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Aerodontalgia among Airline Pilots of India: A Cross-sectional Survey

Dentistry Section

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ABSTRACT

Introduction: Barometric pressure-induced dental pain is a clinical entity elicited by atmospheric changes in pressure. Barodontalgia (also known as aerodontalgia) among pilots is of marked interest as it can be a potential flight safety hazard and compromise the personnel's operational capability and performance. Due to its overlapping signs and symptoms, it may also remain unnoticed and represent itself during a pressure change which may be during ascend or descend of flight.

Aim: To assess presence of barodontalgia and awareness of the phenomenon among commercial pilots based in India.

Materials and Methods: This cross-sectional study was conducted from June to August 2020 using self-reported questionnaire submitted via Google forms (Alphabet, Mountain view, CA, USA) among 410 pilots based in India. It consisted of questions inquiring about the occurrence, localisation, intensity and recurrence of in-flight dental pain. Inferential statistics were performed using Chi-square test, One way analysis of variance (ANOVA) and Independent t-test. The level of statistical significance was set at 0.05.

Results: A total of 370 pilots responded to the questionnaire with a response rate of 90.24%. The incidence was reported among 10.54% (n=39) pilots although 42.7% (n=158) lacked awareness regarding the same. Only a single case of recurrence of pain was reported while none reported any risk to flight safety or accident, secondary to barodontalgia.

Conclusion: The incidence level of barodontalgia among commercial pilots in India is low. However, the lack of awareness is still an unsettling risk and was not found to be of significant difference when compared on the basis of gender and work experience.

Keywords: Aerospace medicine, Atmospheric pressure, Aviation dentistry, Pain

INTRODUCTION

Aviation dentistry is the understanding of the oral and dental health evaluation, prevention and treatment of diseases, conditions or disorders concerning oral and maxillofacial region and its associated structures with its impact on aviators and aircrew members [1]. Exposure to an environment of high altitude with abnormal change in pressure gradient can influence the body's tissues [2]. Conditions of oral and maxillofacial region such as barodontalgia, barotrauma and odontocrexis have been reported frequently since the beginning of the 20th century [3].

Barodontalgia is barometric pressure-induced dental or non dental pain elicited due to inability of the pulp to adapt to this change with supplementary factors such as minute void within a restored tooth or faulty tooth restorations [1,4,5]. The pain can also be evoked after a recent dental treatment and is known as postoperative barodontalgia [6]. The incidence of in-flight pain has been reported at altitudes of 2000 to 5000 ft (610 to 1524 m) however during ascent, pain can be attributed to conditions of vital pulp and necrotic pulpal diseases appear during descent. The most commonly affected teeth are the upper and lower first molars (30% of cases). Barodontalgia terminates as the plane lands and returns to ground atmospheric level, but pain originating due to underlying periradicular pathology or facial barotrauma may still linger [4].

The differential pressure is exerted by gas filled cavity in the human body as it is unable to communicate with the exterior environment to equalise it which leads to clinical pain, oedema, or vascular gas embolism and development of headache, numbness, or dental pain [7]. Even though the experience of barodontalgia is infrequent it is a recognised potential hazard among pilots leading to in-flight vertigo and unforeseen disability compromising flight safety [8]. Dental barotrauma among aircrew can result in a distressing flight experience by precipitating fracture of dental restorations as well as teeth [7].

Pilots and other aircrew members must be subjected to routine dental examinations [9]. The examining dentist must be qualified to recognise, assess and be prepared to provide treatment as well as preventive measures to avoid the incidence of pain [10]. In the current times, a more conservative protocol must be followed in comparison to the conventional one where in it was recommended to extract all pulpless teeth and roots in aircrew members [11]. Flyers must be advised to avoid exposure to pressure changes until completion of all necessary conservative, endodontic and prosthetic procedures. Prevention of intraoperative flare up can be done by scheduling appointments to complete root canal treatment (RCT) prior to exposure to change in cabin pressurisation [9].

Lack of awareness and regulation for dental examination and treatment along with disagreement about grounding period by aircrew members present a limitation. Thus, with the increasing number of air travellers it is essential for the dental clinicians to raise awareness about flyers toothache and other in-flight conditions [10]. The objectives of the present study were to assess the frequency of barodontalgia among commercial pilots based in India and obtain an insight of the characteristics of the pain experienced.

MATERIALS AND METHODS

This cross-sectional research study evaluated commercial airline pilots of India from June to August 2020. The study received approval (Ethical no. MRDC/IEC/2020/05A) from Ethical Committee of Faculty of Dental Sciences, Manav Rachna International Institute of Research Sciences, Faridabad, Haryana, India.

Sample size calculation: Sample size was calculated using G*Power data analysis using formula ($4pq/l^2$) where l is the permissible error (5%), 'p' is the prevalence rate (20.6%) [12] and 'q' is (1-p). As the study, population i.e., aircraft pilots in India is approximately 10,000 thus, sample size of 260 was calculated to be sufficient considering the previous published prevalence of 20.6% [12].

Inclusion criteria: Pilots based in India were only included in this study.

Exclusion criteria: Subjects below 25 years and above 65 years and pilots who were non residents of India were excluded from the study.

Questionnaire

The self-administered questionnaire was designed to inquire information regarding demographics of the pilots like age, sex and their profession related characteristics such as flying hours. Data regarding incidence and characteristics of in-flight pain such as frequency, localisation, intensity and it's recurrence in subsequent flight was obtained. The survey also questioned whether pain was during ascend or descend of flight, its termination, if the pilot visited the dentist and the treatment provided for the same. Pilots were also questioned if they were aware of the term barodontalgia. Thus, a total of 14 questions were framed as multiple choice and liner scale. The questionnaire was anonymous to maintain the privacy and confidentiality of information reported in the present research. The questionnaire used by research published by Rai B et al., was adapted for present day status [12]. The questionnaire was checked for validity using content validity and questions with content validity ratio of 0.7 were included in the study. Reliability was assessed through pilot study inclusive of 30 participants who were administered the questionnaire and a Cronbach's alpha value of 0.738 was obtained. The results of the pilot study have not been included in the study.

Non probability snowball sampling technique was used for data collection. Contact details were obtained through administrative heads of various social media groups of aviation community. The questionnaire was emailed and participants were requested to complete the survey within a period of one week. The survey was submitted using Google Forms (Alphabet, Mountain view, CA, USA) by 410 commercial pilots from governmental and private sectors of India. Data was entered into Microsoft excel spreadsheet and then checked for any missing entries. Responses by 40 pilots were excluded as 13 questionnaires were received incomplete and 27 pilots did not respond.

STATISTICAL ANALYSIS

Data was entered into Microsoft excel spreadsheet and was analysed using Statistical Package for Social Sciences (SPSS) version 21. Categorical variables were summarised as frequencies and continuous variables were summarised as mean and standard deviation. Graphs were prepared on Microsoft excel. Inferential statistics were performed using Chi-square test, ANOVA and independent t-test. Chi-square test was used to compare categorical data. Independent t-test was used to compare two independent means. ANOVA test was used to compare more than two independent means. The level of statistical significance was set at 0.05.

RESULTS

The survey was accessible from June to August 2020. A total of 370 commercial airline pilots responded to the questionnaire. The age of the pilots investigated ranged between 25 to 65 years, with maximum respondents aged between 41-55 years (53.5%, n=198). Male subjects were 290 (78.4%) and female subjects were 80 (21.6%). Notably, the maximal respondents had flying experience of more than 20 years (53.5%, n=198) and were flying more than 500 hours annually [Table/Fig-1].

Barodontalgia was reported by 39 Indian pilots (10.54%, p=0.0001). On intergroup comparison, frequency of barodontalgia was 10.4% (n=14), 12% (n=12) and 6.1% (n=13) seen in age groups 25-40 years, 41-55 years and 56-65 years, respectively [Table/Fig-2]. The pain was reported during ascent by 46.2% (n=18) subjects while 33.3% (n=13) reported it during descent. However, only 35 pilots were able to localise the in-flight pain with 79.5% (n=31) reporting it to be originating posteriorly [Table/Fig-3].

Of the incidences reported, 48.7% (n=19) had persistent pain after landing and 89.7% (n=35) visited their dentist for the same. Most

Variables		Frequency	Percentage (%)
Age	25-40 years	134	36.2
	41-55 years	198	53.5
	56-65 years	38	10.3
Gender	Males	290	78.4
	Females	80	21.6
Years of experience	>5 years	64	17.3
	>10 years	108	29.2
	>20 years	198	53.5
Flying hours	>100 hr	23	6.2
	>300 hr	37	10
	>500 hrs	310	83.8

[Table/Fig-1]: Frequency of response rate according to demographic data.

Age		Barodontalgia		p-value
		No	Yes	
25-40 years	n	120	14	<0.0001, S
	%	89.6%	10.4%	
41-55 years	n	186	12	
	%	93.9%	6.1%	
56-65 years	n	25	13	
	%	65.8%	34.2%	

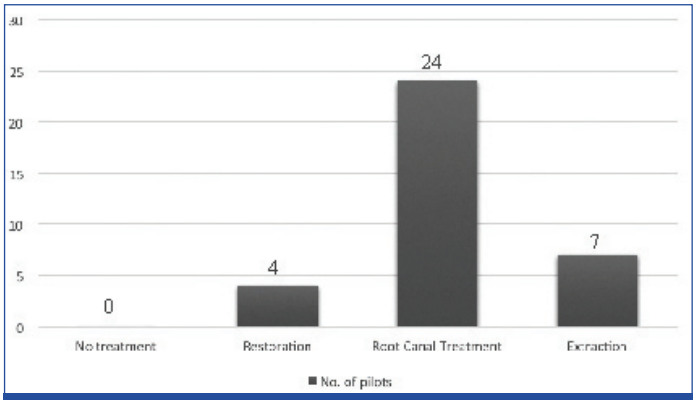
[Table/Fig-2]: Self-Reported barodontalgia among commercial pilots based in India (Chi-square test was used to compare categorical data, S=significant).

Questions			Flying hours			Total	p-value
			100-300	300-500	>500 hrs		
Do you undergo routine dental examination?	No	n	11	16	77	104	0.022, S
		%	47.8%	43.2%	24.8%	28.1%	
	Yes	n	9	15	144	168	
		%	39.1%	40.5%	46.5%	45.4%	
	Only if there is emergency	n	3	6	89	98	
		%	13.0%	16.2%	28.7%	26.5%	
Did you encounter ant in-flight tooth ache that was not existing previously?	No	n	19	35	277	331	0.336, NS
		%	82.6%	94.6%	89.4%	89.5%	
	Yes	n	4	2	33	39	
		%	17.4%	5.4%	10.6%	10.5%	
What was the position of aircraft when pain occurred?	Ascend	n	4	1	13	18	0.207, NS
		%	100.0%	50.0%	39.4%	46.2%	
	Cruise	n	0	0	8	8	
		%	0.0%	0.0%	24.2%	20.5%	
	Descend	n	0	1	12	13	
		%	0.0%	50.0%	36.4%	33.3%	
Were you able to localise the pain?	No	n	1	0	3	4	0.599, NS
		%	25.0%	0.0%	9.1%	10.3%	
	Anterior teeth	n	1	0	3	4	
		%	25.0%	0.0%	9.1%	10.3%	
	Posterior teeth	n	2	2	27	31	
		%	50.0%	100.0%	81.8%	79.5%	
Did the pain subside after the flight landed on ground?	No	n	1	1	17	19	0.605, NS
		%	25.0%	50.0%	51.5%	48.7%	
	Yes	n	3	1	16	20	
		%	75.0%	50.0%	48.5%	51.3%	
Did you visit the dentist post incidence of in-flight pain?	No	n	1	0	3	4	0.543, NS
		%	25.0%	0.0%	9.1%	10.3%	
	Yes	n	3	2	30	35	
		%	75.0%	100.0%	90.9%	89.7%	

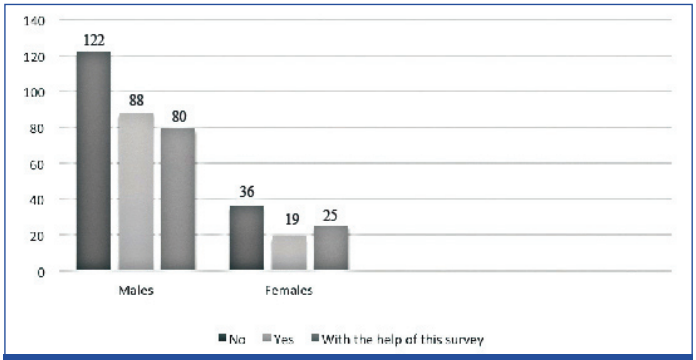
Which treatment was provided to you by the dentist?	No treatment	n	0	0	0	0	0.802, NS
		%	0%	0%	0%	0%	
	Restoration	n	0	0	4	4	
		%	0.0%	0.0%	13.3%	11.4%	
	RCT	n	2	2	20	24	
		%	66.7%	100.0%	66.7%	68.6%	
	Extraction	n	1	0	6	7	
		%	14.3%	9.1%	10.5%	10.6%	
Did the pain re-occur in-flight after treatment by your dentist?	No	n	4	2	32	38	0.911, NS
		%	100.0%	100.0%	97.0%	97.4%	
	Yes	n	0	0	1	1	
		%	0.0%	0.0%	3.0%	2.6%	

[Table/Fig-3]: Flying hours wise distribution of responses of subjects to questionnaire. Inferential statistics were performed using chi-square test, one-way analysis of variance and independent t-test (S=Significant, NS=Not-significant).

of the investigated pilots who had encountered pain, RCT was performed 68.6% (n=24) whereas restoration was done for 11.4% (n=4) pilots and extraction for 10.6% (n=7) [Table/Fig-4]. Only one pilot had complained of recurrence of pain while 97.4% pilots reported that the episode of pain did not occur again. The survey also highlighted that 45.4% (n=168) pilots underwent routine dental examination and 26.5% (n=98) only visited their dentist in case of an emergency (p=0.022) [Table/Fig-3]. Awareness regarding the phenomenon was notably reported by 30.4% (n=88) male pilots and 23.8% (n=19) female pilots while 104 pilots lacked awareness about the same [Table/Fig-5].



[Table/Fig-4]: Bar graph showing various treatment modalities provided to pilots who experienced in-flight pain.



[Table/Fig-5]: Bar graph showing gender wise awareness of barodontalgia among commercial pilots based in India.

DISCUSSION

Air travel is the quickest means of transport, flying at a speed of 800 kms/hr. According to The International Civil Aviation Organisation (ICAO) preliminary compilation of 2018, 4.3 million passengers are carried on scheduled air services [13]. Aircrew members fly an average of 500 hours/annum to provide comfortable services to the passengers. At higher altitude, due to hypobaric environment, pilots and other aircrew members, suffer from deleterious effects on their teeth, gums and bones. This inhospitable environment and cabin pressure changes are also responsible for inducing xerostomia, a causative factor for dental diseases [2]. Such oral manifestations can also be seen with frequent flyers however, the intensity may vary. Significant difference in manifestations of such diseases is also noticed between aircraft personnel of commercial flights and military pilots due to variation in exposure time and intensity of pressure change [7].

Dental surgeons have deduced barodontalgia as an emergency. In the present study, 10.54% (n=39) commercial Indian pilots from government and private sectors of India have reported that they have experienced in-flight dental pain as opposed to 20.6% Indian origin pilots who reported in 2010 [12]. By using similar study design 10 years later the present study reveals that the frequency of barodontalgia has been reduced. This decrease in barodontalgia can presumably be attributed to better oral hygiene maintenance due to regular dental examination. In this context, results from this study report that 45.4% (n=168) of pilots visit their dentist for routine dental examinations. Moreover, improved technology maintaining cabin differential pressure also contributes in lowering the rate of barodontalgia [14]. The current incidence of barodontalgia in pilots based in India is lower than pilots of commercial airlines of Pakistan (29.03%) but higher than commercial pilots of France (6.5%) [15,16]. Military pilots of Kuwait and Saudi Arabia and pilots of Turkish Air Force have reported an incidence of barodontalgic pain of 49.6% and 12%, respectively [17,18]. In contrast, Israeli Air Force reported a prevalence of 8.2% in 2007 and a frequency of 0.26% was reported in the German Air Force Crew by Kollmann W [19,20]. However, Pakistani military pilots have reported 0% of barodontalgia [15]. This discrepancy can be ascribed to the difference in study design, study sample and cultural and ethnic backgrounds. The contrasting difference between commercial and military counterparts can be attributed to the assumption that military pilots are more likely to be subjected to extreme situations [15].

In the present study, data regarding in-flight pain and its characteristics were obtained. None of the participants of this study complained of existence of pain prior to the flight. Ritchey B and Orban B, propounded higher prevalence of barodontalgia due to rapid ascent, this is in correlation with the present study where in 46.2% pilots (n=18) reported pain during flight ascent [21]. The higher incidences recorded during ascent explains that pain was associated to the underlying vital pulp pathology and hence 11.4% (n=4) and 68.6% (n=24) subjects of the study reported that they were provided restoration and root canal treatment, respectively with a possible diagnosis of acute pulpitis, caries or faulty restorations [20]. Based on available evidences, no association between intensity of pain experienced by the pilots and gender was noticed. The mean in-flight pain reported by the male pilots was 5.3 and female pilots was 5.5. In Kollmann's high altitude chamber simulation series, 29% of incidences were due to exposed vital pulp and 14% due to pulpitis or periapical periodontitis. Most common incidental cause of barodontalgia was deep caries without pulp exposure in Kollmann's series likewise for 11.4% (n=4) of subjects participating in the present study, restoration of offending tooth was done, root canal treatment was provided to 68.6% (n=24) of the pilots with in-flight pain while 10.6% (n=7) underwent extraction [20].

Conflicting results have emerged in response to barodontalgia from data obtained from hypobaric simulators and in-flight data due to inconsistency in exposure time and cabin pressurisation thus, participants having minimum of 100 hours of flying time in a year were considered for the study. None of the investigated pilots reported flight safety risk/premature landing due to the oral pain experienced in-flight as opposed by 13.5% of French commercial and military pilots surveyed by Laval-Meunier F et al., [16].

The recurrence rate of in-flight pain documented by Indian pilots was 2.6% (n=1) juxtaposed to the previous studies by Rai B et al.,

in which recurrence rate was 10.2% and Al-Hajri W and AL-Madi E in 2006 in which recurrence rate of 16.4% was reported [12,17]. Subsequently, no case of premature landing due to in-flight pain or reoccurence of pain had been reported by Pakistani pilots [15].

A 42.7% Indian pilots participating in the present study were unacquainted with the phenomenon of barodontalgia. Thus, its essential to raise awareness among pilots as well as dental surgeons. Dental students in Chennai, India displayed low percentage of 41% participants who were aware of the phenomena, while awareness level of 22.2% has been reported among dental students in Saudi Arabia [10,22]. Thus, with thorough knowledge, periodic examinations including vitality tests in extensively restored teeth, retreatment of faulty restorations and diagnostic radiography such incidences can be prevented. In cases, with pulpal pathology meticulous root canal treatment is advised, but recent systematic reviews show promising outcomes with less invasive therapies such as coronal pulpotomy [23]. The root canal treated teeth must be restored with full coverage crowns for functional as well as aesthetic purposes. This also increases the long term survival of the tooth as opposed to direct restorations [24].

Pain due to necrosis of pulp usually appears during descent and was seen in 33.3% (n=13) pilots and 10.6% (n=7) among the total underwent extractions due to the intensity of the pain. Extractions of impacted third molars is also recommended owning to their symptoms which can be sudden in onset and recurrent infections. Most of the subjects (79.5%, n=31) were able to localise their pain to posterior teeth region and this is in association to the higher prevalence of caries in occlusal fissures of first and second molars [25].

Pilots and aircrew must be obligated to resume to duty once the procedure has been completed. Moreover, multi visit RCT must be preferred over single visit as it has a lesser frequency of swelling and analgesic use [26]. The incidence of barodontalgia in different regions of the world has been summarised in [Table/Fig-6] [5,12,15-20,27].

S. No.	Author's name and year	Place of study	Sample size	Incidence of barodontalgia
1.	Kollman W (1993) [20]	Germany	11617 (Military pilots in high altitude chamber simulation)	0.26%
2.	González-Santiago MM et al., (2004) [27]	Spain	499 (Military pilots)	2.63%
3.	Al-Hajri W and Al-Madi E (2006) [17]	Saudi Arabia and Kuwait	135 (Military pilots)	49.6%
4.	Sipahi C et al., (2007) [18]	Turkey	32 (Military pilots)	0.003%
5.	Zadik Y et al., (2007) [19]	Israel	331 (Military pilots)	8.2%
6.	Rai B et al., (2010) [12]	India	304 (Commercial pilots)	20.6%
7.	Laval-Meurier F et al., (2013) [16]	France	1475 (Military pilots, commercial pilots and aircrew)	6.6%
8.	Al Khawalde M et al., (2013) [5]	Jordan	305 (Military pilots)	10.49%
9.	Daud SS et al., (2019) [15]	Pakistan	51 (Military and commercial pilots)	17.64%
10.	Present study	India	410 (Commercial pilots)	10.54%

[Table/Fig-6]: Barodontalgia among commercial and military pilots [5,12,15-20,27].

Patients are advised not to fly in nonpressurised cabins within 24 hours of a dental treatment requiring anaesthetic. Following surgical treatment a mandatory seven days of rest period must also be taken [8]. A compulsory annual examination must be recommended for all pilots and aircrew members by aviation dental specialist to record any deterioration in dental health. It is also advised that pilots and crew must be provided the due precautions and instructions for management of in-flight occurrence of dental pain. The patients examined to be at risk should be Temporary Medical Unfit (TMU) for flying as a flight safety hazard. In the present day, it is recommended that dental health must be incorporated for aviator's physical standards. It has also been highlighted that barodontalgia has been neglected in dental education and research in the recent years, despite demonstrated essential role of atmospheric pressure generation and oral pain.

Limitation(s)

The study is limited to self-reported data and no clinical correlation was conducted however more research into understanding of history, diagnosis, treatment challenges and preventive programmes in the form of increased awareness among pilots is proposed.

CONCLUSION(S)

It is evident from the available data that incidence of barodontalgia was reported 10.54% of the sample population which is relatively low as compared to reports from other countries. It was found to be of minor nature and did not disrupt the health of the pilot or the flight routine. However, dental barotrauma still remains a field of concern for flyers and its awareness among dental surgeons as well as pilots have been found out to be low.

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- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

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