Assessment of the Impact of Stress and Anxiety on Pain Perception in Patients Undergoing Surgery for Placement of their First Dental Implant

Sharat Chandra Pani[1], Bishi AlGarni[2], Lulya Mohammad AlZain[1], Nora Saad AlQahtani[1]

[1]Division of Pediatric and Preventive Dentistry, Riyadh Colleges of Dentistry and Pharmacy, PO Box 84891, Riyadh 11681, Saudi Arabia. [2]Riyadh Dental Center, King Saud Medical City, Riyadh, Saudi Arabia.

Abstract

Aim: This study aimed to record, both subjectively and objectively the anxiety of patients awaiting placement of their first dental implant and their long term stress levels; and evaluate their relation to the perception of pain by the patient during and after the procedure.

Methodology: Early morning salivary cortisol samples were collected from 47 patients awaiting the placement of their first dental implant to evaluate long term stress. The patients filled out a dental anxiety stress questionnaire before the procedure. Heart rate and oxygen saturation were recorded at four key intervals; in the waiting room, while seated in the dental chair, during the placement of the implant and five minutes post operatively. The patients were asked to describe their post-operative sensation of pain on a Wong-Baker facial pain scale. The readings were then compared using regression models to assess the best predictor of pain immediately after the operation

Results and Conclusion: The regression models showed that while heart rate in the waiting area was a significant predictor of the reported pain of the patient, long term stress and reported anxiety were not.

Key words: Stress, Dental anxiety, Dental implant, Salivary cortisol

Introduction

Stress is defined as an organism's total response to an environmental condition or stimulus, also known as a stressor [1]. Stress has been associated with dental procedures, especially surgical procedures [2]. This is particularly relevant in implant dentistry with several authors suggesting that a relationship exists between dental stress and the pain perceived by the patient during the placement of the implant [3-7]. However these studies have relied on questionnaires, the validity and subjective nature of which may cast a doubt on their accuracy [1].

Anxiety measurement is important for clinicians because of the effect it has on the patients' coping strategy and the patient management technique used by the dentist [8-10]. The terms anxiety and fear although related, are distinct from each other.

The fear experienced by a patient is a subjective phenomenon that varies from patient to patient [10]. While scales such as the Wong-Baker facial pain scale and Dental Anxiety Stress (DAS) questionnaire have been used to measure the patient's experience of fear and pain, authors have relied on physiological indicators such as heart rate to objectively evaluate the body's response to pain [6,7].

Over the past decade, salivary cortisol has emerged as an accurate objective measure of stress, especially in patients awaiting dental procedures [1,11,12]. It is important to realize that a difference exists between long term stress, as measured by salivary cortisol; and short term anxiety that is measured using scales such as the DAS. While links exist between long term stress (or stressful life events) and disorders such as musculo-skeletal pain [13] or early childhood caries [14], far less is known about the level of impact this has on fear and behavior in a surgical dental setting.

The aim of this study was to record, both subjectively and objectively the anxiety of patients awaiting placement of dental implants and their long term stress levels; and evaluate their relation to the perception of pain by the patient during and after the surgery.

Methodology

Ethical clearance for the study was obtained from the research center of the Riyadh Colleges of Dentistry and Pharmacy. The methodology followed for the study has been given as a flow-chart (*Figure 1*).

Patient selection

Fifty patients aged between 30 and 60 years who were scheduled to undergo surgery for the placement of their first implant were selected from the implant clinic of the Riyadh Colleges of Dentistry and Pharmacy and the Riyadh Dental Center of the King Saud medical city. Only partially edentulous patients who were to undergo single implant placement were selected for the study. All patients had visited the dentist at least once previously (for the extraction of their teeth), but did not have any previous placement of implants. Patients who had underlying chronic medicals conditions and patients who were under medication for psychological disorders (factors that could affect the level of cortisol) were excluded from the study.

Subjective recording of stress and pain

Patients were administered an Arabic version of the Dental Anxiety Stress (DAS) questionnaire before the placement of the implant. They were given a Wong-Baker facial pain scale after the procedure to describe the level of pain felt during the placement of implant.

Objective recording of fear and stress
Recording of stress

Stress was analyzed using salivary cortisol as a biomarker from saliva collected at the first screening visit. Salivary cortisol was estimated using the Electrochemiluminescence (ECL) immunoassay using an Elecsys ™ e immunoassay analyzer and the Cobas™ Salivary Kit (Roche Diagnostics GmbH, Mannheim Germany).

Corresponding author: Sharat Chandra Pani, Division of Pediatric and Preventive Dentistry, Riyadh Colleges of Dentistry and Pharmacy, PO Box 84891, Riyadh 11681, Saudi Arabia; Tel: +966 920000842; e-mail: sharat@riyadh.edu.sa

Recording of anxiety

Anxiety of the patient was recorded by measuring the heart rate using a pulse oxymeter during the clinical procedure.

Statistical analyses

Independent *t* test were used to compare gender differences in relation to heart rate, oxygen saturation, salivary cortisol levels and pain scores. Pearson's correlations were used to correlate between the reported pain score and possible predictive values i.e. heart rate in the waiting area, oxygen saturation, DAS score and salivary cortisol levels. Two linear regression models; one with heart rate in the dental chair and another with the reported pain score as the dependent variables were formulated to assess the strength of the predictive values of the above mentioned predictors. All tests were set to a significance of $p<0.05$. All statistical analyses were carried out using the IBM-SPSS ver.21 data processing software (IBM corp. Armonk, NY, USA).

Results

Of the 50 patients selected initially two patients had to be excluded from the study due to the contamination of their salivary cortisol samples. The sample comprised of 23 males and 25 females who were aged between 17 and 63 years. The mean age of the sample was 41.4 years (SD ± 11.08) with no significant difference between the ages of the males (42.46 ± 11.98 years) and females (40.36 ± 10.34 years), (t= 0.713, p = 0.434).

Females had greater Mean Dental Anxiety Score (DAS) and Salivary cortisol reading than males. However the independent samples t test showed that neither score was statistically significant (*Table 1*). There was a very strong positive correlation between the DAS score and salivary cortisol levels (r = 0.468, p<0.001).

When the heart rate and oxygen saturations were measured it was found that the lowest Heart rate and highest oxygen saturation were found after the procedure, while the highest Heart rate and lowest oxygen saturation were found during the placement of the implant (*Figure 2*). While males had significantly lower heart rates and considerably less variation in heart rates when compared to females, no such differences existed for the oxygen saturation (*Table 2*).

The pain immediately after the operation perception

***Table 1.** Gender Differences in Salivary Cortisol and DAS score.*

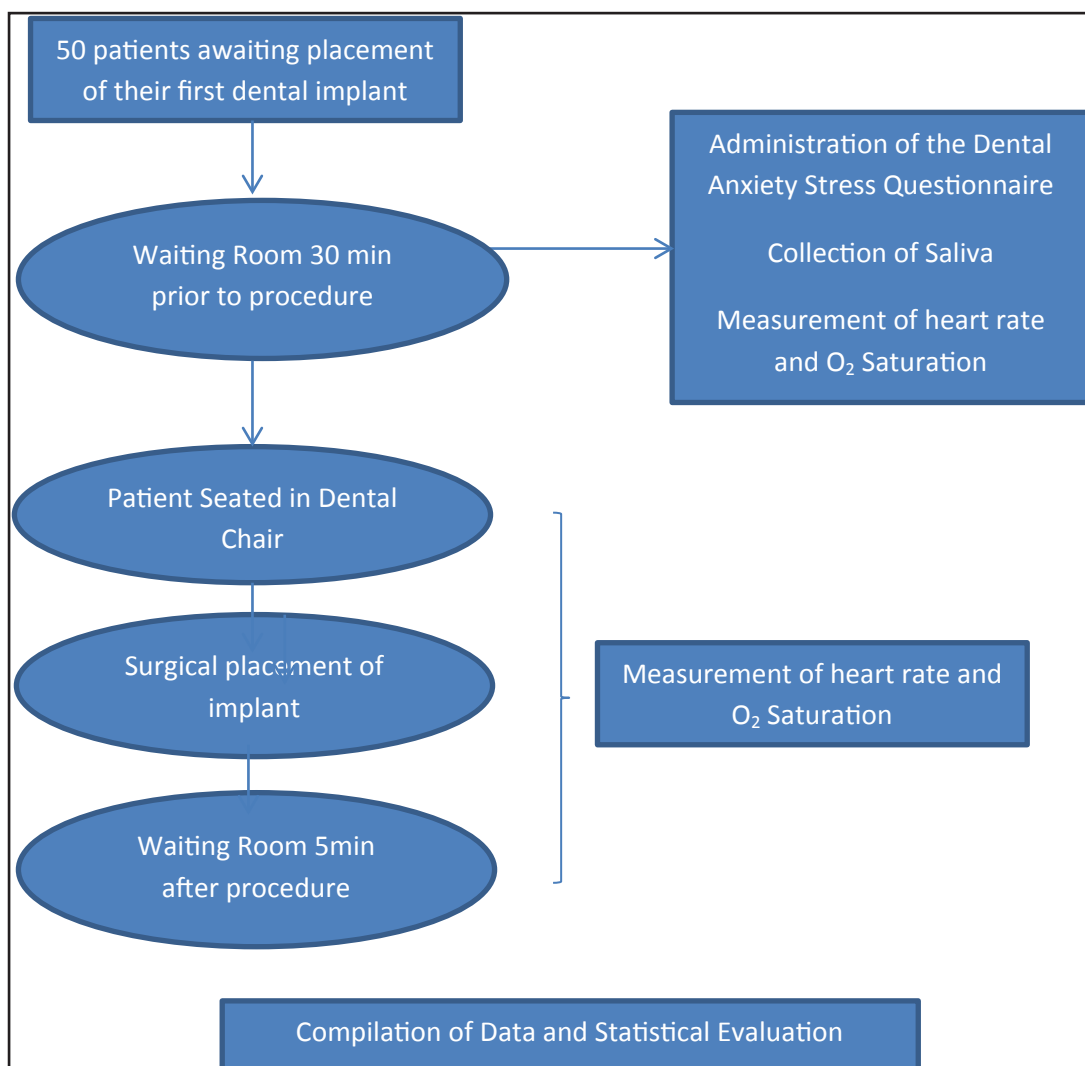|	Male		Female		t	Sig
	Mean	**Standard eviation**	**Mean**	**Standard eviation**		
Salivary Cortisol Level (µg/dL)	19.90	13.09	29.78	28.58	-1.479	.143
DAS Score	38.59	10.14	43.04	8.41	-1.664	.107

***Figure 1.** Flow Chart of the Methodology used.*

Table 2. Gender Differences in heart rate and oxygen saturation.

	Gender	Mean	Std. Deviation	T	Sig
Heart rate in Waiting Area	Male	79.9545	10.37615	-3.888	.001*
	Female	91.7200	13.07835		
Heart rate in the Dental chair	Male	75.2273	8.94391	-4.559	.000**
	Female	88.5600	10.84773		
Heart rate During Procedure	Male	77.3182	9.89173	-4.105	.000**
	Female	92.2800	14.34840		
Heart rate 5 Min After Procedure	Male	75.1818	10.62628	-3.355	.002*
	Female	85.8800	11.15168		
Oxygen in Waiting Area	Male	97.2727	2.43353	-.402	.689
	Female	97.6000	3.05505		
Oxygen in Dental Chair	Male	97.1818	2.15222	.705	.484
	Female	96.3200	5.35973		
Oxygen During Procedure	Male	95.1818	6.82179	-.066	.948
	Female	95.3200	7.43707		
Oxygen 5 min After Procedure	Male	97.7727	1.06600	1.154	.137
	Female	94.7600	9.26589		

* Significant at $p<0.01$
** Significant at $p<0.001$

Table 3. Correlations between reported pain score and the different possible predictive variables.

		Heart Rate in the waiting area	Oxygen saturation in the waiting area	DAS Score	Salivary Cortisol Level
Reported Pain Score	r	.305*	-.028	.147	.128
	sig	.037	.850	.325	.390

* Significant at $p<0.05$

Table 4. Regression Model with reported pain score as the dependent variable and heart rate, cortisol level and DAS scores as predictors.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.338[a]	.114	.030	1.66540

a. Predictors: (Constant), Pulse During Procedure, DAS Score, Pulse in Waiting Area, CORT level

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.443	2.054		1.189	.241
	CORT level	.007	.012	.097	.578	.566
	DAS Score	.012	.030	.068	.411	.683
	Heart Rate in Waiting Area	.041	.020	.321	2.042	.047*
	Heart Rate During Procedure	-.013	.019	-.110	-.667	.508

a. Dependent Variable: Reported Pain Score

* Significant at $p<0.05$

Table 5. Regression Model with mean heart rate during implant placement as the dependent variable and heart rate in the waiting area, cortisol level, reported pain score and DAS scores as predictors.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.483[a]	.233	.160	13.24701

a. Predictors: (Constant), VAS Score, DAS Score, Pulse in Waiting Area, CORT level

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	44.176	15.150		2.916	.006
	CORT level	.131	.097	.208	1.348	.185
	DAS Score	.222	.235	.145	.942	.351
	Heart Rate in Waiting Area	.386	.157	.352	2.456	.018*
	Reported Pain Score	-.815	1.221	-.095	-.667	.508

a. Dependent Variable: Pulse During Procedure

* Significant at $p<0.05$

when recorded on the Wong-Baker scale, ranged from 2 to 8 (median score 6, SD ± 1.69). The independent t test showed no significant difference in the pain scores between males and females (t = 0.233, p =0.817).

Figure 2. Variations in heart rate and oxygen saturation at different time intervals during the placement of the implant.

	Waiting Area	Dental Chair	During Procedure	5 Min After Procedure
O2 Saturation	96.0667	94.1333	94.2000	96.8000
Heart Rate	88.2000	84.8000	90.0000	81.5333

The pain perception score was correlated to possible predictive tools for pain; heart rate in the waiting area, oxygen saturation in the waiting area, DAS score and salivary cortisol levels. It was seen that only the heart rate showed a significant positive correlation to the pain score reported (*Table 3*). The linear regression model showed that only the heart rate in the waiting area was a reliable predictor of reported pain (*Table 4*). The second regression model showed that when the heart rate during the procedure was used as the dependent variable, here again only the heart rate in the waiting area was the only reliable predictor (*Table 5*).

Discussion

The use of dental implants as a means to improve the quality of life of patients with missing teeth has become increasingly common across the world [15]. Dental anxiety regarding the surgical procedure has been cited as one of the most important factors that influence the pre-operative decision of the patient [16]. In this scenario, the ability to predict and assess dental anxiety and fear are critical to the dentist.

Fear, anxiety and stress are related factors however it is important to understand that they are physiologically distinct. Fear and anxiety are primitive protective reflexes that are regulated by the amygdala [17]. Stress on the other hand is a more recently evolved concept and in addition to the amygdala, also involves the hippocampus and the pre-frontal cortex [18]. This is the reason we chose to measure anxiety, fear and stress as different variables. While we found an association between the salivary cortisol readings and the reported stress (DAS score), we found that neither of these correlated to the heart rate during the procedure or to the reported pain score after the procedure.

Heart rate during a surgical procedure is reflective to the body's response to pain and along with self-reported pain scores has been used as measure of both actual and reported pain during and after several dental as well as maxillofacial surgical procedures [19-21]. We found that the heart rate both during the surgical procedure and in the waiting area, were significant predictors of reported pain immediately after the operation. Heart rate has also been used as a measure of dental anxiety in children [22,23]; however, we found no significant correlation between heart rate in the waiting area and the anxiety reported on the DAS.

Increased oxygen saturation due to hyperventilation has been reported in anxious persons [24] as well as patients with anxiety disorder [25]. Although we found an inverse relationship between heart rate and oxygen saturation we found no significant impact of oxygen saturation on the reported pain or heart during surgery. This is in keeping with other dental studies that found that while heart rate was a reliable predictor of anxiety and/or during a dental procedure, oxygen saturation was not [26-28].

Salivary cortisol has repeatedly been shown as a reliable predictor of long term stress. We found that although a significant positive correlation existed between the DAS and Salivary cortisol it was not a significant predictor of the pain in our patients. This is in keeping with the findings of Hashem et al. who found that salivary cortisol was not a good predictor of pain immediately after the operation after the placement of a dental implant [5]. Wennstrom et al. postulated that the failure of salivary cortisol to correlate with fear scores could be because salivary cortisol reflects a different component of the mechanism of fear [29]. A finding corroborated by physiological experiments in laboratory animals [17,18].

This study measured fear in the individual only in the waiting room and did not account for the role of the practitioner placing the implant. The role of the dentist in the fear experienced during the placement of implant is an area that could be evaluated in future research.

Conclusion

The results of our study seem to indicate that while anxiety does play a role in the perception and reporting of pain by patients undergoing placement of their first dental implant, long term stress; as measured by salivary cortisol, does not. The heart rate in the waiting room seems to be the most accurate physiological predictor of pain in patients.

References

1. Brand HS. Anxiety and cortisol excretion correlate prior to dental treatment. *International Dental Journal.* 1999; **49**: 330-336.

2. Sirin Y, Humphris G, Sencan S, Firat D. What is the most fearful intervention in ambulatory oral surgery? Analysis of an outpatient clinic. *International Journal of Oral and Maxillofacial Surgery.* 2012; **41**: 1284-1290.

3. Eli I, Schwartz-Arad D, Baht R, Ben-Tuvim H. Effect of anxiety on the experience of pain in implant insertion. *Clinical Oral Implants Research.* 2003; **14**: 115-118.

4. Fardal O, McCulloch CA. Impact of anxiety on pain perception associated with periodontal and implant surgery in a private practice. *Journal of Periodontology.* 2012; **83**: 1079-1085.

5. Hashem AA, Claffey NM, O'Connell B. Pain and anxiety following the placement of dental implants. *International Journal of Oral & Maxillofacial Implants*. 2006; **21**: 943-950.

6. Schwartz-Arad D, Bar-Tal Y, Eli I. Effect of stress on information processing in the dental implant surgery setting. *Clinical Oral Implants Research.* 2007; **18**: 9-12.

7. Weisensee W, Scheer M, Muller L, et al. Impact of anxiety parameters on prospective and experienced pain intensity in implant surgery. *Implant Dentistry*. 2012; **21**: 502-506.

8. Armfield JM, Milgrom P. A clinician guide to patients afraid of dental injections and numbness. *SAAD Digest.* 2011; **27**: 33-39.

9. Chaves JF, Brown JM. Spontaneous cognitive strategies for the control of clinical pain and stress. *Journal of Behavioral Medicine*. 1987; **10**: 263-276.

10. Corah NL. Dental anxiety. Assessment, reduction and increasing patient satisfaction. *Dental Clinics of North America*. 1988; **32**: 779-790.

11. Blomqvist M, Holmberg K, Lindblad F, et al. Salivary cortisol levels and dental anxiety in children with attention deficit hyperactivity disorder. *European Journal of Oral Sciences*. 2007; **115**: 1-6.

12. Da Silva Andrade A, Gamero GH, Pereira LJ, Junqueira Zanin IC, Gaviao MB. Salivary cortisol levels in young adults with temporomandibular disorders. *Minerva Stomatologica*. 2008; 57: 109-116.

13. Akhter R, Hassan NM, Aida J, et al. Association between experience of stressful life events and muscle-related temporomandibular disorders in patients seeking free treatment in a dental hospital. *European Journal of Medical Research*. 2007; **12**: 535-540.

14. Pani SC, Abuthuraya D, Alshammery HM, Alshammery D, Alshehri H. Salivary cortisol as a biomarker to explore the role of maternal stress in early childhood caries. *International Journal of Dentistry*. 2013; **2013**: 565102.

15. Pennington J, Parker S. Improving quality of life using removable and fixed implant prostheses. *Compendium of Continuing Education in Dentistry*. 2012; **33**: 268-270, 72, 74-6.

16. Narby B, Hallberg U, Bagewitz IC, Soderfeldt B. Grounded theory on factors involved in the decision-making processes of patients treated with implant therapy. *International Journal of Prosthodontics*. 2012; **25**: 270-278.

17. Negron-Oyarzo I, Perez MA, Terreros G, Munoz P, Dagnino-Subiabre A. Effects of chronic stress in adolescence on learned fear, anxiety, and synaptic transmission in the rat prelimbic cortex. *Behavioural Brain Research*. 2014; **259**: 342-353.

18. McEwen BS. Physiology and neurobiology of stress and adaptation: central role of the brain. *Physiological Reviews*. 2007; **87**: 873-904.

19. Zarei M, Ghoddusi J, Sharifi E, et al. Comparison of the anaesthetic efficacy of and heart rate changes after periodontal ligament or intraosseous X-Tip injection in mandibular molars: a randomized controlled clinical trial. *International Endodontics Journal*. 2012; **45**: 921-926.

20. Jeon Y. Reduction of pain on injection of propofol: combination of nitroglycerin and lidocaine. *Journal of Anesthesia*. 2012; **26**: 728-731.

21. Chegini S, Johnston KD, Kalantzis A, Dhariwal DK. The effect of anesthetic technique on recovery after orthognathic surgery: a retrospective audit. *Anesthesia Progress*. 2012; **59**: 69-74.

22. Farhat-McHayleh N, Harfouche A, Souaid P. Techniques for managing behaviour in pediatric dentistry: comparative study of live modelling and tell-show-do based on children's heart rates during treatment. *Journal of the Canadian Dental Association.* 2009; **75**: 283.

23. Uehara N, Takagi Y, Miwa Z, Sugimoto K. Objective assessment of internal stress in children during dental treatment by analysis of autonomic nervous activity. *International Journal of Paediatric Dentistry*. 2012; **22**: 331-341.

24. Studer RK, Danuser B, Hildebrandt H, et al. Hyperventilation in anticipatory music performance anxiety. *Psychosomatic Medicine*. 2012; **74**: 773-782.

25. Kossowsky J, Wilhelm FH, Schneider S. Responses to voluntary hyperventilation in children with separation anxiety disorder: Implications for the link to panic disorder. *Journal of Anxiety Disorders*. 2013; **27**: 627-634.

26. Alemany-Martinez A, Valmaseda-Castellon E, Berini-Aytes L, Gay-Escoda C. Hemodynamic changes during the surgical removal of lower third molars. *Journal of Oral and Maxillofacial Surgery*. 2008; **66**: 453-461.

27. Gonzalez-Lemonnier S, Bovaira-Forner M, Penarrocha-Diago M, Penarrocha-Oltra D. Relationship between preoperative anxiety and postoperative satisfaction in dental implant surgery with intravenous conscious sedation. *Medicina Oral Patologia Oral y Cirugia Bucal*. 2010; **15**: e379-e382.

28. Muinelo-Lorenzo J, Sanfeliu JO, Alegre SV, et al. Haemodynamic Response and Psychometric Test Measuring Dental Anxiety in a Spanish Population in Galicia. *Oral Health & Preventive Dentistry*. 2014; **12**: 3-12.

29. Wennstrom B, Tornhage CJ, Hedelin H, Nasic S, Bergh I. Child Drawings and Salivary Cortisol in Children Undergoing Preoperative Procedures Associated With Day Surgery. *Journal of PeriAnesthesia Nursing*. 2013; **28**: 361-367.