displacement, score (†)</td>
<td>53.53842 (18.37)</td>
<td>22.53339 (11.45)</td>
<td>* &lt;0.05</td>
</tr>
<tr>
<td>Female, % (n)</td>
<td>40.63 (9)</td>
<td>59.38 (21)</td>
<td>0.61</td>
</tr>
<tr>
<td>Male, % (n)</td>
<td>33.33 (6)</td>
<td>66.67 (14)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: MMO, maximal mouth opening; *P < .05 (Student’s t test); †Mean ± SD.
P-value represents differences in continuous or categorical variables which were calculated using a T-test or Pearson's chi-squared test, respectively.
### Table 2. Calculated Odds Ratios of Successful Treatment Outcome By Prognostic Factor

<table>
<thead>
<tr>
<th>Prognostic Factor</th>
<th>Odds Ratio (95% CI)*</th>
<th>P-Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement</td>
<td>0.88 (0.81, 0.96)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Age</td>
<td>0.98 (0.80, 1.19)</td>
<td>0.82</td>
</tr>
<tr>
<td>Preop Pain Score</td>
<td>0.84 (0.25, 2.75)</td>
<td>0.77</td>
</tr>
<tr>
<td>Preop Diet Score</td>
<td>0.91 (0.46-1.82)</td>
<td>0.80</td>
</tr>
<tr>
<td>Preop MMO Score</td>
<td>1.19 (0.99-1.42)</td>
<td>0.06</td>
</tr>
</tbody>
</table>

*Calculation based upon adjustment for other prognostic factors

### Table 3. Mean MMO, Pain, and Diet Scores Preoperative and 12 Months Postoperative by Outcome Group (n=46)

#### Successful Group (n=35)

<table>
<thead>
<tr>
<th></th>
<th>Preoperative</th>
<th>12 Months Postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMO</td>
<td>34.19</td>
<td>40.13</td>
</tr>
<tr>
<td>Pain</td>
<td>6.90</td>
<td>1.58</td>
</tr>
<tr>
<td>Diet</td>
<td>2.71</td>
<td>0.81</td>
</tr>
</tbody>
</table>

#### Failure Group (n=11)

<table>
<thead>
<tr>
<th></th>
<th>Preoperative</th>
<th>12 Months Postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMO</td>
<td>25.68</td>
<td>28.10</td>
</tr>
<tr>
<td>Pain</td>
<td>7.95</td>
<td>7.95</td>
</tr>
<tr>
<td>Diet</td>
<td>4.58</td>
<td>4.38</td>
</tr>
</tbody>
</table>
DISCUSSION

Few studies have evaluated prognostic factors for the outcome in arthrocentesis. However, none of these studies have investigated if the amount of disc displacement as a prognostic factor for the outcome of arthrocentesis. We hypothesized that a specific amount of disc displacement as noted on MRI examination correlated with the outcome of arthrocentesis procedures.

In this study, we examined the degree of anterior disc displacement, preoperative TMJ pain, diet score and MMO as probable prognostic factors on the treatment outcome of arthrocentesis. Success rate of all cases underwent arthrocentesis in this study was 76%. This observed percentage is similar to those found in multiple other scientific investigations but lower than what was observed in some studies conducted by Nitzan et al. Difference in success rates among these different studies are likely attributable to the heterogeneity in patient populations. Nitzan et al. treated only cases of anterior disc displacement without reduction, which is known to respond well to arthrocentesis. Our investigation included patients with disc displacement, both with and without reduction, which is a more diverse patient cohort.

Preoperative pain was significantly lower in successful cases with respect to unsuccessful cases (P < 0.05). These results are consistent with findings by Nishimura who observed a lower pain level on the VAS in successful cases compared to unsuccessful cases. A plausible explanation is that these findings are due to the high
levels of prostaglandin E$_2$ and leukotriene B$_4$ which are pain and inflammatory mediators in synovial fluid as a result of joint pathology$^{31}$. Therefore, cases with high preoperative pain on VAS might have had active inflammation in the TMJ, which in turn might reduce the effectiveness of arthrocentesis. Alternatively, Emshoff$^{25}$ et al. hypothesized that an alteration in the constituents of the synovial fluid is the main mechanism underlying an inflamed joint. Assuming this is true, the joint will benefit from the washout effect of arthrocentesis. However, in less severe instances with other etiologic factors, there is more resistance to the washout effect of arthrocentesis (i.e. disc adhesion and ankylosis).$^{31,32}$

Regarding the MMO scores, the results of this study revealed that preoperative MMO was significantly higher in successful cases than unsuccessful cases. MMO has significantly affected the outcome of the procedure since a higher MMO yields a higher likelihood of a successful outcome. This is consistent with findings from Nishimura$^{23}$ who found that patients with a successful outcome had a higher MMO preoperatively than those with an unsuccessful outcome. However, these results are not consistent with a study conducted by Emshoff$^{25}$ who found that patients with a successful outcome had a more restricted ROM than those with an unsuccessful outcome.

The chance of a successful outcome after therapy is greater than 80% if the displacement is $\leq$ 45 degree which represents a novel finding in the medical literature. However, these results don’t suggest that cases with disc displacement greater than or equal to 45 degrees should not be treated with arthrocentesis. Patients should be informed
about the prognosis of the procedure.

In summary, it has been shown that the degree of disc displacement, preoperative pain level, diet score, and MMO can be used as prognostic factors for the outcome of TMJ arthrocentesis. Future investigations should more carefully evaluate the validity of other variables. Identifying prognostic factors for the outcome on arthrocentesis will help with guiding surgeons in the planned evaluation of TMJ cases. More specifically, clinicians will be able to create tailored treatment modalities based upon prognostic factors.
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Maxillofacial Surgery 48:968, 1990

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(6 months in OMFS, 6 months in other dental specialties)

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University of Miami, Department of Oral and Maxillofacial Surgery  October- 2011
Boston University Medical Center, Department of OMFS  August 2010
Research and publications

Published:
1. Combined Open and Closed Access for Facial Dimple Creation
   Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology, Volume 117, Issue 4, April 2014
   Hamad Al Harbi, Ahmed Al Yamani, Osborn Timothy


3. Pattern of Cleft Lip and Palate in university hospital-Based Population in Saudi Arabia: Retrospective Study. The Egyptian dental Journal, July 2011 Volume 57 Number (3.2) Hamad Alharbi and Ahmed alyamani:

Participated in:
1. Cephalometric values for cleft patients in Saudi Arabia 2010

2. Anthropometric study of the norms of Facial proportion in a Saudi population 2011

3. Survey to assess the knowledge and management of dentists for odontogenic infection in the western region of Saudi Arabia 2011

Currently working on:
1. The Amount of disc displacement as a prognostic factor for the outcome of Arthrocentesis. Hamad Alharbi, Pushkar Mehra,

Oral Presentations

- Combined Open and Close Access for Facial Dimple Creation April 2013
   The ACOMS 34th Annual Scientific Conference, Scottsdale, AZ

- Long Term Follow up of Tibial Bone Graft, for Correction of Alveolar Bone Defects” May 2011
   2nd Balkan Association of Maxillofacial Surgeons (BAMS) and 5th Oral and Maxillofacial Surgery Society, Turkey

- Pattern of Cleft Lip and Palate in a university hospital-Based Population March 2011
in Saudi Arabia: A Retrospective Study” 3rd Cleft Palate and Craniofacial Symposium, King Faisal Specialist Hospital & Research Centre, Riyadh

Poster Presentations

- Standardization of facial photography June 2011
Poster day, King Abdulaziz University, Jeddah, Saudi Arabia.

- Pattern of Cleft Lip and Palate in a university hospital- Based Population in Saudi Arabia: A Retrospective Study May 2011
2nd Balkan Association of Maxillofacial Surgeons (BAMS), Turkey

- Autologous fat graft for treatment of facial asymmetry, January 2011
22nd Saudi Dental Society International Dental Conference, Riyadh, Saudi Arabia.