Association of edentulousness and removable prosthesis rehabilitation with severity of signs and symptoms of temporomandibular disorders

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ABSTRACT

Context: There are very few studies concerning the role of denture status in temporomandibular disorders (TMDs) and those show conflicting results.
Aim: To evaluate the association of edentulousness and removable prosthesis rehabilitation with severity of TMD signs and symptoms.
Settings and Design: Data were collected from 2000 subjects reporting for dental treatment, above 30 years of age.
Subjects and Methods: The subjects were interviewed with a questionnaire and clinically examined for TMD on basis of Helkimo’s index. The number of existing teeth, wearing of removable dentures, need for denture repair, and age of dentures was recorded.
Statistical Analysis: The association between the TMD findings and recorded variable outcomes was analyzed by means of Chi-square test.
Results: Completely edentulous individuals associated more with TMD related findings in incidence and intensity than partially/fully dentate subjects. Complete denture wearers were more associated with TMD symptoms, limited mandibular mobility, muscle tenderness, and pain on mandibular movement. Partial denture wearers were more associated with severely impaired temporomandibular joint function and joint pain. Signs and symptoms of TMD were more prevalent and severe in patients who needed to get their dentures repaired, those wearing dentures more than 5-year-old, and in patients who had not got their dentures repaired during the past 5 years.
Conclusions: Edentulousness, complete/partial denture wearing and poor condition of the dentures associate with greater incidence and intensity of TMD associated signs and symptoms.

Key words: Edentulousness, Helkimo’s index, removable prostheses, temporomandibular disorders

Temporomandibular disorders (TMDs) are a group of conditions characterized by pain or dysfunction in the temporomandibular joint (TMJ) and/or muscles of mastication. In the last few decades, many authors have investigated the etiology, diagnostics and treatment of TMDs. Epidemiological surveys report that 50–70% of the population have signs of a disorder at some stage during their life, whereas, an estimated 20–25% of the population have symptoms of a TMD. It has also been reported that the majority of those who seek treatment are women between the ages of 25 and 35.

TMDs have endogenous and exogenous causes that affect the neurogenous, myogenous, and arthrogenous parts.

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The role of tooth loss, denture wear and denture status on TMDs is controversial. Some studies state that TMDs appear to be almost as prevalent in complete dentures (CD) wearers as in dentate individuals, varying from 15 to 25%.[10,11] Other studies report that CD wearers have a higher prevalence of TMD symptoms than the normal population with natural dentition.[12] However, a higher figure of TMD signs in dentate individuals, compared with completely edentulous patients, has been reported.[13] It has also been said that the incidence and intensity of TMDs is higher in subjects with greater tooth loss in the supporting zones.[14] On the other hand, the current consensus is that loss of teeth and lack of posterior occlusal support have little association with TMDs.[15,16] As far as denture condition is concerned, no statistically significant correlations between signs and symptoms of TMD and denture retention, denture stability, occlusal disturbances, freeway space, age of present denture, or the number of sets of dentures have been found.[17]

The prevalence of TMD signs in partially edentulous patients wearing upper and lower removable partial dentures (RPD) have not been well-documented. On the contrary, much of the published work has been attributed to the completely edentulous CD-wearing and dentate patients. One study concludes that the partially edentulous patients (wearing RPD) exhibit more TMD signs when compared with the CD-wearing patients.[18]

Therefore, the primary objectives of the present study were to evaluate the association of tooth loss with severity of signs and symptoms of TMDs and to evaluate the association of rehabilitation with removable prostheses, with severity of signs and symptoms of TMDs.

The secondary objectives of the study were to evaluate the association of condition of the prosthesis (dentures in need of repair, dentures older than 5 years, and dentures already repaired in the past 5 years) with severity of signs and symptoms of TMDs. Another objective was to evaluate the association of gender with edentulousness, removable prostheses rehabilitation, and denture condition.

**SUBJECTS AND METHODS**

**Study sample**

Over a period of four months, a total of 3894 consecutive patients, who reported to us for dental treatment were screened at their first visit. Out of these, 2000 patients were eligible according to the inclusion and exclusion criteria, and agreed to be a part of this study. These 2000 subjects comprised the study population.

The inclusion criteria for the subjects participating in the study were that they had to be at least 30 years of age and should have been either those patients who were completely edentulous with or without complete dentures, or should have been dentate patients with or without partial dentures. The complete or partially edentulous patients should have had no history of any symptoms of TMD prior to tooth loss. All patients who had a complete or partial prosthesis should have had no symptoms of TMD prior to having received the prosthesis. All patients had to be of Indian Nationality.

Individuals previously diagnosed with any TMD symptom or treated for the same as well as individuals rehabilitated with a single CD opposing natural teeth or partial dentures, cast partial denture, or fixed prostheses were excluded from the study.

All procedures were followed in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. After each participant’s eligibility was confirmed, a written consent for the study was obtained from each subject.

**Data collection**

Age, gender, and level of education of the subjects were recorded. All subjects had their history taken using the Helkimo anamnestic dysfunction index, and clinical examinations were conducted in compliance with the Helkimo clinical dysfunction index. Anamnestic tests using the Helkimo anamnestic dysfunction index were performed using yes/no questionnaires. The information thus obtained allowed the patients to be classified as anamnestically dysfunctional indices (Ai): 0, I, and II. Following that, a clinical test of their masticatory system was conducted in compliance with the Helkimo clinical dysfunction index.[19-21] This is an index which examines the clinically visible dysfunction of the stomatognathic systems on the basis of five signs of TMD: Restricted maximum movement of the mandible, restricted TMJ function (deviation, joint noises and/or locking/luxation of joint), painful mandibular movement, muscle pain (the following bilateral areas were subject to routine palpatory examination: M. masseter profundus, m. masseter superficialis, m. temporalis-pars anterior, medialis, posterior, and insertion at the coronoid process, m. pterygoideuslateralis, m. pterygoideusmedialis), and painful TMJ.

Scores were determined in compliance with a three-level scale of acuteness and the following scores were assigned: 0 point for absence of symptoms, 1 point for mild pain, 5 points for an acute symptom. TMD was defined as the presence of one of the five signs cited. Scores assigned for the five symptoms were summed up. Each individual had a total dysfunction score ranging from 0 to 25 points. The higher the score obtained, the more acute or serious the disorder.
Di 0 = Helkimo dysfunction index 0 = 0 point = no clinical symptoms,
Di I = Helkimo dysfunction index 1 = 1–4 points = mild dysfunction,
Di II = Helkimo dysfunction index 2 = 5–9 points = moderate dysfunction,
Di III = Helkimo dysfunction index 3 = 10–25 points = acute/serious dysfunction.\textsuperscript{19} The clinical examination for assessment of the signs of TMD was done by the same experienced prosthodontist. In dentate patients without removable prostheses, patient’s maximum mouth openings were measured with a digital Vernier Caliper and reported as maximum interincisal distance plus vertical incisor overlap (the distance between the incisal edges of the upper and lower central incisors); it was considered limited when <40 mm. For RPD wearers with natural anterior teeth, the maximum opening was recorded between the incisal edge of the maxillary central incisor that is the most vertically oriented and measured vertically to the incisal edge of the opposing mandibular incisor. The amount of vertical incisor overlap was added to each of these measurements to determine the actual amount of opening. For those wearing CD and RPD with artificial anterior teeth, the maximum opening was recorded between the incisal edges of the maxillary central incisors and measured vertically to the incisal edges of the opposing mandibular incisors (at the midline) and added to the incisal overlap value.\textsuperscript{[1]} To ensure that the dentures stayed in place during maximum jaw opening, denture adhesive powder (Fittydent, ICPA) was used. In cases of severe mandibular and/or maxillary bone resorption coupled with unstable dentures, a light finger pressure was applied on the denture to help retain the denture in place during maximum jaw opening.

Joint tenderness was determined by bilateral digital palpation posteriorly via the external auditory meatus and laterally over the condyle in the immediate periauricular region. The presence of joint noises such as the presence of murmur, crackle, and traction in the joint (for restricted TMJ function) was assessed by the examiner using a stethoscope in front of the external auditory meatus.\textsuperscript{[22,23]}

The masseter and temporalis muscles were palpated bimanually for any signs and tenderness. The lateral pterygoid muscle was examined by recording its response to resisted movements (functional manipulation), as this muscle is not accessible to manual palpation.\textsuperscript{[24,25]}

After the assessment for Helkimo’s index, a clinical intraoral examination was performed. The presence of teeth and removable dentures was recorded during this examination. Number of teeth were recorded including all teeth and teeth remnants, visible and tactile in the mouth. For the analyses, the number of remaining teeth were categorized as 0, 1–9, 10–19, 19, and 20+. The classification was based on the current concept that minimum of 20 teeth is acceptable for assurance of oral function.\textsuperscript{[26]}

Denture status was categorized as follows: Edentate or with complete dentures, dentate with removable dentures, and dentate without removable dentures.

All prosthetic appliances (CD and RPD) were carefully examined to assess if they needed repair. The method of denture evaluation was the same as that performed by MacEntee and Wyatt.\textsuperscript{[27]} For the CD-wearing patients, the existing dentures were examined for support, retention, stability, occlusion, vertical dimension of occlusion, and freeway space. For the partially edentulous patients wearing RPD, the existing dentures were examined for retention, stability, occlusion, and extension of the base. If at least one of the above criteria were unsatisfactory, the need for denture repair was registered as ‘yes’ (need for denture repair in upper or lower denture or both).

Data were also collected with respect to denture age and past repairs for the dentures as follows: Subjects with at least one denture aged > 5 years (yes/no) and subjects with at least one denture repaired during the past 5 years (yes/no).

Statistical analyses
Statistical differences in prevalence for occurrence of clinical signs of TMD in various sub groups were evaluated by Chi-square tests using Statistical Package for Social Sciences (SPSS, Chicago IL, USA), Version 12.0. The test was used to assess the relationship between number of teeth, denture status, and denture conditions (need for repair, age of dentures, already repaired), and the signs and symptoms of TMDs. The significance level was set at \( P = 0.05 \).

RESULTS

Distribution of study population
Out of the 2000 patients that sought dental treatment and were included in the study, 43.75% were men and 56.25% were women. Among men as well as women, majority of the patients, fell into the category of 45–54 years age group (30.6% men, 30.4% women), and the least number of patients were over 75 years of age (4.2% men, 5.1% women). There was a statistically significant difference between edentulousness in men and in women; with women being more common (30.6% men, 30.4% women), and the least number of patients were over 75 years of age (4.2% men, 5.1% women). There was a statistically significant difference between edentulousness in men and in women; with women showing more tooth loss (14.3% women and 11.5% men were completely edentulous, whereas 45% women and 69.6% men having over 20 teeth). There was no statistically significant difference between denture status in men and women. The only denture condition variable with a statistically significant difference was that more men (9.5%) had dentures repaired at least once in the past 5 years when compared to women (5.6%) [Table 1].
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Table 1: Distribution of the study population

|                             | Men, n (%) | Women, n (%) | All, n (%) |
|-----------------------------|------------|--------------|------------|
| All subjects                | 875 (43.75)| 1125 (56.25) | 2000 (100) |
| Age group (P=0.003)         |            |              |            |
| 30-34                       | 82 (9.4)   | 165 (14.7)   | 247 (12.4) |
| 35-44                       | 246 (28.3) | 263 (23.4)   | 511 (25.6) |
| 45-54                       | 268 (30.6) | 342 (30.4)   | 610 (30.5) |
| 55-64                       | 159 (18.2) | 185 (16.4)   | 344 (17.2) |
| 65-74                       | 81 (9.3)   | 113 (10.0)   | 194 (99.7) |
| 75+                         | 37 (4.2)   | 57 (5.1)     | 94 (4.7)   |
| Level of education (P<0.0001) |          |              |            |
| Basic                       | 636 (72.7) | 887 (78.6)   | 1523 (76.2) |
| Secondary                   | 183 (20.9) | 109 (9.7)    | 292 (14.6) |
| Higher                      | 56 (6.4)   | 129 (11.5)   | 185 (9.3)  |
| Number of teeth (P<0.0001)  |            |              |            |
| 0                           | 101 (11.5) | 161 (14.3)   | 262 (13.1) |
| 1-9                         | 62 (7.1)   | 216 (19.2)   | 278 (13.9) |
| 10-19                       | 103 (11.8) | 242 (21.5)   | 345 (17.3) |
| 20+                         | 609 (69.6) | 506 (45.0)   | 1115 (55.8) |
| Denture status (P=0.056)    |            |              |            |
| Edentulous/with complete dentures |        |              |            |
|    | 101 (11.5) | 161 (14.3)   | 262 (13.1) |
| Dentate with removable dentures |       |              |            |
|    | 174 (19.9) | 248 (22.0)   | 422 (21.1) |
| Dentate without removable dentures |       |              |            |
|    | 600 (68.6) | 716 (63.6)   | 1316 (65.8) |
| At least one denture needing repair (P=0.723) | | | |
| Yes                        | 194 (22.2) | 242 (21.5)   | 436 (21.8) |
| No                         | 681 (77.8) | 883 (78.5)   | 1564 (78.2) |
| Subjects wearing at least one denture >5 years (P=0.358) | | | |
| Yes                        | 92 (10.5)  | 133 (11.8)   | 225 (11.3) |
| No                         | 783 (89.5) | 992 (88.2)   | 1775 (88.8) |
| Subjects wearing atleast one denture repaired during the past 5 years (P=0.001) | | | |
| Yes                        | 83 (9.5)   | 63 (5.6)     | 146 (7.3)  |
| No                         | 792 (90.5) | 1062 (94.4)  | 1854 (92.7) |

Relationship between number of teeth and clinical signs and symptoms of temporomandibular disorders

Majority of the patients with least severe signs and symptoms (Ai0-62.5%, normal range of mandibular mobility - 62.9%, least impairment of TMJ function - 60.6%, TMJ Pain - 57.5%, no muscle pain - 62.2%, no pain on mandibular movement - 57.5%, Di0-92.5%) were individuals with 20 + teeth, and this difference between groups was statistically significant.

Majority of the patients with most severe signs and symptoms (Ai11 - 51.1%, severely impaired mandibular mobility - 51.1%, severe muscle pain - 51.1%, severe pain on mandibular movement - 100%, Di11 - 51.1%) were individuals with zero teeth, and this difference between groups was statistically significant.

Statistically significant majority of severe impairment of TMJ function (61.9%) and TMJ pain (65%) was shown by individuals with 10–19 teeth [Table 2].

Relationship between denture status and clinical signs and symptoms of temporomandibular disorders

Majority of the patients with least severe signs and symptoms (Ai0-74.8%, normal range of mandibular mobility - 73%, least impairment of TMJ function - 72.4%, TMJ Pain - 67.9%, no muscle pain - 74.5%, no pain on mandibular movement - 68%, Di0-74.6%) were individuals who were dentate without removable dentures, and this difference between groups was statistically significant.

Majority of the patients with most severe signs and symptoms (Ai11 - 51.1%, severely impaired mandibular mobility - 51.1%, severe muscle pain - 51.1%, severe pain on mandibular movement-100%, Di11 - 51.1%) were individuals with zero teeth, and this difference between groups was statistically significant.

Statistically significant majority of severe impairment of TMJ function (62%) and TMJ pain (65%) was shown by individuals who were dentate with removable dentures [Table 3].

Relationship between subjects with at least one denture needing repair and clinical signs and symptoms of temporomandibular disorders

Majority of patients with most severe, as well as least severe signs and symptoms were those who had at least one denture needing repair, and this was statistically significant with respect to only TMJ pain (most severe - 61.4%, least severe - 65%), pain on mandibular movement (most severe - 63.4%, least severe - 100%), and Helkimo dysfunction index score (Di0-65%, Di11 - 58.3%). However, when compared to patients who did not need to get their dentures repaired, patients who needed to get their denture repaired, showed more signs of TMD; and this was statistically significant with respect to only TMJ pain (in 1to3 sites - 97.7%, in 4 or more sites - 65%), pain on mandibular movements (mild - 63.1%, severe - 100%), Helkimo dysfunction index score (Di I - 66.1%, Di II - 100%, Di III - 58.3%) [Table 4].

Relationship between subjects with at least one denture aged >5 years and clinical signs and symptoms of temporomandibular disorders

Majority of patients with least severe signs and symptoms (Ai0-76.1%, normal range of mandibular mobility - 74%, least impairment of TMJ function - 74.3%, TMJ pain - 69.9%, no muscle pain - 78%, no pain on mandibular movement - 67.9%, Di0-78%) were individuals who did not have dentures aged more than 5 years, and this difference between groups was statistically significant.

Majority of the patients with most severe signs and symptoms (Ai11 - 55.6%, severely impaired mandibular...
Table 2: Relationship between number of teeth and clinical signs and symptoms of temporomandibular disorders

| Number of teeth | 0, n (%) | 1-9, n (%) | 10-19, n (%) | 20+, n (%) | Total, n (%) 2000 subjects |
|-----------------|----------|------------|--------------|-----------|---------------------------|
| Helkimo anamnestic index score (P<0.0001) |          |            |              |           |                           |
| Ai0             | 100 (5.9) | 260 (15.5) | 266 (15.9)   | 1044 (62.5)| 1670 (83.5)               |
| Ai              | 139 (48.7)| 9 (3.1)    | 66 (23.1)    | 71 (24.9)  | 285 (14.3)                |
| Ai0i            | 23 (51.1)| 9 (20)     | 13 (28.9)    | 0 (0)      | 45 (2.3)                  |
| Mandibular mobility (P<0.0001) |          |            |              |           |                           |
| Normal range    | 123 (7)  | 260 (14.8) | 265 (15.1)   | 1101 (62.9)| 1749 (87.5)               |
| Slightly impaired| 116 (56.3)| 9 (4.3)   | 67 (32.5)    | 14 (6.7)  | 206 (10.3)                |
| Severely impaired| 23 (51.1)| 9 (20)     | 13 (28.9)    | 0 (0)      | 45 (2.3)                  |
| Impaired TMJ function (P<0.0001) |          |            |              |           |                           |
| Closing movements ≤ 2 mm | 147 (8.4)| 260 (14.9) | 286 (16.5)   | 1044 (60.1)| 1737 (86.9)               |
| Both joints and/or deviation ≥ 2 mm | 107 (44.2)| 18 (7.4)  | 46 (19.0)    | 71 (29.3)  | 242 (12.1)                |
| Locking and/or luxation of the TMJ | 8 (38) | 0 (0)       | 13 (61.9)    | 0 (0)      | 21 (1.1)                  |
| TMJ pain (P<0.0001) |          |            |              |           |                           |
| No tenderness to palpation | 235 (12.1)| 278 (14.3) | 309 (15.9)   | 1115 (57.5)| 1937 (96.9)               |
| Tenderness in 1-3 palpation sites | 20 (46.5)| 0 (0)       | 23 (53.4)    | 0 (0)      | 43 (2.2)                  |
| Tenderness in 4 or more palpation sites | 7 (35) | 0 (0)       | 13 (65)      | 0 (0)      | 20 (1.0)                  |
| Muscle pain (P<0.0001) |          |            |              |           |                           |
| No tenderness to palpation | 100 (6) | 260 (15.7) | 265 (16)     | 1031 (62.2)| 1656 (82.8)               |
| Tenderness to palpation laterally | 139 (46.4)| 9 (3.0)  | 67 (22.4)    | 84 (28)    | 299 (15)                  |
| Tenderness to palpation posteriorly | 23 (51.1)| 9 (20)     | 13 (28.8)    | 0 (0)      | 45 (2.3)                  |
| Pain on mandibular movement (P<0.0001) |          |            |              |           |                           |
| No pain on movement | 222 (11.5)| 278 (14.3) | 321 (16.5)   | 1115 (57.5)| 1936 (96.8)               |
| Pain on 1 movement | 33 (57.8)| 0 (0)       | 24 (42.1)    | 0 (0)      | 57 (2.9)                  |
| Pain 2 or more movements | 7 (100)   | 0 (0)       | 0 (0)        | 0 (0)      | 7 (0.4)                   |
| Helkimo dysfunction index score (P<0.0001) |          |            |              |           |                           |
| Dii0            | 100 (6)  | 0 (0)      | 265 (16)     | 1031 (82.5)| 1656 (62.2)               |
| Dii1            | 139 (50.1)| 9 (0.2)   | 45 (16.2)    | 84 (30.3)  | 277 (13.9)                |
| Dii2            | 0 (0)    | 22 (100)   | 0 (0)        | 22 (1.9)   |                           |
| Dii2i           | 23 (51.1)| 13 (28.8)  | 0 (0)        | 45 (2.3)   |                           |

TMJ=Temporomandibular joint

Table 3: Relationship between denture status and clinical signs and symptoms of temporomandibular disorders

| Denture status | Edentulous/with complete dentures, n (%) | Dentate with removable dentures, n (%) | Dentate without removable dentures, n (%) | Total, n (%) 2000 subjects |
|----------------|------------------------------------------|----------------------------------------|------------------------------------------|---------------------------|
| Helkimo anamnestic index score (P<0.0001) |          |            |              |                           |
| Ai0            | 100 (5.9) | 320 (19.1) | 1250 (74.8)  | 1670 (83.5)               |
| Ai2            | 139 (48.8)| 89 (31.2)  | 57 (0.2)     | 285 (14.3)                |
| Ai2i           | 23 (51.1)| 13 (28.9)  | 9 (0.2)      | 45 (2.3)                  |
| Mandibular mobility (P<0.0001) |          |            |              |                           |
| Normal range   | 123 (7)  | 350 (20)   | 1276 (73)    | 1749 (87.5)               |
| Slightly impaired| 116 (56.3)| 59 (28.6) | 31 (15)      | 206 (10.3)                |
| Severely impaired| 23 (51.1)| 13 (28.9)  | 9 (0.2)      | 45 (2.3)                  |
| Impaired TMJ function (P<0.0001) |          |            |              |                           |
| Closing movements ≤ 2 mm | 147 (8.5)| 332 (19.1) | 1258 (72.4)  | 1737 (86.9)               |
| Both joints and/or deviation ≥ 2 mm | 107 (44.2)| 77 (31.9) | 58 (23.4)    | 242 (12.1)                |
| Locking and/or luxation of TMJ | 8 (38) | 0 (0)       | 13 (62)      | 0 (0)                     | 21 (1.1)                   |
| TMJ pain (P<0.0001) |          |            |              |                           |
| No tenderness to palpation | 235 (12.1)| 386 (19.9) | 1316 (67.9)  | 1937 (96.9)               |
| Tenderness in 1-3 palpation sites | 20 (46.5)| 23 (53.4)  | 0 (0)        | 43 (2.2)                  |
| Tenderness in 4 or more palpation sites | 7 (35) | 13 (65)  | 0 (0)        | 20 (1)                   |
| Muscle pain (P<0.0001) |          |            |              |                           |
| No tenderness to palpation | 100 (6) | 319 (19.2) | 1237 (74.5)  | 1656 (82.8)               |
| Tenderness to palpation laterally | 139 (46.5)| 90 (30) | 70 (23.4)    | 299 (15)                  |
| Tenderness to palpation posteriorly | 23 (51.1)| 13 (28.9)  | 9 (0)        | 45 (2.3)                  |
| Pain on mandibular movement (P<0.0001) |          |            |              |                           |
| No pain on movement | 222 (11.5)| 398 (20.6) | 1316 (68)    | 1936 (96.8)               |
| Pain on 1 movement | 33 (57.9)| 0 (0)      | 24 (42.1)    | 57 (2.9)                  |
| Pain 2 or more movements | 7 (100)  | 0 (0)       | 0 (0)        | 7 (0.4)                   |
| Helkimo dysfunction index score (P<0.0001) |          |            |              |                           |
| Dii0            | 100 (6)  | 139 (8.4)  | 1237 (74.6)  | 1656 (82.8)               |
| Dii1            | 139 (50.2)| 68 (24.4) | 70 (25.3)    | 277 (13.9)                |
| Dii2            | 0 (0)    | 22 (100)   | 0 (0)        | 22 (1.1)                  |
| Dii2i           | 23 (51.1)| 13 (28.9)  | 9 (20)       | 45 (2.3)                  |

TMJ=Temporomandibular Joint
Table 4: Relationship between subjects at least one denture needing repair and clinical signs and symptoms of temporomandibular disorders

| At least one denture needing repair | Yes, n (%) | No, n (%) | Total, n (%) (684 denture wearing subjects) |
|------------------------------------|------------|-----------|-------------------------------------------|
| Helkimo anamnestic index score (P=0.067) |            |           |                                           |
| A0                                 | 256 (60.1) | 164 (39)  | 420 (61.4)                                |
| Aii                                | 159 (69.7) | 69 (30.2) | 228 (33.3)                                |
| Aiii                               | 21 (58.3)  | 15 (41.7) | 36 (5.3)                                  |
| Mandibular mobility (P=0.011)      |            |           |                                           |
| Normal range                       | 287 (60.7) | 186 (39.3) | 473 (69.2)                                |
| Slightly impaired                  | 128 (73.1) | 47 (26.9)  | 175 (25.6)                                |
| Severely impaired                  | 21 (58.3)  | 15 (41.7)  | 36 (5.3)                                  |
| Impaired TMJ function (P=0.002)    |            |           |                                           |
| Closing movements ≤2 mm            | 297 (62.0) | 182 (38)  | 479 (70)                                  |
| Both joints and/or deviation ≥2 mm | 118 (64.1) | 66 (35.9) | 184 (26.9)                                |
| Locking and/or luxation of the TMJ  | 21 (100)   | 0 (0)     | 21 (3.1)                                  |
| TMJ pain (P<0.0001)                |            |           |                                           |
| No tenderness to palpation         | 381 (61.4) | 240 (38.6) | 621 (90.8)                                |
| Tenderness in 1-3 palpation sites  | 42 (97.7)  | 1 (2.3)   | 43 (6.3)                                  |
| Tenderness in 4/more sites         | 13 (65)    | 7 (35)    | 20 (2.9)                                  |
| Muscle pain (P=0.085)              |            |           |                                           |
| No tenderness to palpation         | 256 (61)   | 163 (38.9) | 419 (61.3)                                |
| Tenderness to palpation laterally  | 159 (69.4) | 70 (30.6) | 229 (33.5)                                |
| Tenderness to palpation posteriorly| 21 (58.3)  | 15 (41.7) | 36 (5.3)                                  |
| Pain on mandibular movement (P<0.0001) |          |           |                                           |
| No pain on movement                | 393 (63.4) | 227 (36.6) | 620 (90.6)                                |
| Pain on 1 movement                 | 36 (63.1)  | 21 (36.8) | 57 (8.3)                                  |
| Pain 2 or more movements           | 7 (100)    | 0 (0)     | 7 (1)                                     |
| Helkimo dysfunction index score (P=0.02) |            |           |                                           |
| D0                                 | 256 (61.0) | 163 (38.9) | 419 (61.3)                                |
| Di                                 | 137 (66.1) | 70 (33.8)  | 207 (30.3)                                |
| Di                                 | 22 (100)   | 0 (0)     | 22 (3.2)                                  |
| Di0                                | 21 (58.3)  | 15 (41.7) | 36 (5.3)                                  |

TMJ=Temporomandibular Joint

mobility - 55.6%, severe impairment of TMJ function - 61.9%, TMJ pain - 100%, severe muscle pain - 55.6%, severe pain on mandibular movement - 100%, DiIII - 55.6%) were individuals who had dentures aged more than 5 years, and this difference between groups was statistically significant [Table 5].

**DISCUSSION**

The present study shows that complete edentulousness, complete, or partial denture wearing, patients with at least one denture needing repair, patients with dentures aged >5 years, and patients who had their dentures repaired in the past 5 years, all associated with positive and increased severity of TMD signs and symptoms.

The study showed that particularly total edentulousness associated with pain-related TMD findings, rather than partial edentulousness. These results are in contrast to those by Al-Jabrah and Al-Shumailan,[18] who found that partially edentulous patients (wearing RPDs) exhibited more TMD signs when compared with the CD wearers, in a sample of 200 patients. Conventionally, it has been thought that TMDs are caused by loss of occlusal support and an increase in joint loading, which in turn pre-disposes to disc displacements and degenerative joint diseases. However, of late, it has been concluded that loss of occlusal support does not necessarily lead to overload in TMJ.[15] Based on the results of the present study, it can be suggested that the association is reverse.

As far as denture status is concerned, the findings of the present study are supported by the recent studies that have...
Table 5: Relationship between subjects at least one denture aged >5 years and clinical signs and symptoms of temporomandibular disorders

| At least one denture aged >5 years | Yes, n (%) | No, n (%) | Total, n (%) 684 denture wearing subjects |
|-----------------------------------|------------|-----------|------------------------------------------|
| Helkimo anamnestic index score (P<0.0001) |            |           |                                          |
| AI0                               | 100 (23.8) | 320 (76.1) | 420 (61.4)                               |
| AI                               | 105 (46.0) | 123 (53.9) | 228 (33.3)                               |
| AIii                              | 20 (55.6)  | 16 (44.4)  | 36 (5.3)                                 |
| Mandibular mobility (P<0.0001)     |            |           |                                          |
| Normal range                       | 123 (26)   | 350 (74)  | 473 (69.2)                               |
| Slightly impaired                  | 82 (46.9)  | 93 (53.1)  | 175 (25.6)                               |
| Severely impaired                  | 20 (55.6)  | 16 (44.4)  | 36 (5.3)                                 |
| Impaired TMJ function (P<0.0001)   |            |           |                                          |
| Closing movements ≤2 mm            | 123 (26)   | 356 (74.3) | 479 (70)                                 |
| Both joints and/or deviation ≥2 mm | 89 (48.4)  | 95 (51.6)  | 184 (26.9)                               |
| Locking and/or luxation of the TMJ | 13 (61.9)  | 8 (38)     | 21 (3.1)                                 |
| TMJ pain (P<0.0001)                |            |           |                                          |
| No tenderness to palpation         | 187 (30.1) | 434 (69.9) | 621 (90.8)                               |
| Tenderness in 1-3 palpation sites  | 18 (41.9)  | 25 (58.1)  | 43 (6.3)                                 |
| Tenderness in 4 or more sites      | 20 (100)   | 0 (0)      | 20 (2.9)                                 |
| Muscle pain (P<0.0001)             |            |           |                                          |
| No tenderness to palpation         | 92 (22)    | 327 (78)  | 419 (61.3)                               |
| Tenderness to palpation laterally   | 113 (49.3) | 116 (50.7) | 229 (33.5)                               |
| Tenderness to palpation posteriorly| 20 (55.6)  | 16 (44.4)  | 36 (5.3)                                 |
| Pain on mandibular movement (P<0.0001) |        |           |                                          |
| No pain on movement                | 199 (32)   | 421 (67.9) | 620 (90.6)                               |
| Pain on 1 movement                 | 19 (33.3)  | 38 (66.7)  | 57 (8.3)                                 |
| Pain 2 or more movements           | 7 (100)    | 0 (0)      | 7 (1)                                    |
| Helkimo dysfunction index score (P<0.0001) |       |           |                                          |
| DI0                               | 92 (22)    | 327 (78)  | 419 (61.3)                               |
| DI                               | 105 (50.7) | 102 (49.3) | 207 (30.3)                               |
| DIii                              | 8 (36.3)   | 14 (63.6)  | 22 (3.2)                                 |
| DIiil                             | 20 (55.6)  | 16 (44.4)  | 36 (5.3)                                 |

TMJ=Temporomandibular joint

shown associations between wearing of CD and TMD.28,29 In the present study, most of the severest signs and symptoms of TMD were associated maximally in CD wearers. Only severely impaired TMJ function and joint tenderness were most prevalent in partial denture wearers. Edentulous individuals generally present parafunctional habits, unstable prostheses and impaired masticatory function, contributing to higher rates of limited mandibular opening and muscle tenderness.3 In the study, partial denture wearers exhibited more signs of impaired TMJ function and joint tenderness, could be that bite force has shown to be five to six times greater in dentate subjects than in the CD wearers. In addition, it has been shown that CD wearers avoid foods that are difficult to chew.30 This indicates that dentate individuals wearing partial dentures often exceed their tissue tolerance and adaptability. However, results differ in another study, where in a group of elderly Norwegians, with 92% wearing some form of removable denture,12,31 no relationship between the prosthetic status and related symptoms was found. Another study also found a low incidence of TMJ symptoms in elderly Brazilian CD wearers, with the exception of pain in the masseter muscle area and articular noises.32 These contradictory findings are probably due to the differences between target populations and the variety of methods used to investigate TMDs.33 Generalization of data from studies on TMD is currently limited by the frequent use of non-standardized diagnostic and classifying procedures, and this shortcoming affects prevalence studies as well.34 In this study, poor condition of dentures, that is dentures that needed repair, had never been repaired or dentures more than 5-year-old, contributed more to TMD when compared to those that did not need repair, had been repaired already or newer dentures. This finding supports the earlier results that problems in denture wearing may pre-dispose to TMD.35,36 However, several other studies have found no correlations between certain characteristics of dentures (denture retention, stability, occlusal errors, freeway space, age of present denture, or number of sets of dentures and the presence or severity of TMD signs and symptoms15,17,37. In addition, loss of vertical occlusal height on its own may not be responsible for the TMD occasionally seen in CD wearers with reduced vertical height.38

Impaired mandibular mobility and impaired TMJ function were the most common signs of TMD observed, and more so in CD wearers. CD wearers might be expected to have reduced maximum opening levels, as stability of the lower denture during this exercise requires muscular co-ordination to prevent displacement of the denture.39 Impaired TMJ function indicates presence of joint sounds or mandibular
deviation on opening or locking/luxation. Joint sounds were recorded as clicking or crepitus.

A variety of different causes to TMJ sounds have been suggested e.g., arthritic changes in the TMJ, anatomical variations, muscular incoordination, and disc displacement. Recent researchers related clicking “to a sudden acceleration of condylar and internally displaced disc tissues”.

Crepitus was encountered in degenerative disease of the articular surfaces, often associated with aging. The results of this study were in accordance with at least one study which found that osteoarthrosis was present more frequently amongst edentulous patients. Patients also reported that they had to clench their teeth together to ensure denture retention during normal function. This could explain the frequency of masseter and temporal muscle tenderness in patients wearing CD.

Another secondary objective was to evaluate the association between gender and edentulousness. Results from the present study indicate that there was a statistically significant difference between edentulousness in men and in women, with women showing more tooth loss. Since greater tooth loss has been associated with greater severity signs and symptoms of TMD in the present study, it is in accordance with reports from other studies that claim that in adults, signs and symptoms of TMD occur frequently, more often in women than in men.

The Helkimo index was chosen as it was developed specifically as an epidemiologic survey examination system for investigating the prevalence of global TMDs and to assess the need for treatment based on severity findings. It remains the most widely used scoring system in TMD research. The merit of the Helkimo index, undoubtedly, is that it introduced a fixed set of symptoms with well-defined assignments of the parts of the index and a computation of the index-class. This has resulted in a number of studies that have demonstrated comparable results concerning the presence of dysfunction, or even better, the presence of a number of symptoms in the patients subject to examination. Thus, well-defined estimates have been revealed and comparisons of the prevalence of symptoms in different populations can be made. On the other hand, it has been concluded that there is insufficient evidence to support the general applicability of this index. It has been suggested that, since Helkimo’s Di index contains many valuable elements, research should be directed to improving the existing scale rather than trying to construct a new one.

### Table 6: Relationship between subjects with at least one denture repaired during the past 5 years and clinical signs and symptoms of temporomandibular disorders

| Helkimo anamnestic index score (P<0.0001) | Yes, n (%) | No, n (%) | Total, n (%) 684 denture wearing subjects |
|------------------------------------------|------------|-----------|------------------------------------------|
| Ai0                                      | 56 (13.3)  | 364 (86.7) | 420 (61.4)                               |
| Ai1                                      | 83 (36.4)  | 145 (63.6) | 228 (33.3)                               |
| Ai11                                     | 7 (19.4)   | 29 (80.6)  | 36 (5.3)                                 |
| Mandibular mobility (P=0.014)            |            |            |                                          |
| Normal range                             | 56 (11.7)  | 423 (88.3) | 479 (70)                                 |
| Slightly impaired                        | 90 (48.9)  | 94 (51)    | 184 (26.9)                               |
| Severely impaired                        | 0 (0)      | 21 (100)   | 21 (3.1)                                 |
| Impaired TMJ function (P<0.0001)         |            |            |                                          |
| Closing movements ≤2 mm                  | 56 (11.7)  | 423 (88.3) | 479 (70)                                 |
| Both joints and/or deviation ≥2mm        | 90 (48.9)  | 94 (51)    | 184 (26.9)                               |
| Locking and/or luxation of the TMJ       | 0 (0)      | 21 (100)   | 21 (3.1)                                 |
| TMJ pain (P<0.001)                       |            |            |                                          |
| No tenderness to palpation               | 139 (22.4) | 482 (89.6) | 621 (90.7)                               |
| Tenderness in 1-3 palpation sites        | 0 (0)      | 43 (100)   | 43 (6.3)                                 |
| Tenderness in 4 or more sites            | 7 (35)     | 13 (65)    | 20 (2.9)                                 |
| Muscle pain (P<0.0001)                   |            |            |                                          |
| No tenderness to palpation               | 48 (32.9)  | 371 (69)   | 419 (61.3)                               |
| Tenderness to palpation laterally        | 91 (62.3)  | 138 (25.7) | 229 (33.5)                               |
| Tenderness to palpation posteriorly      | 7 (19.4)   | 29 (80.6)  | 36 (5.3)                                 |
| Pain on mandibular movement (P<0.0001)   |            |            |                                          |
| No pain on movement                      | 139 (22.4) | 481 (77.5) | 620 (90.6)                               |
| Pain on 1 movement                       | 7 (0)      | 50 (100)   | 57 (8.3)                                 |
| Pain 2 or more movements                 | 0 (0)      | 7 (100)    | 7 (1)                                    |
| Helkimo dysfunction index score (P<0.0001)|           |            |                                          |
| Di0                                      | 48 (11.5)  | 371 (88.5) | 419 (61.3)                               |
| Di1                                      | 91 (44)    | 116 (56)   | 207 (30.3)                               |
| Di2                                      | 0 (0)      | 22 (100)   | 22 (3.2)                                 |
| Di3                                      | 7 (19.4)   | 29 (80.6)  | 36 (5.3)                                 |

TMJ=Temporomandibular joint
The present study does have its limitations; the associations between local background factors and TMD findings differ between genders, and the connection should be observed separately in women and men, which haven’t been done in his study. The need for denture repair could also have been evaluated subjectively, and not just clinically, since psychological factors also were shown to influence TMD. However, the strength of the study design is that it allowed the use of several outcome variables that is the presence as well as severity of the main signs of TMD. All the signs were analyzed separately, by experienced specialists, according to the standardized specifications.

CONCLUSION

The present study showed that edentulousness, complete/partial denture wearing as well as dentures poor condition of the dentures (dentures in need of repair, dentures aged >5 years, dentures that had never been repaired) associated with greater incidence and intensity of TMD associated signs and symptoms, as assessed clinically. This implies that prevention of total dental loss is important to minimize the local risk factors for TMD. Moreover, enhancing denture retention and stability, possibly by implant-supported overdentures, may relieve TMD among edentate subjects. Early repair or replacement of dentures may also reduce the incidence and intensity of TMD among denture wearers.

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Conflicts of interest
There are no conflicts of interest.

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