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Amplitude of accommodation and its relation to refractive errors in presbyopic age group

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Abstract
Introduction: Refractive error is prevalent in 30% of the population which is found to be up to 85% in Asian. Myopia and Hyperopia are the forms of refractive errors whereas Presbyopia is a natural age-related visual condition. Accommodation is the ability of the eye to change the refractive power of the lens to focus on objects at various distances. The objective of this study was to evaluate the amplitude of accommodation in presbyopic age group and observe the subjective acceptance and satisfaction.
Materials and Methods: A hospital-based, descriptive cross-sectional study was carried out at Nepalgunj Medical College Teaching Hospital. A total of 200 patients were included and divided into two group I and II, aged 35 to 60 years.
Results: Out of 200 patients, statistically significant difference in Amplitude of accommodation between myopes and emmetropes ($p<0.05$) and between myopes and hyperopes ($p<0.05$) were observed in 35-44 years age group. Significant difference was also observed between myopes and emmetropes ($p<0.02$) and between myopes and hyperopes ($p<0.01$) in 45-49 years age group. While in 50-54 years age group, significant significance was observed between myopes and emmetropes ($p<0.05$) and between myopes and hyperopes ($p<0.01$). Patients in age group 35-44 years were more satisfied when received presbyopic correction according to amplitude of accommodation however after the age of 45 years presbyopic correction given according to age was tolerated equally well among both the refractive status groups.
Conclusion: The amplitude of accommodation was highest in myopes in all ages groups when compared to hyperopes and emmetropes, and the presbyopic correction to patients between 35-44 years of age should be given according to their amplitude of accommodation keeping $1/3^{rd}$ of their accommodation in reserve for better satisfaction and comfort.

Keywords: Amplitude of accommodation, presbyopia, refractive error

Introduction
Refractive error is prevalent in 30% of the population which is found to be up to 85% in Asian [1]. Since refractive error is considered as an avoidable condition among various conditions leading to visual disabilities, the initiative to eliminate avoidable blindness has given high priority to correction of refractive error and provision of spectacles to the needy is a cost-effective health intervention [2].

Accommodation is a complex constellation of sensory, neuromuscular and biophysical phenomena by which the overall refractive power of the eye changes rapidly to image objects at different viewing distances clearly on to the retina [3]. The amplitude of accommodation (AOA) is the amount of accommodation exerted to move the focus from the far point to the near point or the difference between the refractivity of the eye – when at rest with minimal refraction and when fully accommodated with maximal refraction [4]. AOA is measured with the help of a Royal Air Force (RAF) rule taking into account the fact that, with distance correction in the trial frame in place, the AOA is reciprocal of the near point(in metres) i.e. the reciprocal of Near Point of Accommodation (NPA) is the amplitude of accommodation (Amplitude of accommodation = 1/NPA) [5].

Myopia is a form of refractive error wherein a parallel rays of light come to focus in front of the sentient layer of the retina when the eye is at rest and is measured by the spherical power in diopter of the diverging lens [6].

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Hyperopia is a refractive error in which the parallel rays of light entering the eye reach a focal point behind the plane of the retina, while accommodation is maintained in a state of relaxation. Corrected hyperopia have a lower effective accommodation compared to emmetropes and will need near addition at a younger age, while the converse applies to myopes, which is due to lower effectiveness of convex lenses for near compared to concave lenses [7]. Presbyopia is an age-related visual impairment which results from gradual decrease in accommodation expected with age and can have multiple effects on the quality of vision and quality of life. Although there are a number of approaches for managing the visual disability associated with presbyopia, all of the available modalities are compensatory rather than corrective [8].

The presence of myopia in presbyopic individuals may be masked by their accommodative effort for near work while in that of hyperopic patients need correction at an early age. This study is done to determine the amplitude of accommodation in presbyopic age group patients which has shown promising results in few studies performed taking into consideration the peri-presbyopic patients while prescribing glasses for near work for better tolerance and comfort. This type of study has been carried out in this part of the region, it is necessary to determine and provide better correction method and visual comfort to patients using presbyopic glasses in their day-to-day work seeking care at teaching hospital.

Materials and Methods
This is a hospital based, descriptive cross-sectional study carried out at Nepalgunj Medical College Teaching Hospital, over a period of one year. Ethical clearance from Institutional Review Committee (IRC-NGMC) was taken to carry out the study.
A total of 200 patients were included and divided into two group I and II equally numbered, aged 35 to 60 years.

Unaided and pinhole visual acuity of all the patients included in the study was recorded using a snellen's chart. Anterior and posterior segment of all the patients was examined by direct and indirect ophthalmoscopy. Objective and Subjective refraction of the pre-presbyopic patients up to the age of 60 years improving with pin was obtained. The amplitude of accommodation of the patients was measured using a RAF rule and the NPA was measured with the patient trying to read the smallest letter (N5) on the RAF rule target. And the data thus obtained was recorded.

Prescription
Group I: Presbyopic correction according to age
Group II: Presbyopic correction according to amplitude of accommodation.
Both the groups were again divided into various age groups in which emmetropes, myopes and hyperopes were observed. After obtaining the entire data, keeping in mind the patients working distance, group I patients were prescribed according to the conventional method of accepting presbyopic glasses and group II patients were prescribed correction according to their amplitude of accommodation keeping 1/3rd of their accommodation in reserve after acceptance. Patients were asked to follow up after 2 weeks and the symptoms like eyestrain, headache or difficulty with the usage of glasses and their satisfaction after using the prescribed glasses were noted.
Statistical data was done with the help of SPSS version 21.0. Microsoft Word and Excel were used to generate graphs and tables. Significant association was assessed by calculating 'p' value, observed and were taken significant at 'p' value less than 0.05 and 95% confidence interval for the mean.

Results
Out of 200 patients were divided equally into group I and group II, 54% were male and 46% were female in group I and 49% male and 51% female in group II.
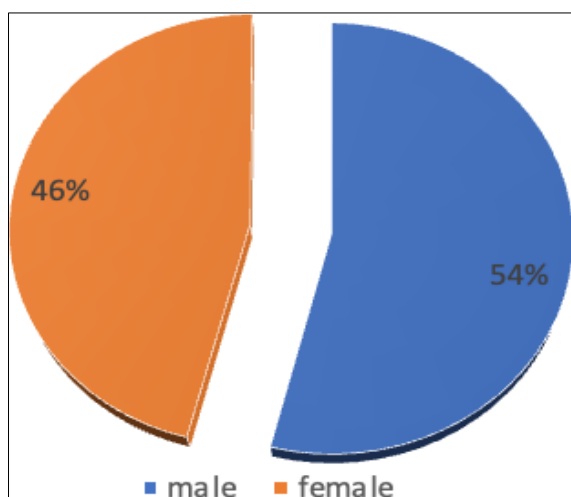

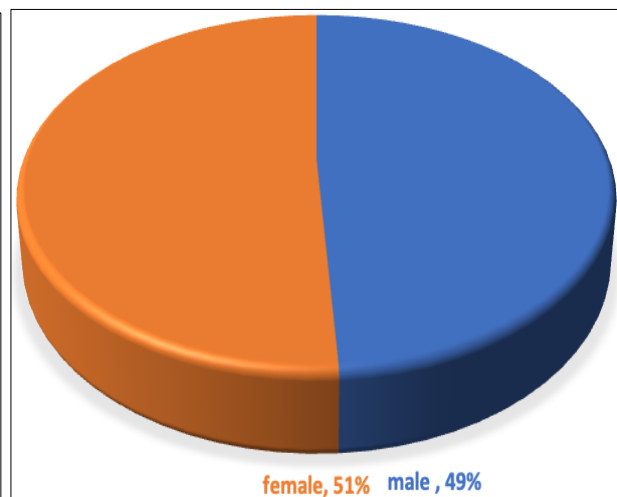**Fig 1:** Sex distribution of group I patients

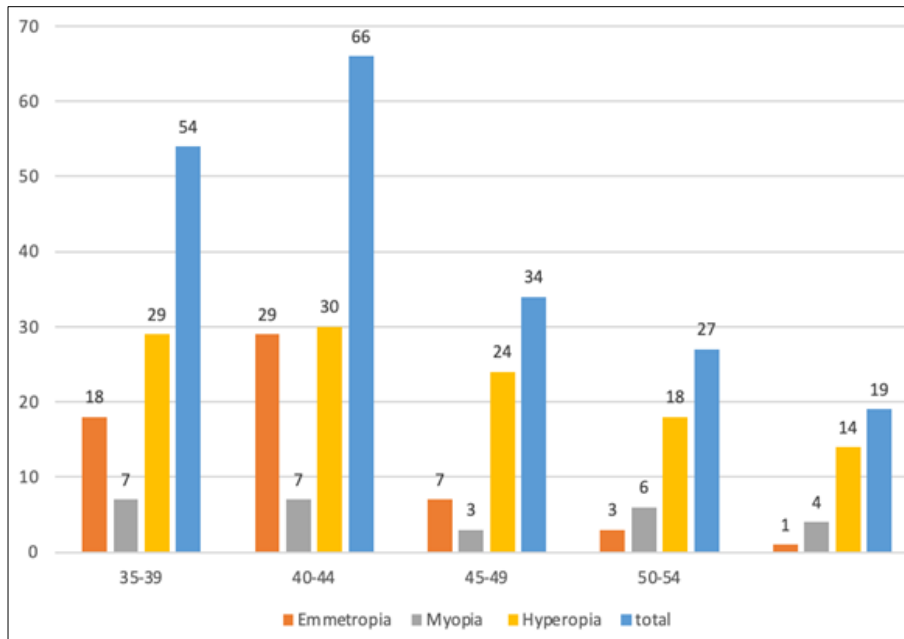**Fig 2:** Sex distribution of group II patients

Fig 3: Bar graph presentation of the total number of cases including their refractive status in both the groups.

It was noted in both the groups that, the percentage of hyperopes was highest being 46% in group I and 60% in group II, while myopes being the lowest 8% in group I and 16% in group II in 35-39years age group. While highest hyperopes 90% were seen between 55-60 years in group I and 91% hyperopes in 45-49 years in group II. The percentage of emmetropes being in between; that is in 35-39 years age group, it was equal to the percentage of hyperopes in group I and more than hyperopes in age 40-44 years in group II.

Table 1: Percentage wise distribution of cases of various refractive status in group I

Age (Yrs)	Emmetropia		Myopia		Hyperopia		Total
35-39	No. of cases	%	No. of cases	%	No. of cases	%	
40-44	11	46%	2	8%	11	46%	24
45-49	13	50%	5	19%	8	30%	26
50-54	6	26%	3	14%	14	61%	23
55-60	1	6%	4	12%	12	70%	17
35-39	0	0	1	9%	9	90%	10

Table 2: Percentage wise distribution of cases of various refractive status in group II

Age (Yrs)	Emmetropia		Myopia		Hyperopia		Total
35-39	No. of cases	%	No. of cases	%	No. of cases	%	
40-44	7	24%	5	16%	18	60%	30
45-49	16	40%	2	5%	22	55%	40
50-54	1	9%	0	0%	10	91%	11
55-60	2	20%	2	20%	6	60%	10
Age(yrs)	1	11%	3	33%	5	56%	Total

Amplituse of accommodation in dioptres was studied in all the patients and the confidence interval was calculated as shown in table 3.

Table 3: Mean amplitude of accommodation in Dioptres in different age groups.

Age (Yrs)	Emmetropia	Myopia	Hyperopia
35-39	AOA - 3.13 (CI : 3.03-3.23)	AOA - 3.35 (CI : 3.19-3.51)	AOA - 2.93 (CI : 2.78-3.08
40-44	AOA - 3.80 (CI : 3.65-3.95)	AOA - 3.16 (CI : 2.96-3.36)	AOA - 2.82 (CI : 2.72-2.92)
45-49	AOA - 2.23 (CI : 1.79-2.67)	AOA - 3.15 (CI : 3.02-3.28)	AOA - 2.29 (CI : 2.14-2.44
50-54	AOA – 2 (CI : 1.84-2.16)	AOA - 2.65 (CI : 2.45-2.85)	AOA - 2.09 (CI : 1.84-2.34)
55-60	AOA – 2 (CI : 1.89-2.11)	AOA - 2.57 (CI : 2.39-2.75)	AOA - 2.09 (CI : 1.89-2.29)

Statistical analysis showed significant difference in AOA between myopes and hyperopes ($p<0.05$) and the mean amplitude of accommodation was highest among myopes followed by emmetropes and lowest in hyperopes in age group 35-39years. In age group 40-44 years, significant statistical difference was found among hyperopes and myopes ($p<0.05$) and between myopes and emmetropes ($p<0.05$). In age group 45-49years, significant difference was seen in myopes and hyperopes ($p<0.02$) and between myopes and emmetropes ($p<0.01$), Statistical difference was found between myopes and emmetropes ($p<0.05$) and between myopes and hyperopes in 50-54 years age group,

no statistical difference was seen among emmetropes and hyperopes in 45-49 and 50-54 years age group. The mean

amplitude of accommodation was highest among myopes and lowest among emmetropes in 55-60 years age group.

Table 4: Patients satisfaction after presbyopic correction according to age in group I

Age (Yrs)	Emmetropia				Myopia				hyperopia			
	No. of cases	Satisfaction percent			No. of cases	Satisfaction percent			No. of cases	Satisfaction percent		
		Yes	No	%		Yes	No	%		Yes	No	%
35-39	11	0	11	0	2	0	2	0	11	0	11	0
40-44	13	7	6	55%	5	2	3	40%	8	1	7	12.5
45-49	6	6	0	100	3	2	1	66	14	10	4	71.5
50-54	1	1	0	100	4	4	0	100	12	0	12	100
55-60	0	0	0	0	1	1	0	100	9	9	0	100

There was no satisfaction noted by the patients after presbyopic correction according to age in all the refractive status groups in age group of 35-39 years, while, 100%

satisfaction was observed in emmetropes of age group 45-49 years; between myopes and emmetropes in 50-54 years and 55-60 years age group.

Table 5: Patents satisfaction after presbyopic correction according to AOA in group II

Age (Yrs)	Emmetropia				Myopia				Hyperopia			
	No. of cases	Satisfaction percent			No. of cases	Satisfaction percent			No. of cases	Satisfaction percent		
		Yes	No	%		Yes	No	%		Yes	No	%
35-39	7	5	2	71.4	5	5	0	100	18	17	1	94.4
40-44	16	15	1	93.7	2	2	0	100	22	21	1	95.4
45-49	1	1	0	100	0	0	0	0	10	0	10	0
50-54	2	2	0	100	2	2	0	100	6	6	0	100
55-60	1	1	0	100	3	2	1	66.7	5	5	0	100

100% satisfaction after presbyopic correction according to amplitude of accommodation in group II was observed in 35-39years, 40-44 years and 50-54 years age group in myopes while 100% satisfaction in hyperopes between age group of 50-54 years and 55-60 years. 71.4% and 94.4% satisfaction was observed in emmetropes and hyperopes respectively in patients under age group of 35-39 years and 93.4% and 95.4% satisfaction in emmetropes and hyperopes respectively in 40-444 years age group.

Discussion
The age of onset of presbyopia depends not only the age but also on the refraction of the individual and his reading habits. A hyperope starts his life with a near point consideration farther away than that of an emmetrope and shows presbyopic symptoms at an early age, while in a myope and opposite condition holds and if he is -4D, presbyopic symptoms will not occur as reported by Abrams[9] which correlates well with the current study.

The effect of age on the amplitude of accommodation and the onset of presbyopic symptoms is a well-known fact. In this study, we found that the hyperopes will need corrected near addition at a younger age due to their lower effective accommodation and are symptomatic earlier than myopes which correlates well with the study done by Abraham *et al*. [10].

The present study also shows that the myopes seek help for presbyopic symptoms much later in life due to the fact that these individuals remove their glasses for near work which is similar to the study conducted by Katz [11].

Our study corresponds well with the study conducted by Mc' Brien *et al*. [12] who demonstrated that the difference on the amplitude of accommodation occurs with respect to refraction and the relationship in non-linear with low myopes exhibiting the largest clinical amplitude of accommodation.

Rambo and Sangal [13], in their study of amplitude of accommodation in presbyopic age group interpreted that after the early thirties every refractive patient should have their accommodation measured and concluded that though age related presbyopic correction can be given in normal practice; more care has to be taken regarding the working distance range and amplitude of accommodation when coming across a young hyperope who tolerates individualized correction better than the convention one, which corresponds well with this study.

Patient's satisfaction while prescribing presbyopic correction according to age and amplitude of accommodation were noted where 1/3rd of the patient's accommodation was kept in reserve which follows Donders rule [7]. following this rule, 100% satisfaction was observed in myopes in 35-44 years age group when prescribed according to amplitude of accommodation as compared to 0% and 40% in same age group when prescribed near correction according to age respectively. However after the age of 45 years presbyopic correction given according to age tolerates equally well among all the refractive status groups, this study does have some limitations as the sample size is small and the time period of the study is limited.

Conclusion
The role amplitude of accommodation in prescribing presbyopic correction showed an overall 100% and 94.9% satisfaction in myopes and hyperopes respectively, when prescribing according to their amplitude of accommodation keeping 1/3rd of their accommodation in reserve considering patients comfort and reading distance of the individual.

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