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Nutritional Status, Oral Rehabilitation, Systemic health conditions, Diabetes mellitus, Oral health, Patient-reported outcomes

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Association Between Nutritional Status, Systemic Health Conditions, and Oral Rehabilitation Outcomes in Adult Dental Patients

Abstract
Nutritional status and systemic health conditions are recognized determinants of oral health and may influence oral rehabilitation (OR) outcomes. There is, however, limited data regarding the relation of these two variables to patient-reported OR outcomes in adult patients attending dental clinics. To evaluate the association between Nutritional Status (NS), systemic diseases, and OR outcomes among adult patients attending a dental clinic. A cross-sectional questionnaire-based observational study was carried out among 80 adult patients attending the dental clinic for OR. Information on demographics, nutritional status, systemic diseases, oral hygiene, rehabilitation details, and patient-reported outcomes was collected using a structured questionnaire. Descriptive statistics were presented as frequency and percentages along with mean ± SD. Independent samples t-test, chi-square test, Pearson correlation analysis, and multiple linear regression were carried out with statistical significance level of $p < 0.05$. Participants exhibited a moderately sound NS along with acceptable OR outcomes. The association between NS and OR outcomes was highly significant ($r = 0.377$, $p = 0.0006$). Diabetic participants had significantly poorer OR outcomes compared to non-diabetics ($p = 0.0049$), while hypertension and obesity had no significant impact on the outcomes of OR. Nutritional status was identified to have a significant impact on OR outcomes through multiple linear regression analysis, whereas diabetes mellitus significantly impacted the outcomes negatively. Good NS positively affected OR outcomes, while diabetes mellitus negatively affected the treatment process. It is recommended that NS assessments and health conditions of patients must be considered during OR processes.

1. Introduction
Oral health is a vital part of overall health and it is important to maintain proper nutrition, communication, aesthetics and general life quality. Oral Rehabilitation (OR) is becoming more and more necessary to adult patients because of tooth loss, periodontal disease, dental caries, trauma and oral aging. Effective OR does not just rely on restoration of dental functionality since the results of any treatment depends on various factors related to the patient, such as nutritional and general health. It has been shown that poor health outcomes and worse clinical recovery are linked to compromised oral health, which underlines the necessity to place oral conditions in the framework of a broader healthcare perspective [1]. Nutrition plays a role in the preservation of oral tissues, immune competence, bone metabolism and wound healing, which are all important in effective OR. Proper consumption of macro- and micronutrients promotes periodontal well-being, mucosal integrity, osseointegration, and adaptation to prosthetic therapy, and nutritional deficiencies can disrupt healing and decrease the success of treatment [2]. A more recent systematic review has also confirmed that Nutritional Status (NS) is highly correlated with oral health outcome and affects how such patients who need dental rehabilitation are managed [3].

Nutrition and OR have a two-way relationship. Though proper nutritional condition is conducive to positive rehabilitation, oral functioning can also enhance diet intake through increasing the efficiency of chewing and food choice. It has been demonstrated by systematic evidence that dietary counseling and OR can help in quantifiable changes in the NS and general health of the adults receiving dental treatment [4]. On the other hand, oral health can tend to restrict the foods intake leading to insufficient nutrient uptake, which can further undermine oral tissues and lead to a vicious oral and systemic health cycle [5]. Medical conditions that are systemic also contribute a significant amount to the outcome of OR. Examples of chronic diseases that can affect the repair of tissues, predispose to oral infections, and affect the prognosis of the treatment include diabetes mellitus, hypertension, obesity, osteoporosis, and cardiovascular disorders. Additionally, nutritional deficiencies are often accompanied by systemic diseases, which present even more difficulties in the rehabilitation process. It has been shown in reviews that effective OR has a beneficial effect on nutrient consumption and quality of diet, whilst chronic oral dysfunction can be associated with malnutrition and worse health outcomes [6]. Equally, loss of teeth has always been linked to impaired nutritional health in adults, and thus the need to maintain oral health during the rehabilitation process [7]. A meta-analysis also revealed that there are significant correlations between oral health parameters and NS in support of the inclusion of nutritional evaluation as part of overall dental care [8]. Despite a long history of research on the connection between oral health and nutritional condition, the majority of existing evidence is based on systematic reviews that included older adults, institutionalized patients or hospitalized patients. As a result, the results might not be transferable to the general adult dental patients receiving routine OR [9]. Geriatric populations have also been primarily targeted in cross-sectional studies and thus the evidence of these associations in adults with varying systems of health receiving rehabilitative dental therapies has been limited [10]. In addition, most of the studies in the past have considered nutrition, oral health or quality of life as an independent variable instead of a concerted analysis of NS, systemic conditions and patient-reported OR outcomes in a single analytical model. Available data has revealed that there is a strong correlation between NS, oral health-related quality of life, and self-efficacy among older adults who are hospitalized; similar data among adult patients with dental is still scarce [11]. Likewise, systematic reviews have noted the strong connection between NS and oral health yet have also reported a significant amount of heterogeneity of study populations and assessment practices and therefore direct clinical translation has been difficult [12]. Other observational reports have indicated the relationship between poor NS and impaired oral health in older adults, but there is limited evidence on the relationship between poor NS and rehabilitation of general adult patients undergoing dental care [13].

The overall knowledge of the relationship between NS, systemic health conditions, and OR outcomes could be used to help in the more personalized planning of treatment and enhance the clinical success of the treatment in the long term. Modern rehabilitation medicine has come to appreciate the need of incorporating oral management with nutritional assessment and systemic health assessment with the aim of maximizing patient recovery and functional outcomes [14]. Similarly, multidisciplinary evidence shows OR is not only associated with improved oral functioning but also with improved oral health-related quality of life, and it is important to have a holistic approach to patient management [15]. Moreover, research on patients with chronic systemic illnesses has shown that there are strong correlations between NS and dental health, indicating that regular nutritional check-ups might have specific usefulness in medically compromised individuals receiving OR [16]. Thus, the current research will assess these interrelationships in adult dental patients in the form of structured questionnaire-based research, thus, contributing to the evidence that could potentially underpin the concept of multidisciplinary clinical decision-making and patient-centered oral healthcare.

Objectives of the Study

1. To assess the nutritional status of adult dental patients undergoing OR.
2. To evaluate the association between systemic health conditions and OR outcomes.
3. To determine the relationship between nutritional status and patient-reported OR outcomes.

2. Materials and Methods

2.1 Study Design and Setting

In this study, a cross-sectional observational survey design was used to explore the relationship between NS, systemic illnesses, and outcomes of OR procedures performed on adults. The study was aimed at reflecting the population of patients undergoing OR treatment in a clinic setting. Information about patients' demographics, NS, systemic illnesses, oral hygiene, experience with OR treatment, and treatment outcomes was gathered using a standardized questionnaire.

2.2 Study Population and Sample Size

The study population consisted of adults who were being treated with, or had undergone, OR treatments, such as full dentures, partial dentures, fixed dental prostheses, crowns, dental implants, and prosthesis supported by implants. There were 80 subjects in total in the study. The sample population was a collection of adults with varied socio-demographic, socio-economic, nutritional, and systemic health parameters.

2.3 Inclusion and Exclusion Criteria

Inclusion criteria for the study included adults age 18 or above, who had undergone or were under treatment for OR, could complete the questionnaire and gave informed consent willingly. People suffering from severe cognitive dysfunction, who had difficulty completing the questionnaire due to communication problems, had acute medical and dental emergencies, and those with an incomplete questionnaire were not included in the study.

2.4 Questionnaire Development

A structured questionnaire was designed after reviewing the relevant literature for examining factors associated with the outcomes of OR. The questionnaire consisted of six dimensions, which were: (i) demographic and socioeconomic variables; (ii) NS; (iii) general health status; (iv) oral health and oral hygiene behaviors; (v) OR attributes; and (vi) OR outcomes perceived by the patients. Treatment outcomes such as masticatory function, speech, comfort, aesthetics, quality of life, satisfaction with treatment, willingness to recommend treatment, and follow-up were rated by a five-point Likert scale. The responses were summed up to produce an Overall Rehabilitation Outcome Score.

2.5 Data Collection Procedure

Participants who qualified for the study answered the structured questionnaire after an explanation regarding the purpose of the study as well as their informed consent. Questionnaires were filled out by the participants individually while researchers were there to answer any queries without swaying their answers. The completed questionnaires were checked for completeness prior to data entry and all data were anonymous.

2.6 Ethical Considerations

All individuals who took part in the study gave informed consent, and their participation was completely voluntary. The anonymity and confidentiality of all participants was ensured during the entire course of the study since all personal data were not collected. All data collected during the survey were used for academic purposes only.

2.7 Statistical Analysis

The data were inputted in Microsoft Excel. Descriptive statistics for continuous data were reported as mean ± standard deviation (SD) and categorical data were reported in terms of frequencies and percentages. Independent samples t-test was conducted to compare OR outcome scores by chosen systemic health problems. Chi-square test was applied to assess the relation between diabetes mellitus and OR outcome score, whereas the correlation between Nutrition Score and Rehabilitation Score was analyzed using the Pearson correlation test. Finally, multiple linear regression analysis was conducted to determine independent predictors of OR outcome scores after controlling body mass index and systemic health problems. The significance level for all tests was set at $p < 0.05$.

3. Results

3.1 Demographic Characteristics of the Study Participants

The total number of adults who were used for the experiment was 80. The participants had varied ages and the distribution was nearly equal between the males and females. In other words, there were heterogeneous people involved in this study with an even number of both genders. Table 1 summarizes age and gender distribution, whereas education, occupation and income are illustrated in Figure 1.

Table 1. Demographic characteristics of the study participants (n = 80)

Variable	Category	Frequency (n)	Percentage (%)
Age group	18–30 years	25	31.25
	31–40 years	15	18.75
	41–50 years	16	20.00
	51–60 years	17	21.25
	>60 years	7	8.75
Gender	Male	41	51.25
	Female	39	48.75

Educational level, profession, and family income of the respondents are shown in Figure 1 below, which presents an illustration of the socioeconomic status of the respondents.

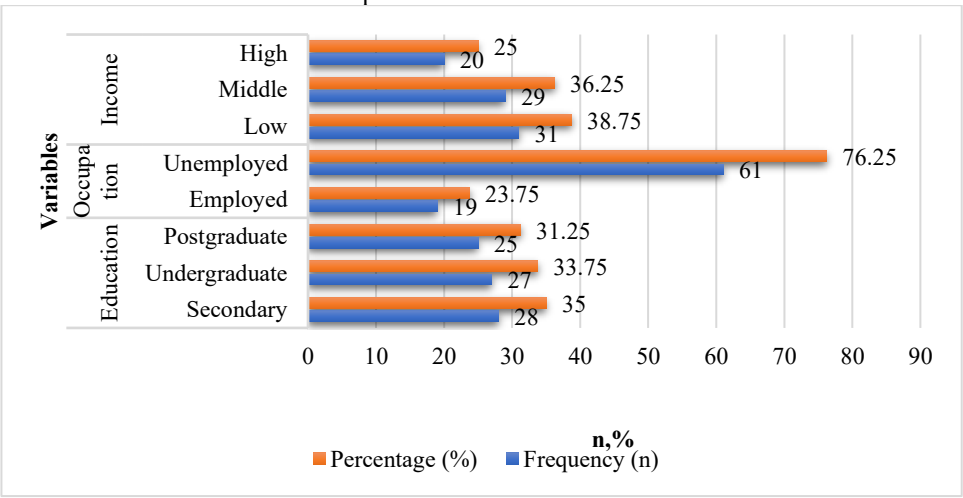

Figure 1. Socioeconomic features

As seen from Figure 1, the educational level that was most often cited by the participants is secondary education. The participants mostly fell under occupations other than employed. Low-income group

constituted the largest part of the study population, while middle- and high-income groups came second. The results obtained can be considered reflective of the socio-economic heterogeneity of the study population, as described in Table 1.

3.2 NS, Anthropometric Characteristics, and Patient-Reported OR Outcomes

The results obtained from anthropometric measurements and nutrition evaluation are outlined in Table 2 below to give a general view of the physical and nutritional profile of the subjects. All in all, the results show that the subjects selected for the study were of different NSes and body profiles, thus making them ideal for the purposes of the study.

Table 2. NS, anthropometric characteristics, and patient-reported OR outcomes

Category	Variable	Mean ± SD
Anthropometric characteristics	Height (cm)	166.74 ± 9.90
	Weight (kg)	71.02 ± 13.17
	BMI (kg/m²)	25.47 ± 3.72
Nutritional assessment	Nutrition Score	15.48 ± 3.33

Patient-reported OR results are displayed in Figure 2 below, which shows patients' perceptions on various facets of their treatments after OR, such as chewing function, speaking, comfort, aesthetics, overall satisfaction, and compliance with follow-up visits.

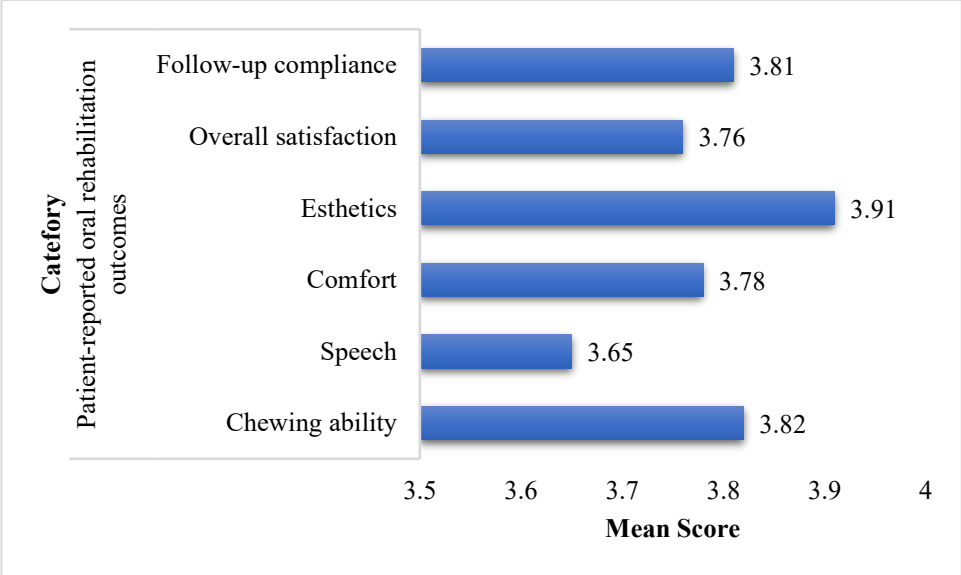

Figure 2. OR Outcomes

As can be seen in Figure 2, all domains of OR were rated favorably by the participants in terms of the experience they obtained after OR. Esthetic appearance domain was the most favorably rated among the evaluated domains, which means that most of the participants were satisfied with the appearance of their OR. The chewing ability and follow-up were also favorably rated which means that there is a satisfactory performance in the restoration of function and satisfaction with post-treatment follow-up. In the same way, comfort and treatment satisfaction were favorably rated, which implies that most participants were successfully adapted to OR. Speech domain was rated slightly less favorably compared to other domains but still favorably, which means that the function of speech was successfully restored in most participants.

3.3 Distribution of Systemic Health Conditions

The frequency of systemic diseases and certain characteristics of lifestyles of the subjects was estimated for the identification of the general state of health of the adults who receive OR. Apart from the common diseases, the impact of behavior factors, like smoking and alcohol consumption, on the process of treatment was also considered. The distribution of the variables is presented in Figure 3.

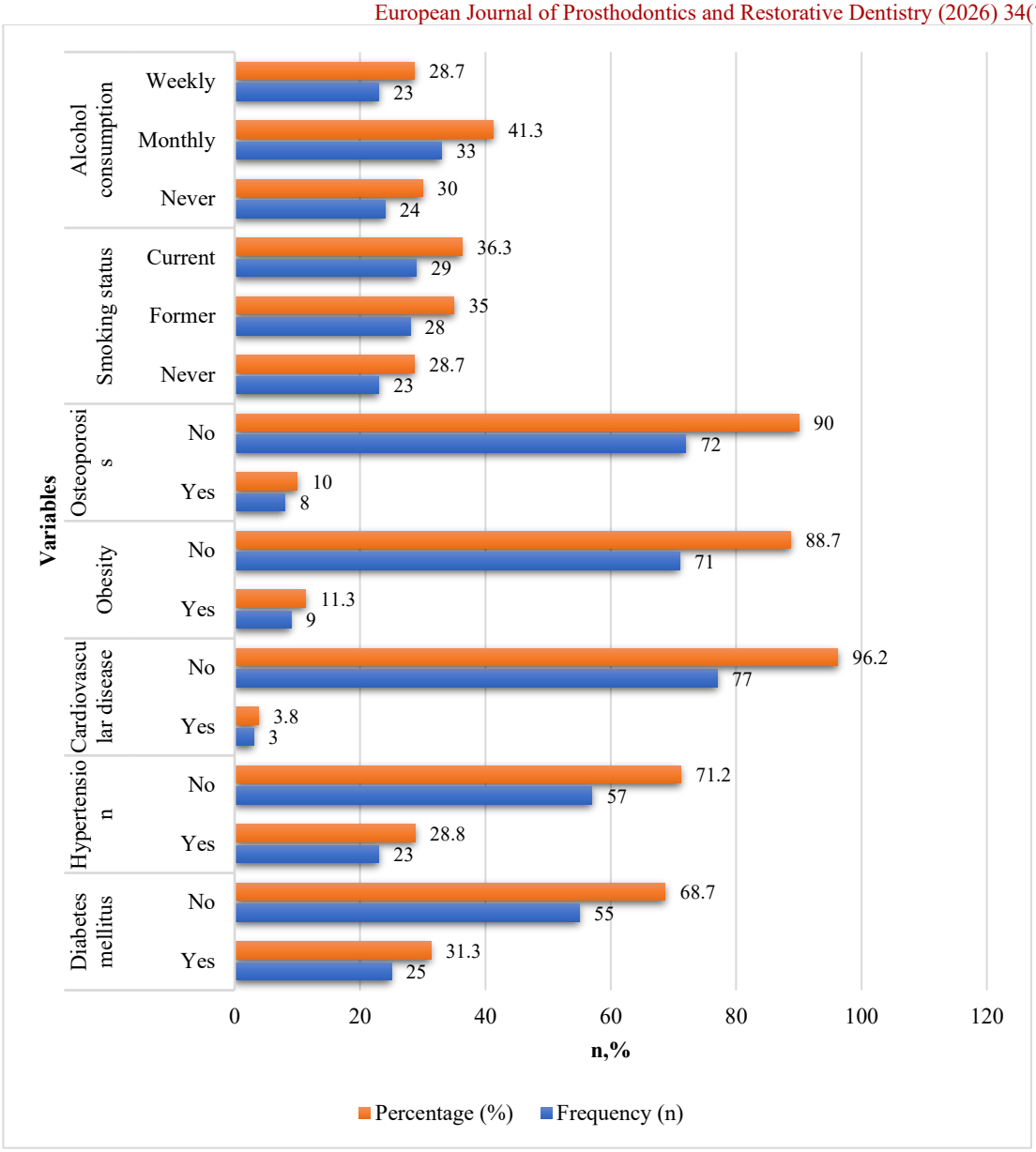

Figure 3. Distribution of systemic health conditions

Figure 3 shows that both diabetes mellitus and hypertension were the conditions reported to occur frequently, while cardiovascular disease, obesity, and osteoporosis were relatively rare. Differences were also noted in the smoking habits and alcohol intake of the participants, which suggests variability in the characteristics related to the participants' lifestyle. In summary, the results suggest a variable health profile among the subjects, and thus a need for further investigation regarding their systemic health problems and OR outcomes.

3.4 Association Between Systemic Health Conditions and OR Outcomes

Independent samples t-test was conducted to compare the results of OR between the participants with and without the selected systemic health conditions. The analysis has shown statistically significant difference in rehabilitation scores based on diabetes status with those with diabetes reporting poorer rehabilitation outcomes compared to those without diabetes. Conversely, there was no significant difference in rehabilitation scores based on whether the respondents had hypertension or obesity implying that these factors did not have an independent relationship with OR outcomes in the current study. Table 3 shows the detailed results of the independent samples t-test.

Table 3. Independent samples *t*-test comparing OR outcomes according to systemic health conditions

Variable	Rehabilitation Score (Yes) Mean ± SD	Rehabilitation Score (No) Mean ± SD	*t*-value	*p*-value
Diabetes	28.52 ± 3.03	30.64 ± 2.78	**−2.969**	**0.0049**
Hypertension	29.43 ± 2.90	30.19 ± 3.05	−1.041	0.3036
Obesity	29.11 ± 1.96	30.08 ± 3.11	−1.295	0.2168

3.5 Association Between NS and OR Outcomes

Additional inferential statistics revealed that there was a large correlation between the status of diabetes and the overall outcome of the OR. The results of Pearson correlation analysis also indicated that there was a significant positive correlation between OR outcomes and NS, indicating that respondents who had better NS had a greater likelihood of achieving better rehabilitation outcomes. Table 4 shows the results of these analyses.

Table 4. Association between NS and OR outcomes

Statistical analysis	Variable(s)	Test statistic	*p*-value
Chi-square test	Diabetes × Overall Rehabilitation Outcome	$\chi^2 = 9.312$ (df = 3)	**0.0254**
Pearson correlation	Nutrition Score vs. Rehabilitation Score	$r = 0.377$	**0.0006**

3.6 Multiple Linear Regression Analysis

The multiple linear regression analysis was conducted to determine independent predictors of OR outcomes. The regression model was significant and accounted a percentage of about 29.2 of the variation in rehabilitation outcomes. NS was found to be an important positive predictor of OR outcomes, but diabetes mellitus did not have any significant influence after accounting other variables. Rehabilitation outcomes were not independently related to BMI, hypertension, cardiovascular disease, obesity, and osteoporosis. Table 5 shows the entire regression model.

Table 5. Multiple linear regression analysis predicting OR outcomes

Predictor	B	Standard Error	*t*-value	*p*-value	95% Confidence Interval
Constant	28.098	2.818	9.972	<0.001	22.481 to 33.715
Nutrition Score	0.313	0.093	3.371	**0.001**	0.128 to 0.498
BMI	-0.095	0.095	-1.000	0.321	-0.283 to 0.094
Diabetes	-2.072	0.682	-3.040	**0.003**	-3.431 to -0.713
Hypertension	-0.129	0.718	-0.179	0.858	-1.560 to 1.303
Cardiovascular disease	-0.187	1.696	-0.110	0.913	-3.568 to 3.195
Obesity	-0.283	1.135	-0.249	0.804	-2.546 to 1.981
Osteoporosis	1.654	1.013	1.633	0.107	-0.365 to 3.673

Model statistics: $R^2 = 0.292$; Adjusted $R^2 = 0.223$; $F = 4.234$; $p = 0.000582$.

4. Discussion

The current research assessed the relationship between nutritional condition, overall health conditions, and OR outcome in adult patients with dental issues. The results revealed that participants had an average nutritional profile and good rehabilitation results. The association between NS and OR outcomes was found to be positive and significant, demonstrating that the NS of the participants was more likely to be improved with fewer reports of functional recovery and overall treatment satisfaction. Conversely, diabetes mellitus was significantly related to rehabilitation outcomes with a negative correlation, but hypertension and obesity were not significantly related. Multiple linear regression also supported that NS was a positive predictor of rehabilitation outcomes with diabetes being a negative independent predictor even after the other variables were accounted. These results imply that the effective treatment of OR is not only determined by the dental treatment but also by the general nutritional and systemic well-being of the patient.

Good NS is crucial in terms of ensuring good health of oral tissues, promotion of wound healing, maintenance of an optimal immune system functioning, and successful adaptation to prosthodontic rehabilitation procedures. The existence of the positive association established through this research means that individuals having a good diet and nutritional state will enjoy improved chewing ability, comfort, aesthetics, and rehabilitation success. On the other hand, poor rehabilitation results observed among diabetic individuals indicate negative consequences related to decreased wound healing, increased inflammatory response, and susceptibility to oral problems caused by diabetes. Although hypertension and obesity have been investigated, they have not shown a statistically significant effect on rehabilitation results in this research.

The current results align with the previous literature that has found that OR has the potential to positively affect NS and enhance functional outcomes. According to Funke et al., OR interventions lead to better nutritional conditions and oral health as well as less treatment load among adults receiving prosthodontic treatment [17]. Similarly, Hussein et al. claimed that an improved NS is closely linked with enhanced oral health and suggested that the nutritional assessment should be considered an inseparable part of dental rehabilitation planning [18]. The positive patient-reported rehabilitation results in the current study are also indicated by Haag et al., who concluded that the better oral conditions the better is the oral health-related quality of life [19]. On the same note, Cao et al. established a positive association between nutrition and oral functions in community dwelling adults, with proper nutrition playing a big role in OR success [20]. Marquezin et al. did find a correlation between the nutritional characteristics and oral health and obesity, but in the current study, obesity was not found to be an independent predictor following multivariate adjustment [21]. Moreover, Schmalz et al. also emphasized the adverse impact of chronic systemic diseases on oral health-related quality of life, which supports the current finding that diabetes has a detrimental impact on rehabilitation outcomes and underlines the importance of managing patients comprehensively [22].

The results of this research have significant clinical importance. Nutritional assessment must be done as part

of the planning for OR to determine which patients are likely to do poorly with the therapy. Also, thorough assessment and appropriate management of any systemic disease conditions, especially diabetes mellitus, can help increase the effectiveness of the rehabilitation therapy. The use of an interdisciplinary team including dentists, prosthodontists, physicians, and nutritionists may further enhance the success of the treatment.

There are various limitations associated with the current study. First, due to its cross-sectional design, there is no way to prove any causation between nutrition, systemic diseases, and results of rehabilitation. Also, there could be some recall and response bias because the information was collected using questionnaires. Furthermore, the sample size used in the research is rather small.

It is necessary to conduct further investigations with the help of prospective or longitudinal designs that will involve larger and more varied populations and will focus on evaluating the impact of nutrition and systemic issues on the rehabilitation outcomes. Moreover, objective evaluation of the patients' state of health and their nutrition should be performed.

Conclusion

In this study, it has been found that NS as well as systemic conditions play crucial roles in determining OR results in adults. The study participants had mostly a moderately high NS and showed good rehabilitation outcomes of the patients with satisfactory results in terms of chewing function, speaking, comfort, esthetics, overall satisfaction and follow-up adherence after treatment. There is a highly statistically significant positive relationship between the NS and rehabilitation outcomes. On the other hand, diabetes mellitus has shown a statistically significant relationship with poor rehabilitation outcomes, acting independently as a negative predictor of OR, while hypertension and obesity did not have any statistically significant relationships. These results indicate that OR does not only depend on the purely technical issues related to dental treatment but also has something to do with the nutritional and systemic state of a patient. It can be concluded that a comprehensive examination of a patient prior to any oral treatment and its consideration in planning an individual treatment regimen can lead to better results of OR. Integration of the nutritional counseling and proper medical treatment into the regular dental practice can result in higher satisfaction and efficiency of OR of the patients. Although there are several limitations related to the cross-sectional design and use of self-report data in the study, the research still offers important evidence for the multidisciplinary approach to the issue. Further longitudinal studies on a larger scale with objective nutritional and clinical measurements are necessary to elucidate these relationships and create evidence-based methods of optimal OR.

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