Results of fusional vergence therapy in managing consecutive esotropia: A case series

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Purpose: To analyze the efficacy of fusional vergence therapy (FVT) in management of consecutive esotropia with diplopia after intermittent exotropia (IXT) surgery. The current study is carried on how FVT affects the duration of treatment, sensory fusion, and exotropic drift. Methods: This was a retrospective study for the medical record of 11 patients with consecutive esotropia after IXT surgery of 543 patients over the period of 5 years, with mean surgery age of 9.5 (range: 4–33 y). FVT was planned after minimum 6 weeks of surgery and was considered for maximum 24 weeks. Patients underwent a combination of office-based and home-based FVT. Successful outcome of therapy was considered where diplopia resolves in free space and achieves sensory fusion, stereopsis with no manifest deviation. Results: Record of 543 patients who had horizontal muscle surgery for IXT were identified and reviewed. Records of 11 patients who showed consecutive esotropia of 10 prism dipter (PD) or more with normal retinal correspondence, with or without diplopia complaint, after 6 week of surgery and had undergone vision therapy management were reviewed. A successful outcome of binocular single vision with good sensory and motor fusion with no manifest deviation or prism requirement was achieved with in the mean duration of 4.8 month of therapy. With a mean duration of 4 weeks of therapy, the mean angle of deviation reduced by 53% for distance (17 PD to 8 PD) and 27% for near (11 PD to 8 PD) and mean stereopsis improvement by 80% with 94% patients demonstrating sensory fusion on Bagolini test and 94% of patients having no symptoms of diplopia or squint. Conclusion: With nonsurgical management involving refractive error correction, FVT, and prism, consecutive esotropia was resolved in 74% cases. Management of consecutive esotropia with FVT can result in satisfactory sensory fusion and successful motor alignment.

Key words: Binocular vision therapy, consecutive esotropia, fusional vergence therapy, intermittent exotropia, motor fusion, sensory fusion

Intercostal exotropia (IXT) is the second most common type of strabismus worldwide and perhaps the most common type in Asian countries. Studies from Asia have shown it to be the most common indication for strabismus surgery in children. It is observed that there is a gradual postoperative exo-drift leading to recurrence of exotropia in 40–70% of patients.[1] On the other hand, studies support that the consecutive esotropia (ET) is a desirable outcome of IXT surgery to prevent the exo-drift[2,4]. and the incidence of consecutive ET has been reported variably from 6 to 20%.[2,4] However, if consecutive esotropia is not improving within 6 month of conservative management, a second surgery is recommended, but the outcome of second surgical treatment for consecutive ET is reported to be variable because of unpredictable long-term results.[4] Further importantly, persistent consecutive esotropia for long term is not essentially positive, as it may lead to a cosmetic problem and binocular vision dysfunction like diplopia, suppression, or amblyopia.[2,4] To the best of our knowledge, there are few reports in the literature where both motor and sensory aspects of the strabismus have been highlighted as important to be addressed.[5,6] Surgery only the approach is based on an assumption that sensory anomalies will disappear and a normal sensory processing will come up spontaneously and passively. Bressler found such spontaneous change to occur in only 8% of patients.[7] Burian stated that the ophthalmologist has a powerful tool (surgery) for permanent correction, but the role of orthoptist in establishing the achieved surgical gains by vision therapy exercises is necessary to optimize the results. Berens et al. stated that the vision therapy in conjunction with surgery improves the postsurgical outcome by almost 300%.[5,8] However, the usefulness of vision therapy in patients with consecutive ET with extended follow-up has not been reported. This case series investigated the long-term results of vision therapy in managing consecutive esotropia, which persisted for more than 6 weeks after a bilateral lateral rectus recession for

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We, therefore, retrospectively have studied the results of patients who were referred to our binocular vision therapy clinic with or without the subjective complaint of diplopia. Specific parameters examined included the angle of deviation, subjective complaint of diplopia, sensory fusion, fusional vergence, and patient complaint about squint. We have also designed the perspective of study to see if the fusional vergence therapy (FVT) at or under the supervision of binocular vision therapy clinic can help in modifying the management plan of consecutive esotropia and prevent the recurrence of exotropia in these patients.

The case series study followed the medical protocol requirements of Institutional Review Board of organization. The record of 543 patients who had the horizontal muscle surgery for IXT were identified and reviewed. Records of 11 patients who showed consecutive ET of 10 prism diopter (PD) for distance or near or both with normal retinal correspondence, with or without diplopia complaint, after 6 week of surgery and had undergone the vision therapy management at our binocular vision therapy clinic were reviewed. A case analysis of all the 11 consecutive ET patients who underwent the FVT at or under the supervision of vision therapy clinic was done. The data collected by reviewing the medical records included, the patient’s age at surgery, duration after surgery to start the therapy, gender, visual acuity, refractive errors, presence of amblyopia or anisometropia, preoperative and postoperative measurements of near and distance deviation, type of surgery, results of stereopsis (titmus stereo-acuity test), sensory fusion test for distance and near (Bagolini striated glass test), prism vergence, and subjective complaints of strabismus or diplopia by the patient. Subjects with possible confiding factors in the development of sensory fusion like lateral incomitancy, near distance disparity, amblyopic, anisometropic, noncooperative for therapies, or neurological disorders were noted.

**Methods**

A comprehensive ophthalmic examination including the detailed oculomotor and sensory assessment was performed in every patient. The examination included strabismus measurement by prism-cover test and Refraction. Sensory functions were evaluated by using the Titmus stereo acuity test, Bagolini striated glass and Worth Four dot test. The range of fusional vergence was assessed with Prism bar. The presence of amblyopia was defined as difference of two or more lines in best-corrected visual acuity (BCVA) of each eye on Log Mar chart.

According to the Institutional Protocol of our binocular vision therapy clinic, subjects with consecutive esotropia and requiring FVT were referred after minimum 6 week of surgery. [Fig. 1]

**Management:** Based on their diagnostic profile, our patients have undergone the following course of treatment at binocular vision therapy clinic:

1. Ensuring the best correction of refractive error.
2. If required than Prism or Bifocal is planned to reduce the magnitude of the deviation for facilitating and establishing the sensory-motor fusion.
3. After establishing normal sensory-motor fusion, a combination of office-based therapy (OBT) and home-based
therapy (HBT) is done with an objective to encourage motor fusion and gradually taper-off the bifocal or prisms if prescribed.

4. In OBT, subjects does any of the 3 and in HBT any of the two exercises from the list given in Table 1.

For OBT, any of the three equipment from Brockstring, Prism bar, Synoptophore, Vectogram, Aperture rule, or Fusional circle card were used. Exercise choice was dependent on the subject’s cooperation and understanding about the process. Those who were not cooperative in understanding about the concept of physiological diplopia on Brockstring were preferred for exercises on Synoptophore and Prism Bar, where examiner can objectively assess the ability to fuse and point of fusion break. Those who could understand and appreciate the physiological diplopia, Brockstring was one of the preferred because of its suppleness to allow the fusion at variable distances and in free space. Base-out Prism was incorporated in the regular spectacles, and Bifocal glass was used for the cases that required initial support to facilitate the fusion and was gradually tapered off as the fusion control developed without prism.

At each follow-up, the data recorded was BCVA, refractive error, and magnitude of consecutive esodeviation for distance and near. Deviation was graded as <10 PD, 10–20 PD, and >20 PD. Sensory evaluation was done with Worth four dot test and/or Bagolini’s glasses, near stereopsis with Titmus stereo-acuity test. Near stereo acuity was graded as good (40–60 arcsec), moderate (80–200 arcsec), poor (>200 arcsec), and absent (no stereopsis). Motor fusion was assessed with prism vergence.

**Results**

Based on the patients recorded progress, the successful outcome of therapy was considered where diplopia resolves in free space and achieves sensory fusion & stereopsis and prism fusional vergence with no manifest deviation within 24 week of therapy. The period required to achieve the successful outcome was analyzed separately for 6–12 Week, 12–24 week, and more than 24 week. Factors like whether the patient did both OBT and HBT or only did HBT were also analyzed to see the influence

| Table 1: Fusional vergence exercises done by the subjects in the study |
|---------------------------------------------------------------|
| **Office-based therapy (OBT) and/or home-based therapy (HBT)** |
| Equipment used for fusional vergence exercises |
| Office-based therapy (OBT): Included any three of the given exercises and home-based therapy (HBT): included any two of the given exercises |
| Synoptophore, Prism bar, Vectogram, Aperture rule, Brockstring, Fusion circle card |

| Table 2: Patient characteristics and pretherapy oculomotor and sensory status |
|---------------------------------------------------------------|
| **Age at surgery (Years)** | Inward deviation with diplopia (PBCT) distance | Consecutive ET (PBCT) distance | Consecutive ET (PBCT) near | Value | Unxed | Unxed |
|-------------------------|--------------------------------------|-----------------------------|-----------------------------|-------|-------|-------|
| 4/F                     | √                                    | 20                          | 20                          | 100   | √     | √     |
| 13/F                    | √                                    | 20                          | 12                          | 400   | √     | √     |
| 5/F                     | √                                    | 8                           | 20                          | 100   | √     | √     |
| 4/F                     | √                                    | 3                           | 14                          | 200   | √     | √     |
| 8/M                     | √                                    | 30                          | 25                          | 200   | √     | √     |
| 12/F                    | √                                    | 15                          | 10                          | 110   | √     | √     |
| 6/M                     | √                                    | 14                          | 12                          | 200   | √     | √     |
| 6/F                     | √                                    | 25                          | 16                          | 50    | √     | √     |
| 12/F                    | √                                    | 25                          | 10                          | 140   | √     | √     |
| 9/F                     | √                                    | 30                          | 16                          | 50    | √     | √     |
| 7/F                     | √                                    | 18                          | 6                           | 50    | √     | √     |

PD – Prism Diopters, D – Distance, N – Near, PBCT – Prism bar cover test, BSV – Binocular single vision, Sx – Surgery, Tt – Treatment, ET – Esotropia, Ex – Exercise, FBVT – Fusional vergence therapy, B – Break, R – Recovery. Patients who persisted with consecutive esotropia with diplopia after 6 week of surgery have been included for this analysis.
of type of therapy. Records of eleven patients who persisted with consecutive esotropia after six weeks of post-operative follow-up were reviewed and analyzed [Table 2]. Before FVT, all the 11 patients had the complaint of inward deviation with uncrossed diplopia and deviation measuring more than 10 PD for either distance or near or both [Table 2]. There were no patient with inward deviation without diplopia or outward deviation.

Along with refractive correction cases, C2, C3, and C8 required prisms and C3 and C4 bifocal lens to reduce the magnitude of the deviation to facilitate establishing the sensory-motor fusion. After establishing normal sensory-motor fusion, a combination of OBT and HBT was done with the objective to encourage motor fusion and gradually taper-off the bifocal or prisms if prescribed [Table 3].

The successful outcome of binocular single vision (BSV) with good sensory and motor fusion with no manifest deviation or prism requirement were recorded after fusional vergence exercises. Within 6 month of FVT, inward deviation with diplopia has significantly improved in all patients. Cases number C1, C2, C4, C6, C7, C9, C10, and C11 improved the deviation measurements to within 10 PD for both distance and near. Other three cases C3, C5, and C8 also showed significant reduction in deviations and was within 10–18 PD. In all three cases, the deviation was either phoria or intermittent with no diplopia in free space and was maintaining good sensory status. Prism and bifocal got discontinued for all four patients within 6 month of therapy [Table 4].

In all cases improvement of prism fusional vergence recorded after the completion of therapy and till the last mean follow-up visit (58 months), all patients maintained BSV and 40 sec of arc stereopsis and none of the patient showed drifting for exotropia on long-term follow-up. [Table 5 and Fig. 2].

**Discussion**

The main goals of BVT for the treatment of consecutive esotropia were to promote sensory and motor fusion by eliminating diplopia or suppression and to improve verge reserves in order to restore normal binocular vision; a combination of OBT and HBT is recommended.\(^{[2]}\) Any significant refractive

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**Table 3: Duration of therapy done and follow-up status**

| Duration b/w Sx and BBVT started (Month) | Fusional vergence | Fusional vergence | Fusional vergence | Therapy period to achieve targeted outcome | Duration of FU after surgery (Month) |
|------------------------------------------|-------------------|-------------------|-------------------|------------------------------------------|-------------------------------------|
|                                          | Ex at clinic      | Ex at home        | maintenance       |                                           |                                     |
| 7.7                                      | 10                | 30                | 90                | 4.2                                      | 55                                  |
| 12                                       | 35                | 90                | 30                | Prism                                    | 4.7                                  | 58                                  |
| 5.4                                      | 10                | 540               | 180               | Prism/Bifocal                            | 23                                  | 13                                  |
| 46                                       | 40                | 0                 | 30                | Bifocal                                  | 5.4                                  | 22                                  |
| 2.3                                      | 20                | 21                | 30                |                                         | 2.7                                  | 12                                  |
| 4.1                                      | 10                | 0                 | 0                 |                                         | 1                                    | 5.7                                  |
| 20                                       | 20                | 180               | 90                | Contact lens                             | 9.4                                  | 7                                   |
| 3                                        | 20                | 90                | 60                | Prism                                    | 4                                    | 8                                   |
| 1.8                                      | 20                | 0                 | 30                |                                         | 0.9                                  | 4                                   |
| 1.6                                      | 20                | 283               | 52                |                                         | 11                                  | 4                                   |
| 3.1                                      | 10                | 0                 | 0                 |                                         | 1.2                                  | 2                                   |

D – Day, M – Month, n – Number, BSV – Binocular single vision, Sx – Surgery, Tt – Treatment, Ex – Exercise, FBVT – fusional vergence therapy. *Patients who persisted with consecutive esotropia with diplopia after 6 week of surgery have been included for this analysis

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**Table 4: Patient posttherapy oculomotor and sensory outcome**

| Age at surgery (Years) | No inward deviation or diplopia | Consecutive ET (PBCT) distance | Consecutive ET (PBCT) near | Value | Sensory fusion (Bagolini) near | Sensory fusion (Bagolini) distance |
|------------------------|---------------------------------|-------------------------------|---------------------------|-------|------------------------------|---------------------------------|
| 4/F                    | √                               | 10                            | 10                        | 100   | √                            | √                               |
| 13/F                   | ✓                               | 6                             | 6                         | 60    | ✓                            | ✓                               |
| 5/F                    | √                               | 10                            | 18                        | 40    | √                            | ✓                               |
| 4/F                    | √                               | 8                             | 6                         | 100   | √                            | ✓                               |
| 8/M                    | √                               | 0                             | 14                        | 40    | ✓                            | ✓                               |
| 12/F                   | √                               | 0                             | 6                         | 40    | √                            | ✓                               |
| 6/M                    | √                               | 0                             | 2                         | 100   | √                            | ✓                               |
| 6/F                    | √                               | 12                            | 8                         | 40    | √                            | ✓                               |
| 12/F                   | √                               | 10                            | 4                         | 40    | √                            | ✓                               |
| 9/F                    | √                               | 10                            | 6                         | 40    | √                            | ✓                               |
| 7/F                    | √                               | 6                             | 10                        | 50    | √                            | √                               |
Table 5: Posttherapy prism fusional vergence

| Variables | Prism vergence (B/R) near | Prism vergence (B/R) distance |
|-----------|---------------------------|-------------------------------|
|           | Base-out | Base-in | Base-out | Base-in |
| Pretherapy |          |         |          |         |
|           | 0        | 0       | 0        | 0       |
|           | 0        | 0       | 0        | 0       |
|           | 0        | 0       | 0        | 0       |
|           | 0        | 0       | 0        | 0       |
|           | 10/8     | 4/2     | 18/16    | 2/0     |
|           | 0        | 0       | 0        | 0       |
|           | 0        | 0       | 0        | 0       |
|           | 0        | 0       | 0        | 0       |
|           | 0        | 0       | 0        | 0       |
|           | 0        | 0       | 0        | 0       |
|           | 0        | 0       | 0        | 0       |
|           | 0        | 0       | 0        | 0       |
| Posttherapy | 25/20   | 8/6     | 16/14    | 6/4     |
|           | 25/20   | 18/16   | 20/18    | 10/8    |
|           | 8/6     | 4/2     | 6/4      | 4/2     |
|           | 8/6     | 8/6     | 4/2      | 4/2     |
|           | 30/25   | 8/2     | 16/14    | 6/4     |
|           | 35/30   | 6/4     | 30/25    | 6/4     |
|           | 16/14   | 6/4     | 4/2      | 6/4     |
|           | 25/20   | 4/2     | 14/12    | 4/2     |
|           | 14/12   | 10/8    | 10/8     | 8/6     |
|           | 6/4     | 4/2     | 6/4      | 4/2     |
|           | 6/4     | 2/1     | 6/4      | 2/1     |

error should be corrected, and amblyopia (although rare) if present should be treated. Actual therapy can then follow, first to equalize monocular skills (i.e., accommodation and eye movements) then therapy is focused on vergence skills by improving fusional vergence ability and vergence facility. Although IXT recurs frequently after surgery, initial overcorrection after surgery for exodeviation can persist. Small angle of initial postoperative esodeviation after exotropia surgery usually recovers to orthophoria within 2 weeks, so it can be observed without any treatments. However, consecutive esotropia can persist without improvement of deviation over time. When consecutive esotropia persists, it can cause suppression and amblyopia in children or diplopia in adults. Reduced stereo acuity and amblyopia under 4–6 years of age, with consecutive esotropia, was reported. The incidence of consecutive esotropia after IXT surgery has been reported to be 6–20%. In our case series, consecutive esotropia reported at our vision therapy clinic as 11 (2.03%) of the 543 patients may appear to be lower to that of other reported studies. This low rate may be due to patients of consecutive esotropia with diplopia were particularly referred to the vision therapy clinic and the patients without diplopia may have continued under observation at strabismic clinic to the plan for second step surgery.

Kim et al. analyzed long-term outcome of patients with large overcorrection following surgery for exotropia and concluded that initial overcorrection of more than 20 PD had been reduced to 10 PD or less at distance and near within 4 weeks postoperatively in most patients. In our review, we included the patients whose consecutive esotropia persisted of 10 PD or more PD after minimum 6 weeks or more of surgery because an early angle of postoperative esotropia could decrease even if the initial angle was large.

There are still controversies about age at surgery as a risk factor for consecutive esotropia. According to Keech and Stewart, greater mean age was noted as a risk factor (P less than 0.02). However, early age at exotropia surgery, as a risk factor for consecutive esotropia, has been reported by several authors. Pratt–Johnson et al. found that consecutive esotropia occurred more frequently in patients who had undergone exotropia surgery prior to age 4 years.

However, in the cases that we reviewed at our binocular vision therapy clinic included the patients from more than equal to 4 years of age.

As nonsurgical options for management of consecutive esotropia, full correction of hyperopia, base-out prism therapy can be applied to reduce overcorrection and maintain fusion. Hardesty et al. reported that consecutive esotropia of less than 15 PD can be cured with prism therapy alone. In our review, the successful outcome of BSV with good sensory and motor fusion and no manifest deviation or prism requirement was achieved within 6 month in majority of cases. Only patients C7 and C10 required the therapy till 9.4 and 11 month, respectively, and C3 could be completely weaned-off from the prism and achieved the desired outcome after 23 month of therapy.

In our study, the success with binocular vision therapy was achieved in 11 consecutive esotropia patients. Three patients attained orthotropia for near and distance both and seven patient had deviation less than 10 PD with mean stereopsis of 40 sec of arc with Titmus fly test. Till the last mean follow-up visit (58 months), all patients maintained BSV and 40 sec of arc stereopsis and none of the patient showed drifting for exotropia on long-term follow-up.

Conclusion

In conclusion, with nonsurgical management involving refractive error correction, FVT and prism can better help to achieve the stereopsis, sensory and motor fusion thus further reducing the chance of exotropia recurrence on long-term follow-up.

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Conflicts of interest
There are no conflicts of interest.

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