International Journal of Applied Mathematics

Volume 38 No. 1 2025, 14–21
ISSN: 1311-1728 (printed version); ISSN: 1314-8060 (on-line version)
doi: http://dx.doi.org/10.12732/ijam.v38i1.2

MODELING DATA FOR ATYPICAL CERVICOFACIAL PAIN USING TWO-STAGE LOGISTIC REGRESSION

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Received: November 25, 2024

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Abstract

Osteoarthrosis of the temporomandibular joint is a slowly progressive degenerative disorder. Clinical symptoms usually manifest unilaterally, and some joints with osteoarthrosis-related structural alterations don't show any symptoms at all. However, we have observed some rare cases of atypical high-intensity pain ($\geq$ 9 in VAS scores) in the contralateral non-osteoarthrosis joint, cervical, and masticatory muscles without any discomfort in the osteoarthrosis (OA) joint, but with pronounced hypomobility and deviation of the mandible to the OA joint. Our purpose was to determine if the presence of unilateral OA predisposes to the development of atypically severe pain in the contralateral joint and cervicofacial muscles, as well as the time at which the pain is likely to manifest itself from the initial symptoms of osteoarthrosis. Material and methods: A total of 90 patients with unilateral OA were divided into three groups according to the presence of cervicofacial pain and into two groups according to mandibular deviations. A two-stage logistic regression was performed to obtain an adjusted estimate of the odds and to identify if unilateral osteoarthrosis is a predictor of severe contralateral cervicofacial pain. The software package STATISTICA 13.0 was used for analysing the real data. Results and conclusions: Patients with unilateral OA and deviation to the OA side had a higher rate of atypical severe contralateral cervicofacial pain, which can occur in the first 21 months after the initial symptoms of OA.

Math. Subject Classification: 62J20, 62J12

Key Words and Phrases: DC/TMD, osteoarthrosis, cervicofacial pain, two-stage logistic regression

1. **Introduction**

Reduced mandibular range of motion is one of the typical hallmarks of osteoarthrosis (OA) of the temporomandibular joint (TMJ), a non-infectious, inflammatory-degenerative condition. Because some joints with structural condylar abnormalities are clinically asymptomatic, OA does not always impact the TMJs evenly or equally. A number of studies indicate that characteristics related to pain are not dependent on the degree of degenerative changes in the TMJ or condylar mobility capability (see [1], [2]). The aching, if present, is normally restricted to the joint location, although additional muscular complaints may cause it to spread to the affected side of the face. The increased prevalence of OA in adults may have some implications for treating cervicofacial pain. Depression and anxiety, which have been significantly increasing in recent decades due to the accumulation of stress in society, are often associated with daily bruxism, i.e., compression and joint overload, which provokes the development of OA (see [3]).

In our clinical practice, we have observed some rare cases of atypical severe cervicofacial pain that affects specifically the contralateral non-osteoarthrosis side in the presence of hypomobility and absence of pain in the osteoarthrosis joint (see [4]). This can be an embarrassing situation for practitioners who do not take into account the relationship between OA joint hypomobility and deviations and their impact on the functionality of the contralateral healthy joint and associated tissues (see [5]).

The mandibular deviation to the OA joint may provoke a contralateral non-OA joint distortion (overstretching and twisting of the TMJ ligaments and associated tissues), which may progress to atypical high-intensity cervicofacial pain localised in the contralateral non-OA joint and masticatory muscles, radiating to the cervical region and shoulders, affecting the sternocleidomastoid, trapezius, digastric, omohyoid, splenius capitis, and levator scapulae muscles (see [6], [7], [8], [9]). The TMJ distortion is not yet classified separately in the taxonomy as a subspecies of joint dislocations, and this is a gap in the TMD classification system (see [10], [11]). Unlike general orthopaedics and traumatology, where distortions, e.g., of the ankle or knee, are a well-studied pathology, the overstretching and twisting of the TMJ ligaments that lead to specific symptoms other than those of typical subluxations have not been studied (see [12]).

The aim of this analysis of data from a random sample is to investigate the frequency of contralateral cervicofacial pain and its association with unilateral osteoarthrosis (erosive and osteochondral forms) (see [13]) and deviation to the osteoarthritic side. A two-stage logistic regression was used to obtain an adjusted estimate of the odds and identify if unilateral osteoarthrosis is a predictor of atypical contralateral cervicofacial pain.

2. Material and methods

A total of 90 patients with unilateral TMJ osteoarthrosis had undergone clinical and radiological assessment according to DC/TMD criteria (see [14]) at the Department of Dental, Oral, and Maxillofacial Surgery, Faculty of Dental Medicine, Sofia. The patients were examined for the type of degenerative changes, the presence of arthralgia, and myogenic trigger points. The protocols were processed in a table with indicators sex, the time for initiation of OA symptoms, and the presence of cervicofacial pain. The patients were divided into three groups: without pain at the OA side; with ipsilateral (OA side) pain only; and with severe contralateral pain only.

3. Mathematical models

Logistic regression is used to estimate the relationship between one or more independent variables and a binary (dichotomous) outcome variable. Logistic regression model has been applied in a variety of contexts, including cohort and case-control studies, problems in differential diagnosis and prediction, and the analysis of survey data (see [15], [16]).

Multinomial logistic regression is a classification method that generalizes logistic regression to more than two possible discrete outcomes. These models are used to predict the probabilities of the different possible outcomes of a categorically distributed dependent variable, given a set of independent variables (covariates), which may be real-valued, binary-valued, categorical-valued, etc. In two-stage logistic regression, tests for the contribution of one or more parameters from the same regression are usually constructed with a large sample Wald test with a test statistic (see [17]).

In this study we use three discrete outcomes: without pain at the OA (coded by 1), with ipsilateral (OA side) pain only (coded by 2) and with severe contralateral pain only (coded by 3).

4. Results and discussion

For our data, the dependent variable Y has three outcomes $j = 1, 2, 3$: the first is that the patient has no cervicofacial pain at the OA site; the second is that the patient has ipsilateral OA cervicofacial pain; and the last outcome is that the patient has contralateral cervicofacial pain only.

The independent variables in the model are two: sex (x_1) and unilateral osteoarthrosis (x_2). The codes for the categories of these qualitative variables are:

- The sex: female (”1”) and male (”2”);
- The mandibular deviations (mD): without mD (”0”) and with mD (”1”).

When the outcomes are three, an approximate solution can be obtained by fitting two separate binary (dichotomous) logistic regressions. The first should exclude all respondents in the unrestricted category, and the second should exclude all respondents in the prohibited category.

Let us consider two binary logistic models. The dichotomous (binary) logistic regression model assumes that the logit function (logarithm of odds - *log odds*) is linear function $f(x) = B_0 + B_1x_1 + B_2x_2$.

The first logit compares outcome $j = 1$ to the remaining categories. The second logit then compares the outcome $j = 2$ to the remaining category from the second set of the first partition. The diagram below illustrates the pattern for a total three categories:

Logit 1: 1 versus {2, 3}.

Logit 2: 2 versus 3.

It is important to note that only the first model equation uses the entire data set for estimation. The second equation uses only the observations corresponding to categories 2 and 3, and therefore.

By use of software package STATISTICA 13.0 (see [18]) and all 90 data the following dichotomous logistic regression model is obtained

$$\ln \frac{\bar{p}}{1-\bar{p}} = -1.23 - 0.71x_1 - 0.35x_2 \,.$$

The remaining 63 data for the patients with cervicofacial pain are coded “1” - ipsilateral cervicofacial pain, “2” – contralateral pain only and from the second binary regression we get:

$$\ln \frac{\bar{p}}{1-\bar{p}} = -1.13 + 0.16x_1 + 0.62x_2 \,.$$

The Wald test statistic tells us that in the first binary model, both parameters are statistically significant at the $p = 0.05$ level: B_1 ($p = 0.00003$), B_2 ($p = 0.015$) and in the second, only parameter B_2 ($p = 0.032$).

From the results in the first model and according to the remarks in the previous section, we can infer that the probability of experiencing contralateral cervicofacial pain is higher when:

- The gender of the patient is female.
- The patient has unilateral osteoarthrosis.

From the results in the second model, we can conclude that sex is not significant predictor of contralateral cervicofacial pain and that the probability of this type of pain is higher when the patient has deviation to the OA side.

Using Kaplan-Meier method (see [19]), we estimate that atypical contralateral cervicofacial pain occurs in the first 21 months after the initial symptoms of OA.

5. **Conclusion**

Unilateral OA-dependent hypomobility may cause the contralateral joint's ligaments to be distorted as a result of compensatory overstretching and the manifestation of high-intensity contralateral cervicofacial pain. In such cases, practitioners could be confused when selecting the appropriate therapeutic modality, given the absence of a standardised instruction for operating or an authoritative explanation of the mechanism. This survey provides information about a rare, unclassified pain pathology that can manifest in women, covering simultaneously three categories: unilateral OA, condylar hypomobility, and mandibular deviation to the OA side. The presence of severe contralateral neck pain significantly differs from the standard OA symptomatology and can occur most likely in the second year after the onset of the disease. We believe that our findings could contribute to any future analyses validating these relationships.

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