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A cross-sectional analysis of facial palsy-related quality of life in 125 patients: Comparing linear, quadratic and cubic regression analyses

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Abstract

Introduction: Facial function correlates with quality of life in facial palsy. Previous studies have examined a linear relationship; based on clinical experience, we hypothesize a curved regression (i.e. quadratic or cubic) will be more fitting to show the correlation between quality of life and facial function.

Methods: We compared the fit of a linear regression model between Sunnybrook scores (facial function) and FaCE and FDI scores (quality of life) to a quadratic and cubic regression model in 125 patients cross-sectionally.

Results: A total of 125 patients were included, 53.6% female with a mean (standard deviation) age of 56.6 (16.7) and a median (interquartile range) duration of palsy of 6.6 (1.5; 18.3) years. The quadratic regression proved a significant improvement over a linear regression analysis in the model using the FaCE total score (linear R_2 =.346, quadratic R_2 = .378, p = .033) and the FDI physical score (linear R_2 = .245, quadratic R_2 =.276, p = .034). The cubic regression analysis was no significant improvement over a quadratic regression.

Discussion: The relationship between facial function and quality of life in facial palsy is not linear meaning that there is a lot of variation in QoL in cases with severe and moderate facial impairment. This is most applicable to patients suffering from post-paralysis synkinesis, proving the highly individually experienced burden of synkinesis. As the relationship is not linear it should not be included as such in future research studies.

1 | INTRODUCTION

Facial palsy is a condition characterised by disturbed function of the facial muscles. Long-standing facial palsy can be categorised into two groups, those in whom synkinesis is absent (chronic flaccid paralysis) and those in whom synkinesis is present (post-paralysis synkinesis). Post-paralysis synkinesis is characterised by unwanted facial movements during a volitional alternate movement, due to aberrant reinnervation of the facial nerve. Both can result in functional problems such as oral incompetence and speech impairment and can influence psychosocial well-being by introducing problems with negative self-image and feelings of anxiety or depression.[1] Evaluation of facial palsy should thus not solely consists of a measure of facial function but must also include a patient-reported outcome measure. Prior studies have examined factors influencing quality of life (QoL) in facial palsy and found that facial function was the greatest contributing

factor currently known to influence QoL.[2] Until now, the relationship studied between facial function and QoL has always been assessed as a linear one, assuming an equal decrease in QoL in relation to the decrease in facial function. Based on our clinical experience, we believe the relationship between facial function and QoL is non-linear: we expect a strong correlation between QoL and mild impairment of facial function, while the correlation between QoL and facial function in severe and moderate cases may be weak.

In the present study, we examined if the curved relationship is a better fitting model compared to the most commonly used linear model.

2 | METHODS

This study was a reanalysis of previously collected data for the translation and validation studies of the Dutch versions of the Facial Clinimetric Evaluation (FaCE) scale,[3] Synkinesis Assessment Questionnaire (SAQ)[4] and Facial Disability Index (FDI).[5] No new patients were included and no new data was gathered for the current study. Approval of the Medical Ethics committee and written consent of participants were gathered with the before-mentioned studies.

Key points

1. Facial function correlates with quality of life in facial palsy.
2. Previous studies examined a linear relationship; based on clinical experience, we hypothesize a curved regression (i.e. quadratic or cubic) will be more fitting to show the correlation between quality of life and facial function.
3. We compared the fit of a linear regression model between Sunnybrook scores (facial function) and FaCE and FDI scores (quality of life) to a quadratic and cubic regression model in 125 patients cross-sectionally.
4. The quadratic regression proved a significant improvement over a linear regression analysis in the model using the FaCE total score (linear $R^2 = .346$, quadratic $R^2 = .378$, $p = .033$) and the FDI physical score (linear $R^2 = .245$, quadratic $R^2 = .276$, $p = .034$). The cubic regression analysis was no significant improvement over a quadratic regression.
5. The relationship between facial function and quality of life in facial palsy is not linear and should not be included as such in future research studies.

TABLE 1 Results of nested regression analyses for the FaCE total score, FDI physical function, FDI social/well-being in the total study sample ($n = 125$)

Model[a]	R^2	R^2 change	Significance change
FaCE total score			
1	.138		
2	.346	.208	**<.001**
3	.378	.032	**.033**
4	.378	.001	.785
FDI physical function			
1	.190		
2	.245	.055	**.006**
3	.276	.031	**.034**
4	.279	.003	.525
FDI social/well-being function			
1	.090		
2	.113	.023	.089
3	.113	.000	.990
4	.113	.001	.777

Note: Significant results ($\alpha = .05$) are reported in bold.
[a]Model 1 includes the descriptive variables gender, age, duration of palsy and aetiology. Model 2 consists of model 1 with an added variable for the linear relationship between facial function and the outcome variable. In model 3, a quadratic function for facial function is added. In model 4, a cubic function is added.

TABLE 2 Results of nested regression analyses for the FaCE total score, FDI physical function, FDI social/well-being in the patients suffering from chronic flaccid paralysis ($n = 60$)

Model[a]	R^2	R^2 change	Significance change
FaCE total score			
1	.331		
2	.493	.162	**.002**
3	.497	.004	.617
4	.513	.016	.299
FDI physical function			
1	.271		
2	.368	.097	**.011**
3	.374	.006	.524
4	.405	.031	.138
FDI social/well-being function			
1	.169		
2	.169	.000	.890
3	.171	.002	.758
4	.201	.030	.189

Note: Significant results ($\alpha = .05$) are reported in bold.
[a]Model 1 includes the descriptive variables gender, age, duration of palsy and aetiology. Model 2 consists of model 1 with an added variable for the linear relationship between facial function and the outcome variable. In model 3, a quadratic function for facial function is added. In model 4, a cubic function is added.

TABLE 3 Results of nested regression analyses for the FaCE total score, FDI physical function, FDI social/well-being in the patients suffering from post-paralysis synkinesis ($n = 65$)

Model[a]	R^2	R^2 change	Significance change
FaCE total score			
1	.171		
2	.350	.179	**.001**
3	.393	.043	.081
4	.408	.015	.300
FDI physical function			
1	.147		
2	.160	.013	.368
3	.272	.112	**.007**
4	.290	.018	.264
FDI social/well-being function			
1	.130		
2	.183	.052	.068
3	.205	.023	.223
4	.240	.035	.130

Note: Significant results ($\alpha = .05$) are reported in bold.
[a]Model 1 includes the descriptive variables gender, age, duration of palsy and aetiology. Model 2 consists of model 1 with an added variable for the linear relationship between facial function and the outcome variable. In model 3, a quadratic function for facial function is added. In model 4, a cubic function is added.

2.1 | Data collection

Adult patients with facial palsy visiting the outpatient department of plastic surgery at the University Medical Centre, Groningen, the Netherlands, or the department of otorhinolaryngology at the Radboud University Medical Centre, the Netherlands, were approached to participate. Patients filled out the FaCE scale, the FDI and some demographical questions. Facial function was measured using the Sunnybrook Facial Grading System (Sunnybrook),[6] and at each institution an assessor experienced in performing Sunnybrook scoring performed the Sunnybrook scoring. Patients younger than 18 years old or not sufficiently fluent in Dutch were excluded from participation.[3–5]

2.2 | Statistical analysis

Descriptive statistics were calculated using numbers and frequencies, means and standard deviations (SD), and medians and interquartile ranges (IQR). Nested regression models were analysed for each of the outcome variables: FaCE total score, FDI physical score and FDI social/well-being score. The first model contained the descriptive variables gender, age, duration of palsy and aetiology. The second model contained a linear function for facial function. The third model contained a quadratic function for facial function (i.e. a relationship with one curve), and the fourth, a cubic function (i.e. a relationship with two curves). The model correlation coefficient (R^2) was calculated as a measure of fit for each model; the R^2 represents the proportion of variance in the output variable that can be explained by the input variable. R^2 was compared between the nested models, change in R^2 and a p-value for change was calculated.

A sub-analysis was performed for patients suffering from chronic flaccid paralysis and post-paralysis synkinesis separately. Additionally, above-described analyses were performed with all FaCE scale sub-domain scales as outcome variables and are presented as additional material.

All statistical analyses were done using the Statistical Package for Social Sciences (SPSS) version 23 (IBM). A p-value ≤.05 was considered statistically significant.

3 | RESULTS

One hundred and twenty-five patients could be included for this study. Sixty-seven patients were female (53.6%) and mean (SD) age at the time of inclusion was 56.6 (16.7) years. Both groups of chronic flaccid paralysis ($n = 60$ [48%]) and post-paralysis synkinesis ($n = 65$ [52%]) were equally represented. The most common aetiology of facial palsy was Bell's palsy ($n = 31$ [24.8%]), followed by postoperative complication of vestibular schwannoma treatment ($n = 24$ [19.2%]), Ramsay Hunt syndrome ($n = 11$ [8.8%]) and trauma ($n = 9$ [7.2%]). Median (IQR) duration of palsy was 6.6 (1.5; 18.3) years. Median (IQR) Sunnybrook scores were 34.0 (25.0; 55.5), FaCE total scores were 51.7 (40.0; 61.7), FDI physical function scores were 70.0 (55.0; 80.0) and FDI social function scores were 76.0 (64.0; 88.0).

The quadratic regression model was found to be a statistically significant improvement over the model containing a linear function for the outcomes FaCE total score and FDI physical function

(Table 1). In both models, an increase in explained variance of 3% was seen. The cubic model did not prove to be an improvement compared to the quadratic model. Correlation between facial function and the FDI social/well-being score was weak, and both the quadratic and cubic models were not improved compared to the linear function (Table 1).

Interestingly, the model including a quadratic function proved to be better fitting in patients suffering from post-paralysis synkinesis (R^2 changes of 4.3%, 11.2% and 2.3% for the FaCE total score, FDI physical function and FDI social/well-being function, respectively) compared to patients suffering from chronic flaccid paralysis (R^2 changes <1%) (Tables 2, 3). A similar trend was seen in the FaCE sub-domain score models (additional material Tables S1–S3).

4 | DISCUSSION

In the current study, we found that a quadratic regression model provides a significantly better estimation of the association between facial function and QoL compared to a linear regression model. A cubic regression model did not prove an improvement over a quadratic regression.

The explained variance (R^2) of both the FaCE total score and the FDI physical score model improved significantly by 3.2% and 3.1%, respectively. The FDI social score showed no-significant improvement for any of the applied models. This is in line with previous research showing a weak and often non-significant correlation between facial function and the social aspect of QoL in facial palsy.[7]

In a previous study, examining factors influencing quality of life in facial palsy, an explained variance of 3.8% was found for a multivariate model predicting FaCE total scores by age, gender, duration of palsy and aetiology.[8] In a follow-up study, the authors found an explained variance of 18.9% in a linear model predicting FaCE total scores by eFACE facial function scores.[2] The addition of 10 clinical and demographic variables to this model increased the explained variance by 7.2%. In our study, the explained variance of the models containing descriptive characteristics and a quadratic function for facial function was 37.8% and 27.6%, respectively. Modelling a quadratic regression can be seen as a rather large and and clinically relevant improvement, since we were able to achieve similar values for explained variance with far fewer variables.

The quadratic function was most clearly present in patients suffering from post-paralysis synkinesis with changes in explained variance of 4.3%, 11.2% and 2.3%, compared to a change in explained variance of smaller than 1% in patients suffering from chronic flaccid paralysis. These changes were not statistically significant, which could be due to small sample size. We believe this means the experienced burden of synkinesis is much more individual compared to flaccid paralysis, as is supported by a previous study demonstrating the importance of incorporating patient self-experience synkinesis scores in QoL modelling in patients suffering from synkinesis.[9]

One of the limitations of our study was that we reanalyzed data previously collected in two different centres. All Sunnybrook scores were performed by experienced assessors. However, small local differences could be present. Furthermore, the scores from the Radboud University Medical Centre were retrospectively collected from the medical charts. Although only patients with stable disease were included, this could potentially allow for variation in the Sunnybrook scores.

The findings from the current study cannot directly be generalised to other situations. We have used the Sunnybrook scale as a measurement for facial function and although it is shown to be valid, reliable, and is frequently used, findings may be different for other facial grading instruments such as the more recently developed eFACE scale or the historically much used House-Brackmann facial grading scale. A future study comparing linear and non-linear functions between individual items of facial function and QoL would be very interesting but was outside the scope of this pilot-type study.

We present a study of QoL and although the FaCE scale and FDI were translated and culturally validated according to standard guidelines, QoL remains highly individual and may very well be influenced by cultural background.[10] Variables predicting QoL may differ, so the magnitude of association found in our study population may not necessarily be equal in other populations.

5 | CONCLUSIONS

Our study demonstrates that a quadratic relationship between severity of long-standing facial palsy and QoL provides a better estimation compared to a linear regression analysis. This means that in mild cases of facial palsy, QoL can be relatively well estimated, while there is a lot of variation in QoL in cases with severe and moderate facial impairment. This is most applicable to patients suffering from post-paralysis synkinesis, proving the highly individually experienced burden of synkinesis.

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AUTHOR CONTRIBUTIONS

RV analysed and interpreted data, and drafted and revised the manuscript. TEB was involved in the design of the study, data collection and critical revision of the manuscript. KJAOI and PNMW were involved in the design of the study and critical revision of the manuscript. MMvV was involved in the design of the study, data analysis and interpretation and critical revision of the manuscript. All authors agree to be accountable for all aspects of this work.

[Correction added on May 31, 2022, after first online publication: Peer review history is not available for this article, so the peer review history statement has been removed.]

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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