IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 14, Issue 8 Ver. II (Aug. 2015), PP 105-111
www.iosrjournals.org

Laser-Assisted Uvulopalatoplasty for Management of Obstructive Sleep Apnoea: Pre and Post Operative Analysis Using Parameters of Polysomnography and Magnetic Resonance Imaging

Jiten N[1], Ramalingam WVBS [2], Rajput AK[3], Giriraj Singh[4], Mukesh Chandra[5], kalpana Th[6], Satish N[7]
Ex-Resident, Dept of Otorhinolaryngology, Army Hospital (R & R), New-Delhi,India)
Ex- Prof and HOD, Dept of Otorhinolaryngology, Army Hospital (R & R), New-Delhi,India)
Ex- Prof and HOD, Dept of Respiratory Medicine, Army Hospital (R & R), New-Delhi,India)
Ex- Associate Prof, Dept of Radiology, Army Hospital (R & R), New-Delhi,India)
Asstistant Prof, Dept of Radiology, Army Hospital (R & R), New-Delhi,India)
ENT specialist, Manipur Health Services, Manipur, India)
Ex-Assistant Prof, Dept of Otorhinolaryngology, Army Hospital (R & R), New-Delhi,India)

Abstract:
Purpose: *To evaluate the efficacy of Laser-assisted uvulopalatoplasty (LAUP) in the treatment of obstructive sleep apnoea using pre and post operative polysomnography and magnetic resonance imaging (MRI) assessment, and to examine the subjective impact of LAUP on quality of life.*
Materials and Methods: *A total of thirtyfour patients with obstructive sleep apnoea (OSA) were prospectively studied. Patients were evaluated by pre- and post-operative polysomnography and MRI in a tertiary care hospital. Means of BMI, ESS, AI, HI, AHI and min SaO2 before and after LAUP were compared. Means of minimum velopharyngeal lumen area, total pharyngeal wall width, total parapharyngeal fatpad area, soft palate length and area were also compared for both awake and asleep state before and after the surgery. Subjective data and post op complications were also analysed. LAUP was done under local anaesthesia and also under general anaesthesia using CO2 laser. Appropriate statistical tools were used for analysis of datas.*
Results: *In the study, there were 29 males (85.30%) and 5 females (14.70%). Almost two third (64.71%) were between 30-50 years of age while 32.35% were more than 50 years old. Only one patient was below 30 years of age. The mean age was 46.32 years. Mean BMI decreased from 28.32 to 28.23 postoperatively ($p > 0.05$). Upto 75% improvement in snoring were found in 21 (61.76%) and a 50% or less improvement in snoring found in 13 (38.24%) patients. An improvement upto 75% in daytime sleepiness (median value = 4; range = 3 - 5), and more than 75% improvement in arousal from sleep (median value = 4.5; range = 3 – 5) was noted. Epsworth sleepiness scale (ESS) showed a reduction from a median value of 11.5 to 4 ($P < 0.001$). The Apnoea Index (AI) fell by 49.17% postoperatively while the Apnoea hypopnea Index (AHI) fell by 41.82% ($p < 0.001$). Fall in Hypopnea Index (HI) was 41.82 % ($P<0.05$). The minimum oxygen saturation (Min SaO_2) increased from the preoperative mean value of 77% to 81.65% postoperatively ($P<0.05$). Mean velopharyngeal lumen area in awake state increased nearly two fold while in sleep state this increase was more than three times, postoperatively ($P<0.001$). Total parapharyngeal fat pad area decreased amounting to 0.5 mm^2 across both the states ($P<0.05$). Mean total pharyngeal wall width decreased across both states ($P<0.001$). Soft palate area decreased by 33.37% and 34.59% for awake and sleep states ($P<0.001$.) Soft palate length decreased by 26.08% and 27.54% in awake and sleep states ($p<0.001$).*
Conclusion: *LAUP is safe and beneficial for all patients suffering from OSA. However, a careful patient evaluation and selection are critical for the best possible outcome and safety in patients undergoing the surgical procedure for OSA.*
Keywords: *Laser-assiated uvulopalatoplasty, obstructive sleep apnoea, polysomnography, magnetic resonance imaging.*

I. Introduction

In recent years it has been observed by various researchers that disturbing sleep with daytime somnolence may be related to obstructive sleep apnoea (OSA). It affects 2% of women and 4% of men.[1] A more recent analysis of the epidemiology of OSA has suggested the prevalence of it to be approximately 5 percent in a given population, but it is likely that it will increase as the prevalence of obesity has increased in all age groups.[2]

OSA is defined by the presence of at least 5 obstructive apnoeas/ hypopnoeas, or both per hour during sleep. An apnoea is a cessation of airflow by 80-100% for 10 seconds or more. A hypopnoea is a 30-50% reduction in airflow for more than 10 seconds. The severity of OSA is measured by an apnoea-hypopnoea-index (AHI) value, which is the mean number of apnoeas and hypopnoeas per hour. OSA is divided into three categories: mild (AHI = ≥5 but <15 events per hour); moderate (AHI = ≥15 but <30 events per hour); and severe (AHI = ≥30 events per hour). An AHI value of less than 5 is within normal ranges, and these patients are not at risk of developing OSA.

Currently OSA is diagnosed through history, physical examination, imaging studies and polysomnography. The gold standard for the diagnosis of OSA is the overnight polysomnogram (PSG). Magnetic resonance imaging (MRI) techniques have also permitted a detailed understanding of the process of the narrowing and collapse of the upper airways. [3]

The management of OSA focuses on prevention or bypass of the upper airway collapse. The most effective treatment for OSA is nasal continuous positive air pressure (CPAP). However, patient compliance with this methodology is poor.[4,5,6] Uvulopalatopharyngoplasty (UPPP) was the first surgery to address specific sites of obstruction in OSA and was designed to enlarge the retropalatal airway.[7] The use of the procedure is limited by relatively high complication rates of velopharyngeal insufficiency and, occasionally, nasopharyngeal stenosis.[8]

Laser-assisted uvulopalatoplasty (LAUP) was initially designed for the management of snoring. [9] It gained limited acceptance as an alternative to UPPP for the treatment of OSAS secondary to retropalatal obstruction.[10,11,12]

The purpose of our study was to evaluate the efficacy of LAUP in obstructive sleep apnoea using pre and post operative polysomnography and MRI and its impact on quality of life. Till now no study has analysed LAUP by using both PSG and MRI in OSA.

II. Materials and Methods

Thirtyfour patients with OSA were prospectively studied at the Department of ENT and Head and Neck Surgery, Army Hospital (Research and Referral), New Delhi over a period of 18 months in collaboration with department of respiratory medicine and department of radiodiagnosis. Subjects with complaints of loud snoring, excessive daytime sleepiness, early morning headache, irritability and impaired mental or emotional functioning, frequent arousals from sleep associated with choking sensations and sweating etc. had undergone a detailed pre-surgical history including a questionnaire relating to medical and sleep history, Epworth Sleepiness Scale (ESS), clinical evaluation consisting of general, systemic and otorhinolaryngological examinations. The nasopharynx, oropharynx, hypopharynx and larynx were examined using nasopharyngolaryngoscopy. Initial body weight and height were recorded, and body mass index (BMI) was calculated. Pre-LAUP polysomnography and MRI evaluation of the upper airway were done in these subjects.

During polysomnography test, the following parameters were monitored: heart rate, SpO2, snoring, respiratory flow, respiratory effort (thoracic and abdominal breathing movements) and body positions in relation to apnoea. Instances of sleep apnoea and hypopnoea lasting > 10 sec and the number of apnoea/hypopnoea per hour were calculated. OSA was diagnosed if ≥ 5 apnoeas per hour in polysomnogram.

MRI of the upper airway was performed with a 3.0 Tesla MRI scanner from skull base to hypopharynx with subjects lying supine and head in neutral anatomical position. MR images were acquired in axial, sagittal and coronal planes in T1w sequences with TR 500-700 and TE of 8-15 msec in both awake and sleep state. Patients were refrained from ingesting alcohol or sedatives the day prior to the procedure. Sleep was induced using diazepam 5 – 10 mg intravenously. Sleep was documented through patient's response to radiologist and when snoring was heard through microphones. Measurements made from transverse MR images included the velopharynx (VP) lumen area, total lateral pharyngeal wall width, and total parapharyngeal fatpad area. The lateral pharyngeal wall width is defined as the distance between the lateral edge of the airway and the medial margin of the parapharyngeal fatpads, and was calculated when the airway lumen is minimal. This calculation was performed for both the left and right lateral pharyngeal walls and the data was summed to determine the total pharyngeal wall thickness. Parapharyngeal fatpad areas were calculated in awake and sleep state and expressed as the sum of the fatpads on each side. From sagittal MR images, the soft palate area and length were measured. The airway and soft tissue structure dimensions were measured after a previous selection of the most appropriate images, where different structures were clearly visible. The limits of these structures were traced by hand and a region of interest (ROI) was generated. The computer then adjusted each point around the circumference of this original ROI to determine an objective edge of the structure at that location, and a new ROI was generated. The radiologist then quantified the area of the final ROI. A workstation with image processing software was used for MRI measurements.

LAUP was performed under local and sometimes under general anaesthesia. No premedications were given. 10% lignocaine spray was applied to the palate and the base of tongue followed by infiltration of either side of the base of the uvula and soft palate area with 2 ml mixture of 2% lidocaine and adrenaline (1:80,000). Boyle-Davis mouth gag was placed. The procedure was carried out with patient seated in a chair and using CO2 laser with hand pieces designed to protect the posterior pharyngeal wall. The laser power was set at 15W in continous mode. The incision was taken from upper half of posterior pillar of tonsil vertically then curving horizontally onto soft palate about 3-4 mm from free margin upto base of uvula and continued just above it, horizontally on other side of soft palate curving vertically to encompass upper half of contralateral posterior pillar of tonsil. So the end result is complete excision of upper half of both posterior pillars of tonsil, 3-4 mm margin of soft palate and entire uvula. Sometimes when it was felt that tonsils were found to be hypertrophied, tonsillectomy was also done in the same sitting. In one case where nasal polyposis was present, FESS was combined with LAUP. Postoperative medication included oral antibiotics, analgesics and hydrogen peroxide mouth gargle for 5 days.

These subjects were followed up post-operatively using the same protocol, from 6 weeks upto 6 months after surgical procedure. PSG and MRI along with subjective questionnares were taken 3 months after the procedure. The pre and post LAUP, subjective and objective datas including PSG and MRI findings were analysed. Means of age, BMI and ESS were calculated. Mean preoperative and postoperative AI, HI, AHI and min SaO2 were calculated from polysomnographic data. From the MRI data means of minimum velopharyngeal lumen area, total pharyngeal wall width, total parapharyngeal fatpad area, soft palate length and soft palate area were calculated for both awake and asleep state before and after the surgery. Snoring, daytime sleepiness and arousal from sleep were evaluated from the subjective sleep questionnaires. The data so collected were compiled and appropriate statistical tools were used to analyse the data. The probability value of $P < 0.05$ was considered significant.

III. Inclusion Criteria

Subjects who are entitled defence personnel and their dependents taking health cover from the hospital and those patients referred from other service hospitals all over the country presenting with habitual snoring associated with excessive daytime sleepiness and other signs and symptoms of obstructive sleep apnoea.

IV. Exclusion Criteria

The following subjects with OSA were excluded from the study: 1. Patients having bleeding disorders. 2. Any comorbid medical condition. 3. Patients having psychiatric and neurological disorder. 4. Patients with history of previous radiation therapy. 5. Patients with upper aerodigestive malignancies. 6. OSA due to macroglossia.

V. Results

A total of thirty five patients were followed-up. One patient was excluded as MRI could not be performed due to cardiac pacemaker. So, a total of thirty-four patients were subsequently included in the study. Gender distribution: Total 34 patients consisted of 29 male (85.30%) and 5 female (14.70%).

Age distribution: Almost two third (64.71%) were between 30-50 years of age while 32.35% were more than 50 years old. Only one patient was below 30 years of age. The youngest was 29 years old and oldest 71 years. The mean age was 46.32 years with Std. Deviation ± 8.69.

Pre-op and Post-op MRI of Velopharynx lumen area (mm²): An increase in velopharynx lumen area from a mean ± SD of 37.52 mm² ± 9.92 mm² to 73.52 mm² ± 6.65 mm² in awake state ($P < 0.001$), and from 9.97 mm² ± 5.38 mm² to 30.48 mm² ± 4.16 mm² in sleep state ($P < 0.001$) were noted, and were statistically highly significant (Fig.1).

Pre-op and Post-op MRI Soft palate length(mm) showed a decrease in soft palate length from a mean ± SD of 40.14 mm ± 3.21 mm to 29.67 mm ± 2.13 mm in awake state ($P < 0.001$), and from 43.46 mm ± 3.33 mm to 31.49 mm ± 2.29 mm in sleep state ($P <0.001$), which were statistically highly significant (Fig. 2).

Pre-op and Post-op MRI Soft palate area(mm²) showed a decrease in soft palate area from a mean ± SD of 379.20 mm² ± 46.20 mm² to 252.60 mm² ± 19.24 mm² in awake state ($P < 0.001$), and from 413.90 mm² ± 47.18 mm² to 270.70 mm² ± 19.85 mm² in sleep state ($P <0.001$),which were statistically highly significant (Fig.3).

Pre-op and Post-op MRI Total pharyngeal width (mm) showed change from a pre-operative mean ± SD of 33.66 mm ± 5.38 mm to post-operative mean ± SD of 33.21 mm ± 5.34 mm in awake state ($P < 0.001$), and from preoperative mean ± SD of 46.23 mm ± 4.42 mm to post-operative mean ± SD of 45.62 mm ± 4.50 mm in sleep state ($P < 0.001$),which were statistically highly significant (Fig.4).

Pre-op and Post-op MRI Total parapharyngeal fatpad area (mm2) showed change from a pre-operative mean ± SD of 206.60 mm² ± 26.49 mm² to post-operative mean ± SD of 206.10 mm² ± 26.64 mm² in awake state ($P < 0.01$), and from pre-operative mean ± SD of 206.60 mm² ± 26.49 mm² to post-operative mean ± SD of 206.10 mm² ± 26.64 mm² in sleep state ($P < 0.01$), which were statistically significan (Fig.5).

Pre-op and Post-op AI, HI, AHI: The polysomnographic findings include a decrease in apnoea hypopnea index (AHI) from mean ± SD of 33.05 ± 21.63 to 19.23 ± 17.49 ($P < 0.001$), a decrease in apnoea index (AI) from mean of 19.97 ± 18.14 to 10.15 ± 13.21 ($P < 0.001$), which were both statistically highly significant. The hypopnoea index (HI) decreased from mean ± SD of 13.08 ± 8.67 to 9.16 ± 7.20 ($P < 0.01$), which was significant (Fig.6).

Pre-op and Post-op Min SaO2: The polysomnogram data demonstrated an increase in minimum oxygen saturation (Min SaO2) from a mean ± SD of 77 ± 13.57 to 81.65 ± 10.66, which was significant ($P < 0.05$) (Fig. 7). Pre-op and Post-op ESS: On analysis of Epsworth sleepiness scale (ESS) data of the patients, reduction from a median value of 11.5 to 4 was found in the study, which was highly significant ($P < 0.001$).

Post-op change in snoring, excessive daytime sleepiness and sleep arousal: On analysis of subjective measures, snoring was reduced to about 75% (median value= 4; range = 3 – 4). There was an improvement upto 75% in daytime sleepiness (median value = 4; range = 3 - 5). There was also more than 75% improvement in arousal from sleep (median value = 4.5; range = 3 – 5) (Table 1).

Postoperative complications in these patients were minor in nature which included pain for an average duration of 4.08 days (range 2 – 7 days) and 2 (5.88%) patients developed velopharyngeal regurgitation for about 2 days.

VI. Discussion

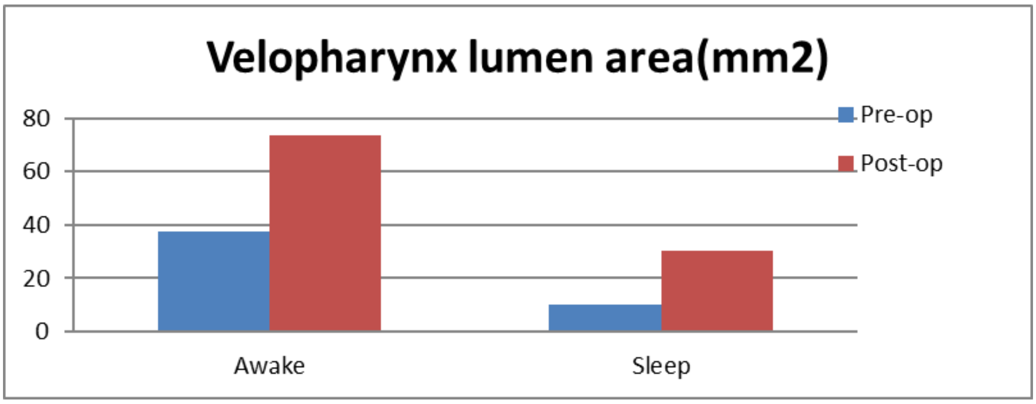
Obstructive sleep apnoea syndrome is a disease process that results from pharyngeal narrowing and/or complete collapse while asleep.[13] This results in sleep fragmentation, frequent arousals, abnormally negative intrathoracic pressures, and daytime symptoms of fatigue and cognitive impairment. Serious medical consequences of untreated OSA may include cardiac arrhythmias, systemic and pulmonary hypertension, myocardial infarction, and an increase in the risk of motor vehicle accidents.

Though nasal CPAP has been effective in suppressing apnoea, acceptance and long-term compliance remain a major problem.[14] Compliance is an issue with oral devices as well. Since the introduction of Fujita's UPPP for the treatment of OSA, many surgical procedures have been developed to enlarge the compromised airway. These procedures specifically address the airway at the retropalatal and retrolingual levels. Riley et al have reported much higher success rates by surgically treating the pharyngeal airway at multiple levels.[15] However, the surgical treatment options for retrolingual obstruction require more extensive surgical training and are more invasive than palatal procedures. Thus palatal surgery is used as the first-line surgical treatment before other more invasive procedures.

LAUP was first performed for snoring by Kamami and subsequently used for patients with obstructive sleep apnoea.[9,16] He first studied on 63 OSA patients and reported that 87% of the patients responded, using a definition of response as greater than 50% reduction in the postoperative RDI. He also noted improved sleep efficiency and a reduction in preoperative oxygen desaturation index. No complications were reported in the series. In Walker's initial study of 105 snorers who underwent LAUP, 60 % of patients and bed partners reported complete or near complete elimination in the snoring, 29% noted a partial improvement and 10 % noted no improvement. Kamami's report showed almost similar results. In our study, snoring was reduced in all pts. A mean 75 % improvement in snoring was seen. Upto 75% improvement in snoring were found in 21(61.76%) and a 50% or less improvement in snoring found in 13 (38.24%) patients.

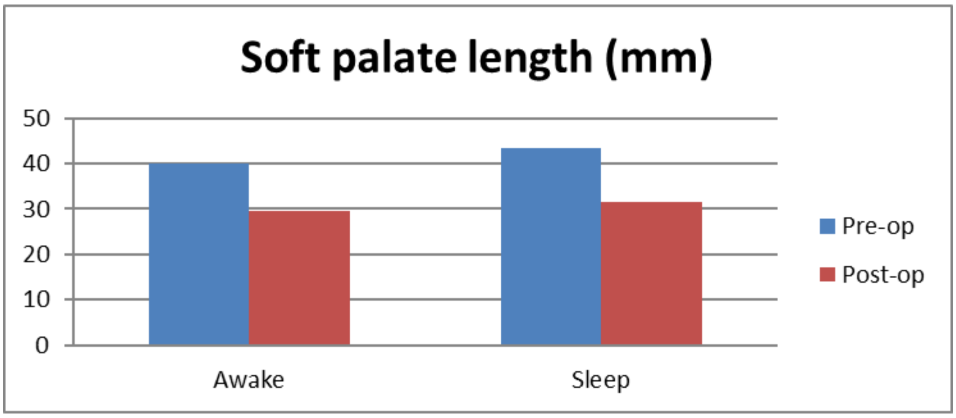
Mickelson in a study, reported apnoea index decreased from 19.4 to 4.2, AHI from 31.2 to 15.7. AHI fell to 10 or lower in 38.5%. [17] In another study, Michelson and Ahuja reported apnoea index decreased from 14.4 to 5.8, AHI from 28.1 to 7.9. AHI fell to 10 or lower in 44.4% and AHI fell to 10 or lower or reduced by more than 50 in 50.0%.[12] Walker et al reported AHI fell to 10 or lower in 48.4%.[18] In our study, apnoea index decreased from 19.97 to 10.15, hypopnoea index from 13.08 to 9.16 and AHI from 33.05 to 19.23. AHI fell to 10 or lower in 35.29% and AHI fell to 10 or lower or reduced by more than 50 in 44.11%. Polysomnography findings also showed an increase in the minimum oxygen saturation (Min SaO_2) in all of 34 patients. From the preoperative mean value of 77%, the Min SaO_2 rose to 81.65% postoperatively amounting to 6.04% rise over the preoperative value. The finding was statistically significant ($P<0.05$). Similar findings were reported by Michelson.[17]

In our study, on analysis of MRI findings revealed a significant post op increase in the velopharynx area in both awake and sleep states. Study patients in awake state showed nearly two fold increase in their mean velopharyngeal lumen area postoperatively while in sleep state this increase was more than three times. Both these findings were found to be statistically highly significant ($P<0.001$). A decrease was noticed postoperatively in total parapharyngeal fat pad area among patients which amounted to 0.5 mm^2 across both the states and was statistically significant ($P<0.05$). It was observed that mean postoperative total pharyngeal wall width also registered a decrease across both states, which was again found to be statistically highly significant ($P<0.001$). MRI findings indicated that there was more than one third reduction in the soft palate area among the study patients. The percentage decrease in soft palate area was 33.37% and 34.59% for awake and sleep states respectively. The findings were found to be statistically highly significant (P<0.001.) MRI data also demonstrated a considerable decrease in the soft palate length post-operatively, amounting to 26.08% and 27.54% in awake and sleep states respectively. Statistically, the findings were found to be highly significant (p<0.001). Although a marginal decrease in BMI from 28.32 to 28.23 was noticed postoperatively, the findings were not statistically significant (p > 0.05). Daytime sleepiness and arousal from sleep showed an improvement upto 75% in daytime sleepiness (median value = 4; range = 3 - 5), and more than 75% improvement in arousal from sleep (median value = 4.5; range = 3 – 5). Epsworth sleepiness scale (ESS) of the patients showed a reduction from a median value of 11.5 to 4 and was highly significant (P < 0.001). Although pain was present in all cases post-operatively, only 2 (5.88%) patients had mild nasal regurgitation in the first week. There was no case of postoperative bleeding.



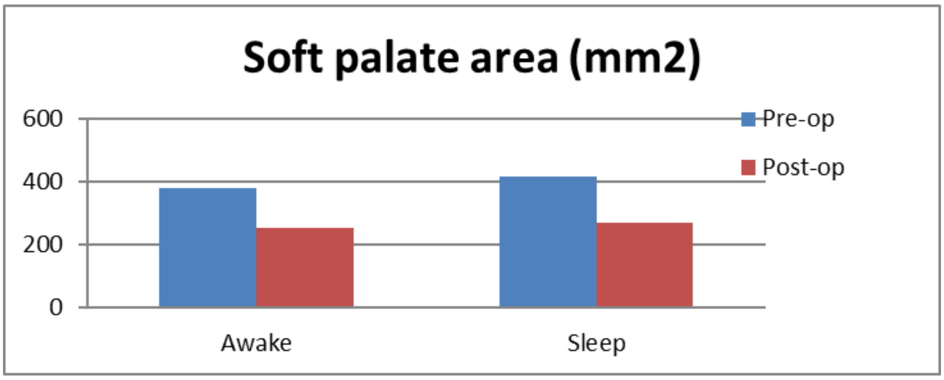
*paired t test

Fig.1: Pre-op and post-op mean velopharyngeal lumen area (mm2) in awake and sleep



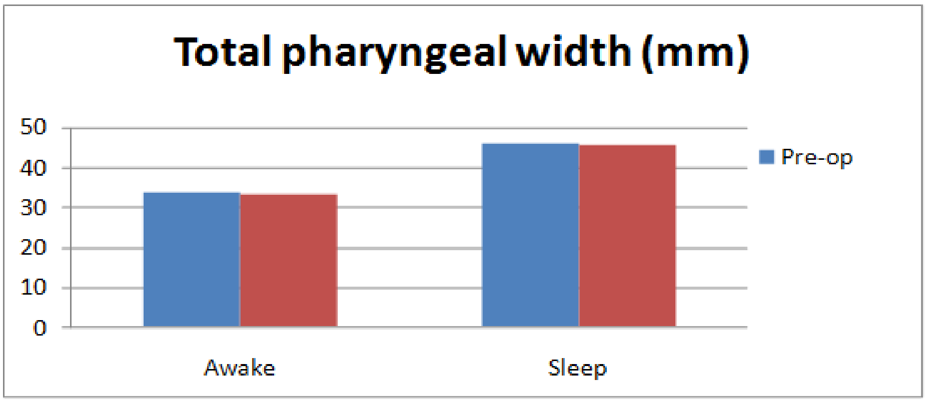
*paired t test

Fig. 2: Pre-op and post-op mean soft palate length (mm) in awake and sleep



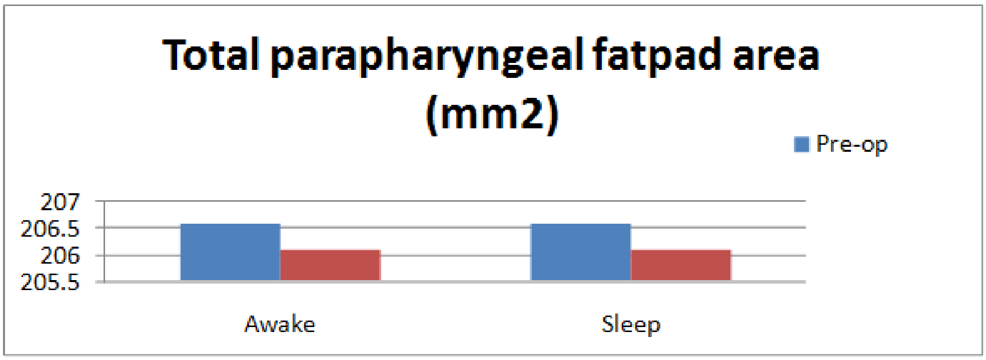
*paired t test

Fig.3: Pre-op and post-op mean soft palate area (mm2) in awake and sleep



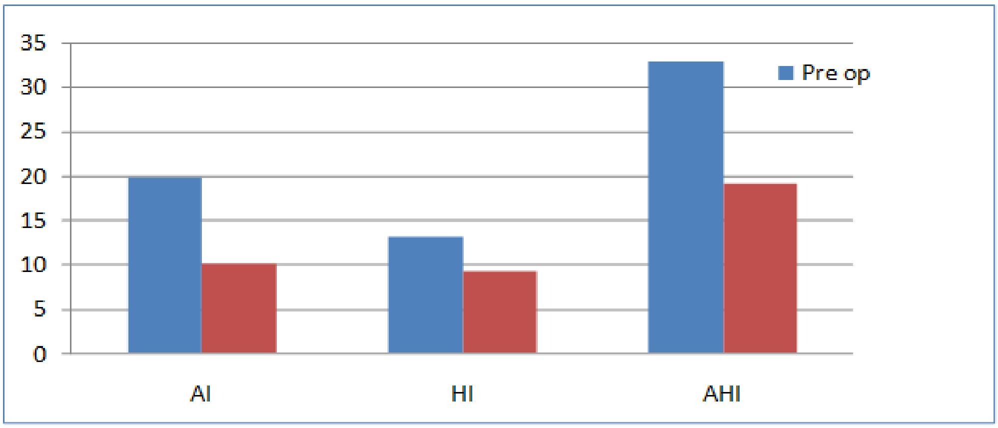
*paired t test

Fig.4: Pre-op and post-op mean total pharyngeal width (mm) in awake and sleep



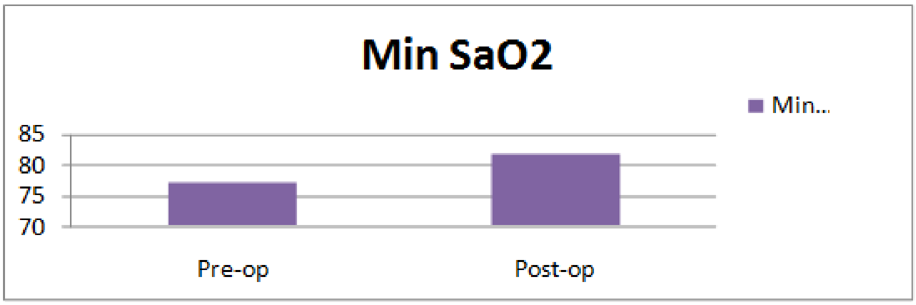
*paired t test

Fig. 5: Pre-op and post-op mean total parapharyngeal fatpad area (mm2) in awake and sleep



*paired t test

Fig.6: Pre-op and post-op mean AI, HI, AHI.



*paired t test

Fig.7: Pre-op and post-op mean Min SaO2

Table 1: Post-op change in snoring, excessive daytime sleepiness and sleep arousal:

	Snoring scale (out of 5)	Excessive daytime sleepiness (out of 5)	Arousal from sleep (out of 5)
Median improvement	4 (range = 3 - 4)	4 (range = 3 - 5)	4.5 (range = 3 - 5)

1 = no change, 2 = upto 25% improvement, 3 = upto 50% improvement, 4 = upto 75% improvement and 5 = 100% improvement of subjective symptoms

VII. Conclusion

LAUP had previously been proposed for the treatment of only mild sleep apnoea. A significant improvement in sleep apnoea symptoms occurred in our study. Both polysomnogram and MRI parameters were improved after LAUP. Subjective symptoms were also improved after the surgery. There were no reported cases of hypernasal speech, oral candidiasis, emergent airway complications, blood transfusions or deaths. We concluded that LAUP is beneficial for apnoea of all severities.

References

[1]. Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep-disorder breathing among middle-aged adults. New England Journal of Medicine 1993; 328:1230-1235.
[2]. Young T, Peppard PE, Gottlieb DJ. Epidemiology of obstructive sleep apnoea: A population health perspective. Am J Respir Crit Care Med 2002; 165:1217-1239.
[3]. Woodson BT, Conley SF, Dohse A, Feroah TR, Sewall SR, Fujita S. Posterior cephalometric radiographic analysis in obstructive sleep apnea. Ann Otol Rhinol Laryngol 1997; 106:310-313.
[4]. Engelman HM, Martin SE, Douglas NJ. Compliance with CPAP therapy in patients with sleep apnea/hypopnea syndrome. Thorax 1994; 49:263-266.
[5]. Reeves-Hoche MK, Meck R, Zwillich CW. Nasal CPAP: an objective evaluation of patient compliance. Am J Respir Crit Care Med 1994; 149:149-154.
[6]. Krieger J. Longterm compliance with nCPAP in OSA patients and nonapneic snorers. Sleep 1992; 15(Suppl 6): S42-46.
[7]. Fujita S, Conway WA, Zorick FJ, et al. Surgical corrections of anatomic abnormalities in obstructive sleep apnea syndrome: uvulopalatopharyngoplasty. Otolaryngol Head Neck Surg 1981; 89:923-934.
[8]. Sher AE, Schechtman KB, Piccirillo JF, et al.The efficacy of surgical modifications of the upper airway in adults with obstructive sleep apnea syndrome. Sleep 1996; 19:156-177.
[9]. Kamami YV. Laser CO2 for snoring: preliminary results. Acta Otorhinolaryngol Belg.1990; 44:451-456.
[10]. Walker RP, Grigg-Damberger MM, Gopalsami C: Laser-assisted uvulopalatoplasty for the treatment of mild, moderate and severe obstructive sleep apnea. Laryngoscope 1999; 109:79-85.
[11]. Walker RP, Grigg-Damberger MM, Gopalsami C: Early polysomnographic findings and long-term subjective results in sleep apnea patients treated with Laser-assisted uvulopalatoplasty. Laryngoscope 1999; 109:1438-1441.
[12]. Mickelson SA, Ahuja A: Short-term objective and long-term subjective results of laser-assisted uvulopalatoplasty for obstructive sleep apnea. Laryngoscope 1999; 109:362-367.
[13]. American Sleep Disorders Association Report: Practice parameters for the treatment of obstructive sleep apnoea in adults: the efficacy of surgical modifications of the upper airway.Sleep 1996; 19(2):152-155.
[14]. Collop NA, Block JA, Hellard D. The effect of nightly nasal CPAP treatment on underlying obstructive sleep apnoea and pharyngeal size. Chest 1991; 99:855-860.
[15]. Riley RW, Powell NB, Guilleminault C. Obstructive sleep apnea syndrome: a review of 306 consecutively treated surgical patients. Otolaryngol Head Neck Surg 1993; 108:117-125
[16]. Kamami YV: Outpatient treatment of sleep apnea syndrome with CO2-laser, LAUP: laser assisted UPPP on 46 patients. J Clin Laser Med Surg 1994 Aug; 12(4):215-9.
[17]. Mickelson SA: Laser-assisted uvulopalatoplasty for obstructive sleep apnea. Laryngoscope 1996; 106(1Pt1):10-3.
[18]. Walker RP, Grigg-Damberger MM, Gopalsami C: Laser-assisted uvulopalatoplasty for snoring and severe obstructive sleep apnea: results in 170 patients. Laryngoscope 1995; 105:938-943.