# COMPARATIVE MEASUREMENT OF EXODEVIATIONS AT TWENTY AND ONE HUNDRED FEET*

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IN HIS DISCUSSION of Bielschowsky's paper on divergence excess James White[1] suggested that patients with exodeviations should be measured at fixation distances greater than 20 feet to bring out the maximum distance deviation. The reasoning was evident and convincing. Divergence increases with increase in fixation distance. If there is an excess of divergence the deviation should continue to increase beyond optical infinity, at which distance the visual axes are presumably parallel in patients with a normal divergence function. White's suggestion has been widely accepted, but a review of the literature has disclosed no data to substantiate White's proposal. We have, therefore, undertaken a prospective study to investigate quantitatively the difference in exodeviations measured at 20 and 100 feet.

## MATERIAL AND METHODS

The material for this study consisted of 105 consecutive patients with an exodeviation, seen in the Strabismus Service of the Department of Ophthalmology of the University of Iowa. All patients were given a general ophthalmic examination and an examination of their ocular motility. In addition to the measurement at 20 feet, the deviation was also measured at 100 feet, the maximal distance available to us. The test was done by having the patients fixate a light on a brick wall located opposite a window through which they looked.

On the basis of comparative measurement at 20 feet and 33 cm the

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patients were divided into the categories of basic exotropia (35 cases or 33 per cent), convergence insufficiency (35 cases or 33 per cent) and divergence excess (28 cases or 27 per cent). There were 7 patients (or 6.6 per cent) with secondary (consecutive) exotropia. The cases of divergence excess were subdivided into those with true and simulated divergence excess on the basis of their response to short term occlusion[2] (Table 1). Sixty-nine patients had never been operated upon, 29 had had a previous operation for an exodeviation, the patients with a consecutive exodeviation had been operated on for an esotropia.

TABLE 1. CLASSIFICATION OF PATIENTS AND EFFECTS OF FIXATION AT 100 FEET

| CLASSIFICATION | NUMBER OF PATIENTS | NUMBER OF PATIENTS WITH INCREASE AT 100 FEET | NUMBER OF PATIENTS WHO CHANGED FROM INTERMITTENT TO CONSTANT DEVIATION AT 100 FEET |
|---|---|---|---|
| BASIC XT | 35 (33.3%) | 10 (28%) | 4 |
| CONV. INSUFF. | 35 (33.3%) | 11 (31.4%) | 1 |
| DIV. EXCESS | 14 (13.3%) | 3 (21%) | 2 |
| SIM. DIV. EXCESS | 14 (13.3%) | 4 (28%) | 1 |
| CONSEC. XT | 7 (6.6%) | 3 (41%) | 1 |
| TOTAL | 105 | 31 (29%) | 9 (8.5%) |

## RESULTS

Of the total number of 105 patients 34 demonstrated an increase of the deviation measured at the 100 feet fixation distance over the deviation measured at 20 feet. The smallest increase measured 2△, the largest 40△ (Table 1, Figure 1). Since a measurement of 2△ is within the limits of error of the method (Ludvigh[3]), the three patients who gave such a measurement were left out of account, reducing the number to 31. Of this number 22 (or 21 per cent of the total) showed an increase from 3 to 9△, whereas 9 patients (or 8.5 per cent of the total) increased by 10△ or more.

The distribution between the various subgroups of the cases showing an increase was surprising (Table 1). One would have expected that the greatest number would be found among those with divergence excess. As it turned out, there was, in percentages, little difference between the various subgroups. Even if one were not to accept the differentiation

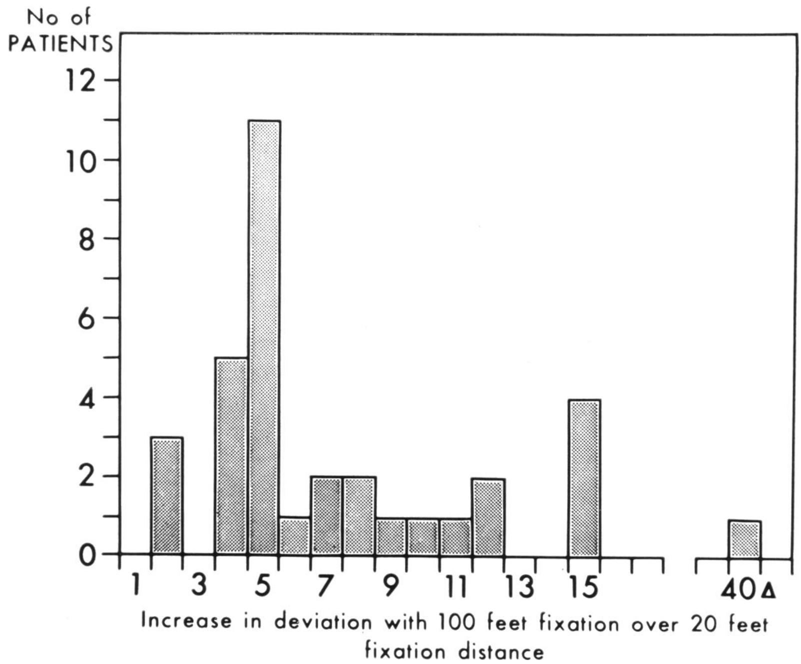


FIGURE 1
Distribution of amount of increase in deviation with measurement at 100 feet in 31 patients with exodeviations.

between true and simulated divergence excess, the number of patients in both subgroups whose deviation increased at 100 feet amounted to only 7 out of 28, or 25 per cent.

It was noted, furthermore, that the deviation in some patients changed its character when they were measured at 100 feet. In eight of them the deviation which had been intermittent at 20 feet became constant, and in one patient who had been heterophoric in all other measurements it became intermittent. In two of the patients who became constantly exotropic, and in the one who became intermittent, there was no concurrent increase in the deviation, in the other six there was an increase (Table 1).

REFRACTIVE ERROR

In addition to these findings our material allowed us also to review the refractive error in 188 eyes of patients with primary exodeviations and in 14 eyes of patients with consecutive exodeviations.

TABLE 2. REFRACTIVE ERRORS (SPHERICAL EQUIVALENT) OF PATIENTS WITH PRIMARY EXOTROPIA

| | REFRACTIVE ERROR | NUMBER OF EYES | |
|---|---|---|---|
| MYOPIA | -0.25 TO -1.00 | 23 | |
| | -1.25 TO -1.75 | 16 | |
| | -2.00 TO -2.75 | 7 | |
| | -3.00 TO -3.75 | 6 | |
| | -4.00 TO -4.75 | 2 | |
| | SUBTOTAL | | 54 |
| PLANO | PLANO | 57 | |
| | SUBTOTAL | | 57 |
| HYPERMETROPIA | +0.25 TO 1.25 | 56 | |
| | +1.50 TO 2.25 | 17 | |
| | +5.25 | 1 | |
| | +6.00 | 1 | |
| | +7.00 | 2 | |
| | SUBTOTAL | | 77 |
| | TOTAL | | 188 |

Table 2 lists the data for the patients with primary exodeviations. It shows that in the vast majority of patients the refractive error was low. If refractive errors up to 1.75 D are considered to be low, 152 eyes of the patients belonged in this classification: 39 eyes had a myopia of − 0.25 to − 1.75 D, 56 eyes a hypermetropia of + 0.25 to + 1.25 D and 57 eyes were recorded as having a plano refraction.

Among the seven patients with consecutive exotropia none had a myopic refraction. The spherical equivalent varied from + 1.00 to + 1.75 D in eight eyes and from + 2.50 to + 5.00 D in six eyes (Table 3).

Seven patients had an anisomyopia of greater than ½ D, and four

TABLE 3. REFRACTIVE ERROR (SPHERICAL EQUIVALENT) OF PATIENTS WITH CONSECUTIVE EXOTROPIA

| REFRACTIVE ERROR | NUMBER OF EYES |
|---|---|
| +1.00 | 2 |
| +1.25 | 2 |
| +1.50 | 2 |
| +1.75 | 2 |
| +2.50 | 1 |
| +2.75 | 1 |
| +3.50 | 1 |
| +4.00 | 1 |
| +5.00 | 2 |
| TOTAL | 14 |

TABLE 4. PATIENTS WITH ANISOMETROPIA OVER ½ D

| LIST NUMBER | AMOUNT OF ANISOMYOPIA | AMOUNT OF ANISOASTIGMATISM | CLASSIFICATION |
|---|---|---|---|
| 102 | -0.75 | 1.25 | CONV. INSUFF. |
| 65 | -1.00 | -- | DIV. EXCESS |
| 66 | -1.00 | -- | CONV. INSUFF. |
| 96 | -1.00 | 0.75 | SIM. DIV. EXCESS |
| 4 | -1.75 | -- | CONV. INSUFF. |
| 59 | -1.75 | 0.75 | CONV. INSUFF. |
| 78 | -3.00 | -- | BASIC XT |
| 36 | -- | 1.25 | CONSECUTIVE XT |

patients had an anisoastigmatism greater than ½ D (Table 4). In four of seven patients the anisometropia was 1.00 D or less, only in one was it as high as 3 D (Table 4). Lastly, patient Number 36 in Table 4 had a consecutive exotropia, so that his anisometropia cannot be held responsible for his exodeviation.

TABLE 5. COMPARISON OF OPERATED AND NON-OPERATED PATIENTS*

| CLASSIFICATION | NUMBER OF NON-OPERATED PATIENTS | NUMBER OF PATIENTS OPERATED FOR EXOTROPIA | NUMBER OF PATIENTS OPERATED FOR ESOTROPIA |
|---|---|---|---|
| BASIC XT | 22 (6.27%) | 13 (4.31%) | -- |
| CONV. INSUFF. | 31 (10.32%) | 4 (1.25%) | -- |
| DIV. EXCESS | 6 (2.25%) | 8 (2.25%) | -- |
| SIM. DIV. EXCESS | 10 (4.25%) | 4 (0) | -- |
| CONSEC. XT | -- | -- | 7 (3.41%) |

*The figures in parentheses give the number and percentage of the subgroup, of those in whom there was an increase with fixation at 100 feet.

## DISCUSSION

Judging from our material one may expect at a fixation distance of 100 feet an increase in deviation over that measured at 20 feet in about 30 per cent of the patients with exodeviations. The increase is modest; between 5 to 9Δ, in most patients, but it may go exceptionally as high as 40Δ. There was no difference with regard to this response in the various forms of exodeviations. This was very surprising to us and we have at present no explanation why this should be so.

Neither is there a systematic difference between the patients who had a previous operation for their exodeviation and those who did not (Table 5). However, the percentage was largest among patients with a consecutive exotropia (Table 1), although it is doubtful whether this finding is meaningful, in view of the small number of cases. But it should be noted that three of the four patients with consecutive exotropia were among the patients with the largest increase (Table 6).

In Table 6 are listed the measurements in the nine patients with an increase in deviation of 10Δ or more. Three of them had a consecutive exotropia, taking the form of a convergence insufficiency in one (Number 53) and of a basic exotropia (Numbers 90 and 54). Among all the nine patients, three were of the basic exotropia type, four of the convergence insufficiency type and one each of the true and simulated divergence excess type.

One of the patients (Table 6, Number 23) changed from an intermittent to a constant exotropia when fixating at 100 feet. It is also of interest to note that in three patients (Table 6, Numbers 29, 53, 57) the deviation measured at 100 feet equalled the measurements at 33-cm

TABLE 6. DATA ON PATIENTS IN WHOM THE DEVIATION INCREASED BY 10 OR MORE WITH FIXATION AT 100 FEET

| LIST NUMBER | DEVIATION | | | | | | | CLASSIFICATION | DIFFERENCES BETWEEN 20' & 100' |
|---|---|---|---|---|---|---|---|---|---|
| | BEFORE PATCHING | | | | AFTER PATCHING | | | | |
| | 100' | 20' | 33CM | 33CM c̄ +3.00 | 20' | 33CM | 33CM c̄ +3.00 | | |
| 29 | 35 X | 25 X | 35 X | 40 X | 25 XT | 35 XT | 40 XT | CONV. INSUFF. | $10^{\Delta}$ |
| 53* | 25 XT | 14 XT | 25 XT | 35 XT | 18 XT | 25 XT | 35 XT | CONV. INSUFF. | $11^{\Delta}$ |
| 23 | 30 XT | 18 X(T) | 6 X | 30 X(T) | 35 XT | 10 XT | 30 XT | DIV. EXCESS | $12^{\Delta}$ |
| 90* | 18 XT | 6 XT | 9 XT | 9 XT | 6 XT | 10 XT | 10 XT | BASIC XT | $12^{\Delta}$ |
| 13 | 50 XT | 35 XT | 35 XT | 55 XT | NOT MEASURED | | | BASIC XT | $15^{\Delta}$ |
| 57 | 25 XT | 10 XT | 25 XT | 30 XT | 14 XT | 30 XT | 35 XT | CONV. INSUFF. | $15^{\Delta}$ |
| 79 | 25 X(T) | 10 X(T) | 18 X(T) | 20 X(T) | 10 X(T) | 22 X(T) | 25 X(T) | CONV. INSUFF. | $15^{\Delta}$ |
| 89 | 35 XT | 20 X(T) | 12 X(T) | 30 XT | 30 XT | 30 XT | 35 XT | SIM. DIV. EXCESS | $15^{\Delta}$ |
| 54* | 60 XT | 20 XT | 25 XT | 35 XT | 20 XT | 25 XT | 35 XT | BASIC XT | $40^{\Delta}$ |

* CONSECUTIVE EXOTROPIA

made prior to short term occlusion. All three patients were of the convergence insufficiency type. After patching, the deviation at 33-cm tended to be closer to the one at 100 feet in two patients (Table 6, Numbers 79, 89).

The AC/A ratio, as evaluated by measurement at near with + 3.00 D sph lenses added (Brown[4]), was high in three patients, one each with true and simulated divergence excess (Table 6, Numbers 23 and 89), and one with basic exotropia (Table 6, Number 13). In the remaining six patients the AC/A ratio was low.

No relation between the AC/A ratio and changes in the measurements with fixation at 100 feet would be expected, and there appeared to be none. Among all the patients of this series, including the three listed in Table 6, there were 18 who had an AC/A ratio higher than 5Δ/D. Of this total only five, the three in Table 6 and two others, belonged to those in whom there was an increase in deviation at the 100 feet fixation distance.

The refractive findings in our material suggest a few words of comment.

When Donders had discovered the relationship between accommodation and convergence, he believed that he had also solved the problem of the etiology of comitant strabismus. His theory undoubtedly holds for a group of patients with esotropia. It is less convincing for patients with exotropia. Our data give no evidence for a causal relationship between refractive errors and exodeviations. Nevertheless, it is clear that their distribution is quite different from the distribution which would be found among a comparable number of patients with esotropia. The distribution in our population of exotropes resembles that in the general population. Also, even though the number of our patients with consecutive exotropia is very small, it is striking that none of these patients who were originally esotropic have a spherical equivalent of less than + 1.00 D (Table 3).

Jampolsky[5] has stated that exodeviations in his experience were not correlated with myopia but that anisomyopia and anisoastigmatism bore a distinct relationship to them. He proposed the thought that unequal clarity of the retinal images, and thus a differential cerebral impressiveness at distance fixation, might account for an exodeviation becoming manifest at distance before it does so at near. Judging from our material this cannot be the general rule. We found only seven patients with an anisomyopia greater than ½ D and only four patients with an anisoastigmatism greater than ½ D. In view of the fact that the vast majority of patients with minor anisometropia have no intermittent or manifest exodeviation, this finding is not surprising. Also, in infants and young children one would expect a major anisometropia to lead to an esodeviation rather than to an exodeviation.

### SUMMARY

In 31 patients out of 105 patients with exodeviations a larger deviation, with a difference of more than 2△, was measured at 100 feet than at 20 feet.

In 22 of these patients the increase was from 3 to 9△, in the remaining nine it was 10△ or more. No difference was, in this respect, found in the various types of exodeviations.

The distribution of the refractive errors among these patients indicated no causal relationship between myopia and exodeviations. Anisometropia greater than ½ D was present in only eight of the patients and appeared to play no etiologic role.

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## *DISCUSSION*

DR PHILIP KNAPP. I was surprised at the low number of patients showing an increase in the amount of exotropia at 100 feet compared to 20 feet. I therefore had Dr Richard Zipf, a fellow who has been with me, pull some of my charts for comparison. I was mortified to find that many charts lacked this measurement.

Of the records with such measurements recorded 60 per cent showed five or more diopters greater measurement at far distance as compared to 20 feet. Of these, 75 per cent showed an increase of 10 to 25. This apparent discrepancy in the figures may be explained in two ways: (1) The greater distance used, and (2) we feel that a light is a poor target as it may or may not attract the individual's visual attention.

We used to use an animated Johnny Walker billboard until some environmentalist removed it. Now we use the various configurations on the other side of the Hudson to attract visual attention. Costenbader has previously shown that identifying figures frequently brings out a larger deviation than looking at a light.

Another factor that must be analyzed is the amount of brightness. In a prospective study we are noting the type of weather at the time the measurements are recorded. Of course, in New York one rarely gets a bright clear day any more.

A second surprise in this paper was the low incidence of anisometropia reported (10 per cent). I would have estimated that 30 to 40 per cent of patients with exotropia would show anisometropia of over 0.50 diopter. Our incidence was 10 per cent, which is identical to that reported.

I have one or two minor objections to this paper: I think it would be more meaningful if only unoperated cases were included rather than including patients who had had previous surgery for exotropia and esotropia. I object to calling exotropic patients after surgery for esotropia "consecutive exotropia." I feel these patients should be called postoperative exotropias, reserving the term "consecutive" for those cases of esotropia that became divergent without the help of a surgeon.

DR HAROLD W. BROWN. This paper by Dr Burian and Dr Smith is an excellent follow-up of a paper presented at this Society last year by Dr Burian and Dr Franceschetti. It was entitled, "Evaluation of Diagnostic Methods for the Classification of Exodeviation." I had the pleasure of discussing that paper, and at that time I expressed my opinion about the basis of their classification.

The classification of exodeviation presented last year was the same as that used in the paper this morning. The evaluation of accommodative convergence by the use of plus add was given as a valuable diagnostic method in the classification of exodeviation. It is interesting to note that the status of the AC/A ratio had no effect on the difference in the measurement between 20 feet and 100 feet. This is in contrast to the marked difference between the conventional near and distant measurement in the presence of a high AC/A ratio as given last year.

Of major interest to me in this year's paper is their report on the AC/A ratio. In this year's report they state that 18 cases in their series of 105 cases had a higher than 5 to 1 ratio. A 5 to 1 ratio in my experience is high. A higher than 5 to 1 ratio is very high.

On the basis that a greater than 5 to 1 ratio is very high, approximately 18 per cent of the authors' series of 105 cases could be classified as having a very high AC/A ratio. I found in a series of 261 cases that 45 per cent of these cases of exodeviation had an AC/A ratio of 5 to 1 or higher.

For practical purposes, a comparison of my series with the series of the authors is not worth discussing, chiefly because of the many variables that

Dr Knapp has already pointed out. However, what is worthwhile is an awareness that a significant percentage of exodeviations have a high AC/A ratio.

DR CHAMBERLAIN. The objective in evaluation of these exodeviations is to bring out the maximum deviation. The authors have shown their increase in measurements to be about 29 per cent on fixing the light at 100 feet. At Dr Burian's suggestion I evaluated a series of 49 patients using accommodative type targets at 20 feet, and what I choose to call "interest" targets at about one mile, e.g., ships in the harbor and planes at the lakefront airport. The patient was asked to identify the actual target, and I agree with Dr Knapp that this is important.

I prefer to use the plus 3.00 lenses to unmask the maximum exodeviation for near, and thereby bring out the simulated divergence excess group. In each instance I performed the examination, using a prolonged prism and cover test. In 27 of 49 patients there was an increase in exodeviation measured at one mile. This is 55 per cent, which agrees more nearly with Dr Knapp's figure. In other words, I found 55 per cent increased at one mile compared with the authors' 29 per cent at 100 feet.

In this same series, 20 per cent converted from exophoria-intermittent exotropia to exotropia at one mile compared with the authors' 10 per cent.

In conclusion, the greater distance, and certainly an interesting type of fixation target, would seem to be important. The measurements beyond 20 feet at "far distance" do elicit a significant percentage of increases in exodeviations.

I would like to ask Dr Burian why he includes in his series the postoperative esotropias. I would note that the only patient in his group who measured more than 15 diopters was a large angle consecutive exodeviation. This single case, measuring 40 diopters, significantly affects his statistics.

DR BURIAN. We are fully aware of the importance of what should be and has been called in this discussion "interest target," because the accommodation at one mile or even at 100 feet is clearly not very active. However, our setup was such that we didn't have the possibility of using such a target. And so, since we were dealing with a comparative measurement, we considered that it was better to have the same type of fixation target for the 100 feet, the 20 feet and the near measurements, in order to have comparable stimulus situations.

Dr Knapp brought out a very interesting item – the matter of luminance. This is a new item in the examination of the patients, particularly in patients with exodeviations, and we are looking forward with anticipation to the results that he and Miss Moore will obtain in the study they are making. Actually, in our study the tests were taken within minutes of each other, or essentially at the same time, and therefore the luminance reaching the eyes was the same.

Lastly, Dr Knapp objects to the term "consecutive exotropia." I like it, and this is purely a personal prejudice. It seems to me there has been an understanding among us that when we say "consecutive exotropia" we mean a postoperative exotropia following an original esotropia, whereas a "postoperative exotropia" would be one which persisted after an operation for exotropia.

I do not claim that "consecutive exotropia" is a particularly good expression. Dr Knapp's criticism points up the fact that at least those of us who are interested in problems of ocular motility and neuromuscular anomalies of the eyes should get together, and by compromise or by discussion establish a clear and, we hope, generally acceptable terminology for the various conditions.

Why did we measure patients with consecutive exotropias? True, theoretically one would not expect them to have an increase in deviation for distance. Nevertheless they are patients with an exodeviation, and it appeared to be of interest to see whether such patients, who are not basically exotropic by nature, differ in their response from other patients.