CASE REPORT

SURGICAL OUTCOME OF MUSCLE TRANSPLANTATION AS A MONOCULAR SURGERY FOR LARGE ANGLE STRABISMUS

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ABSTRACT

Introduction: *The management of large-angle strabismus can be difficult for surgeons, and successful outcomes may require multiple surgeries. However, modern surgical techniques aim to achieve desired results with a single operation. Muscle transplantation is one such technique that increases the effective muscle length, allowing for a large correction in a one-stage surgery.*

Objective: *To report the outcome of muscle transplantation surgery in large-angle strabismus.*

Case Illustration: *Three patients presented with large-angle strabismus, of which two cases showed >50Δ ET and one case had >50ΔXT. All patients had normal anterior and posterior segment findings and underwent muscle transplantation under general anaesthesia. The first and second cases showed good alignment post-surgery, with no limitations in ocular motility in all gaze directions and improved visual acuity. However, none of the cases achieved stereoscopic vision due to chronic strabismus. In the third case, improvement in the primary position was observed two weeks post-operative, but ocular motility still had limitations.*

Conclusion: *Muscle transplantation is a good option to correct large-angle strabismus, specifically in the unilateral case in a single procedure.*

Keywords: *rectus muscle transplantation, large-angle strabismus, monocular surgery*

INTRODUCTION

The definition of large-angle strabismus varies in different references, but some studies use a threshold of 40 to 60 prism diopter (ΔD) in the primary position to define large-angle strabismus. Managing large-angle strabismus is quite challenging,[1,2] and several techniques are available for its treatment, such as hang-back, three muscle in one-stage surgery, bilateral medial recession, botox-augmentation injection with recession-resection, supramaximal recession-resection, and muscle transplantation. However, the best surgical approach for large-angle strabismus remains in the grey area due to the lack of controlled clinical trials.[1,3]

Supramaximal recession-resection is the preferred surgical procedure for large-angle strabismus. The current surgical dosage table shows that two muscle surgery can effectively treat deviations of up to 50Δ. However, for deviations is ≥ 50$^{\Delta}$, a second intervention for the other eye is required to achieve a successful outcome.[4,5,6]

Nowadays, surgeons attempt to correct a higher degree of deviation with a single surgery. This logical concept reduces the operating time, cost, and patient inconveniences while preserving the other eye for future surgery and lowering the risk of complications. [4,6,7]

An alternative surgical procedure for large-angle strabismus is muscle transplantation. In this procedure, the resected muscle segment is sutured to the recessed muscle's disinserted end, thereby increasing the effective muscle length available for recession. In unilateral cases, it enables a significant surgical correction, using only two recti muscles. Muscle transplantation can provide stable results over the long term and can be performed in a single-stage surgery.[7,8]

CASE ILLUSTRATION

Surgical Procedure

The surgical procedure for treating esotropia involved performing Intraoperative forced duction and force generation tests. A medial conjunctival periotomy was then performed, and the medial rectus (MR) muscle was cleaned from the tenon that wraps it and fixed with a non-absorbable nylon-suture 6.0. Afterwards, an incision was made on the lateral conjunctival to isolate the lateral rectus (LR) muscle. A double-arm 6-0 absorbable suture was passed through its insertion, followed by a non-absorbable nylon 6.0 suture passed at 9 mm from insertion. The muscle was cut and transplanted to the medial rectus, then sutured with a 6.0 non-absorbable suture, and attached to the sclera at a distance of 7 mm from its original insertion using absorbable nylon 6.0. Furthermore, the LR was attached to its original insertion site on the sclera using nylon 6.0. The conjunctiva was sutured with Vicryl 8.0. (**Figure 1**) and the patient was given antibiotic eye drops and the eye bandaged. The same procedure was followed for exotropia cases, except that the MR muscle was transplanted to the LR and performed under general anaesthesia.

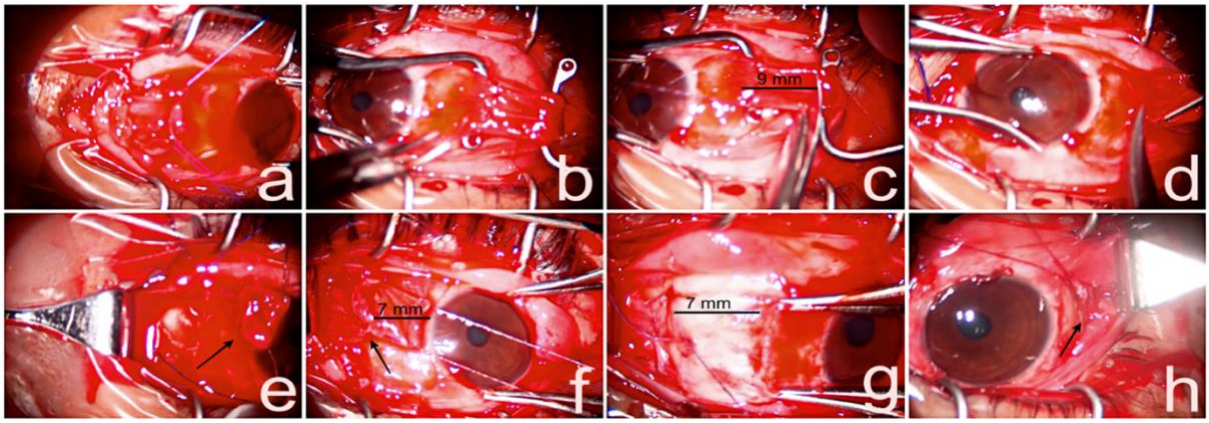

Figure 1. Intraoperative steps in left esotropia patient. (a) MR was fixed with 6.0 nylon non-absorbable; (b) LR hooked, and double arm suture was performed using nylon 6.0 suture; (c) The LR was cut 9 mm from its insertion; (d) the graft cut at its insertion; (e) the graft (7mm); (f) the 7-mm LR graft transplanted to the medial rectus; (g) the MR was attached to sclera at 7 mm from its original insertion using nylon 6.0; (h) the LR attached to its original insertion.

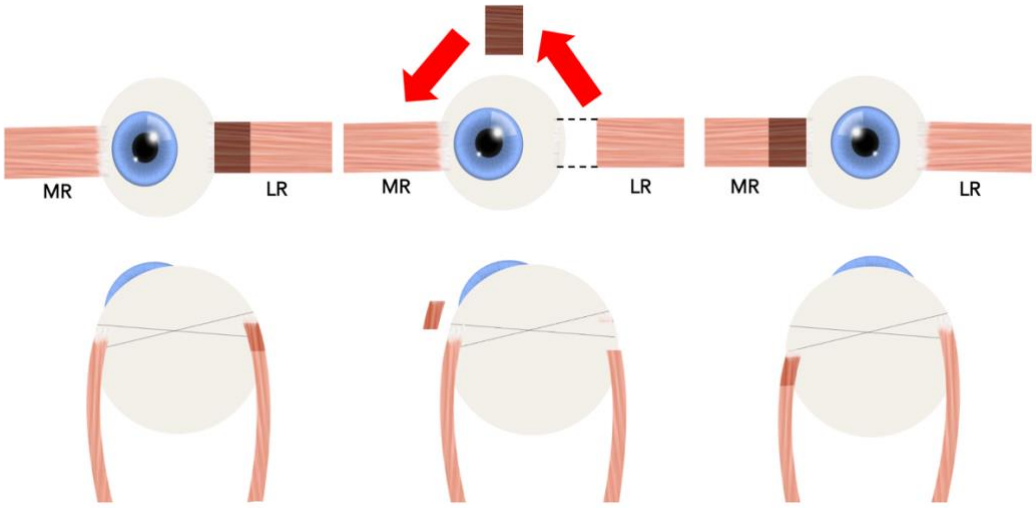

Figure 2. The schematic representation for muscle transplantation in esotropia patient. (A1, A2) Frontal view and transverse sections showing intact LR segment to be resected illustrated using a darker shade. (B1, B2) Frontal and transverse views following LR resection showing resected segment. (C1, C2) Frontal and transverse sections showing the resected LR segment transplanted to the MR and sutured behind its insertion, meanwhile the LR was sutured at its insertion

Case 1

The individual in question is a female aged 24 who has suffered from an inward deviation of the left eye since she was four. Upon ophthalmological examination, the BCVA for the RE and LE were 20/20 and 1/60, respectively.

The Hirschberg test revealed a 45º LET, while the Krimsky test revealed a 90Δ base outward deviation of the same eye. Ocular motility was normal in all directions of gaze. The Worth Four Dot Test (WFDT) revealed suppression in the left eye. The examination of both eyes' anterior and posterior segments showed no abnormalities.

The patient was diagnosed with comitant esotropia and strabismic amblyopia. The treatment plan involves performing a MR recession procedure with muscle transplantation and LR resection.

Two weeks after the surgery, the Hirschberg test indicated that the inward deviation of the eye had reduced to 10º. However, the residual esotropia measured about 10-12ΔD BO. Ocular motility was normal in all directions of gaze.

Figure 3. Case 1 (A) pre-operative; (B) 2 weeks post operative; (C) 9 months post-operative

After nine months following the surgery, the patient had no complaints and was satisfied with the cosmetic outcome and became orthotropic. Additionally, the BCVA improved for LE to 20/250 after the surgery. The Hirschberg test was 0o, APCT at 30 cm and 6 m were 50-55ΔD BO and 50ΔD, respectively. Finally, ocular motility was normal in all directions of gaze. (Figures 3 and 4).

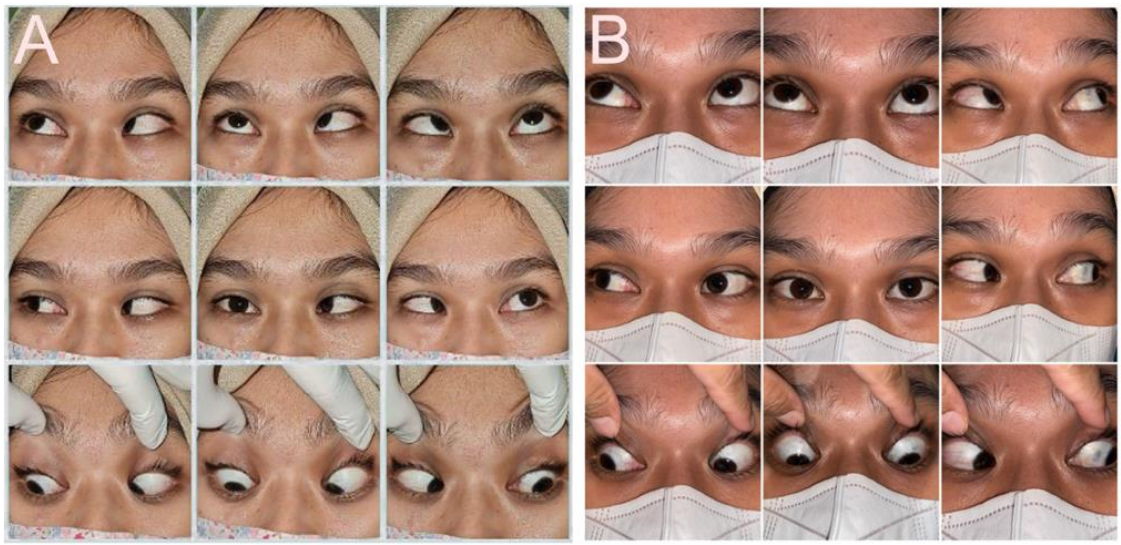

Figure 4. (A) Case 1 showed limited movement of the left eye pre-operative; (B) 9 months post-operative showed no limitation in all gazes.

Case 2

The patient in question is a 39-year-old female who has been suffering from an inward deviation of the right eye since the age of seven. An ophthalmological examination revealed BCVA was 20/20 for both eyes. The Hirschberg test was 45^{o} LXT, while the cover test showed alternate exotropia. APCT was taken at both 30 cm and 6 m, showed 80Δ Base in and 65Δ Base in, respectively. Ocular motility was normal in all directions of gaze.

Worth Four Dot Test (WFDT) revealed there was suppression in the RE, while the examination of both eyes' anterior and posterior segments did not show any abnormalities. Following the evaluation, the patient was diagnosed with alternate exotropia + A pattern strabismus and planned to undergo LR recession + inferoplacement with muscle transplantation and MR Resection + superoplacement.

A week after the surgery, the Hirschberg test showed that the LXT was 10^{o}. However, ocular motility was found to be normal in all directions of gaze.

The patient reported no complaints one-month post-surgery, and the Hirschberg test showed 15^{o} LXT. The APCT measurements taken at 30 cm and 6 m revealed 30Δ Base in and 20Δ Base in, respectively. Ocular motility was normal in all directions of gaze (**Figures 5 and 6)**.

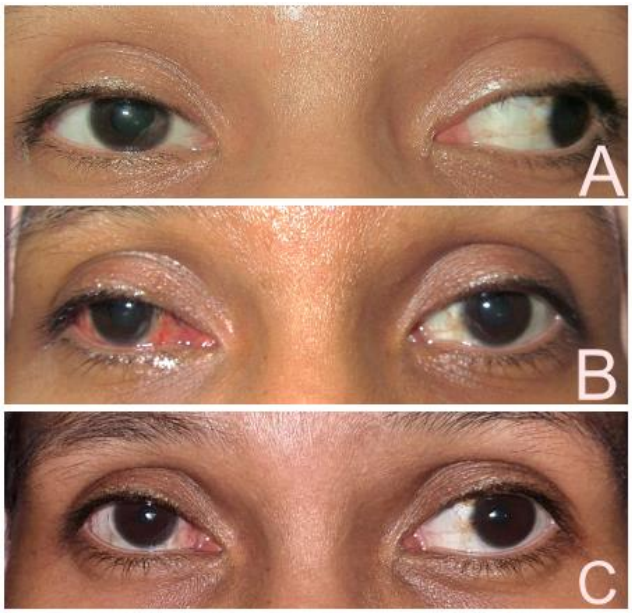

Figure 5. (A) pre-operative; (B) 1 week post operative; (C) 1-month post-operative

Figure 6. (A) Case 2 showed limited movement in version of the left eye pre-operative; (B) A months post-operative showed no limitation in all gazes.

Case 3

A-15-year-old female who has been experiencing inward deviation of the right eye since birth, and the symptoms are occasionally felt in the other eye, as well. Upon ophthalmological examination the BCVA was 20/20 for both eyes. The Hirschberg test showed >45^{o} RET, APCT measurements taken at both 30 cm and 6 m were more than 95Δ Base out and 90Δ Base out, respectively. Ocular motility showed no limitation in all gaze directions. The WFDT revealed suppression in the right eye. Finally, there were no abnormalities detected in the anterior and posterior segments of both eyes.

The patient was diagnosed with bilateral congenital esotropia. It has been decided that the patient will undergo MR recession + muscle transplantation and LR Resection for the RE. Two weeks following their surgery, the patient presented with a complaint of diplopia. The Hirschberg test was within 15-20^{o} RET. APCT measurement taken at 30 and 6 m were 45 PD, and 50 PD base out, respectively. Ocular motility examination showed limitation in both eyes while performing the lateral gaze. (**Figures 7)**. Six month post operative showed Hirschberg test showed 30^{o} RET. The APCT at 30 cm and 6 m revealed 50Δ Base in and 45Δ Base in, respectively. Ocular motility was normal in all directions of gaze. The patient has an upcoming appointment scheduled for second surgery.

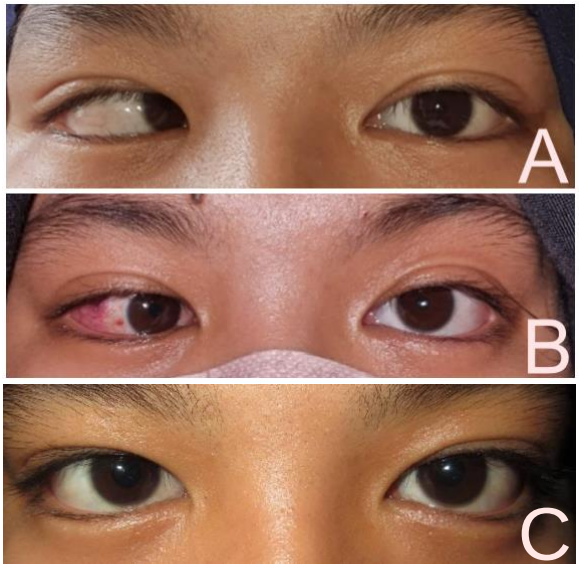

Figure 7. Case 3 (A) pre-operative; (B) 2 weeks post-operative; (C) 6 months post-operative

DISCUSSION

Strabismus is a medical condition that can result in permanent visual impairment and a range of complications such as amblyopia, reduced stereopsis, asthenopia, diplopia, nystagmus, abnormal head, and neck posture, as well as impaired social and mental growth.[9] It has been observed that in patients with chronic strabismus, surgery is often perceived to be purely cosmetic in nature as a result of the psychosocial and economic benefits from the restoration of ocular alignment. Several studies have proven that unexpected sensory fusion can occur in patients who have undergone successful postoperative motor alignment for their strabismus. [(10)] However, in this case series presented, all patients had chronic and large-angle strabismus, which led to a primary concern for the cosmetic aspect of the surgery.

Different techniques are available to manage large-angle strabismus, including muscle transplantation, hang-back recession, or muscle elongation. Meanwhile, muscle transplantation was initially described by Diamond and Hiatt, though it has not gained widespread popularity. In the past, attempts were made to transplant synthetic materials such as silicone bands or autologous antecubital veins, through animal experiments. However, the use of synthetic materials was found to increase the risk of extrusion and inflammation leading to the adoption of autogenous homografts, such as contralateral muscle grafts.

Histological studies showed that transplanted muscle remained viable but lost its contractile property during the healing process following ocular muscle surgery.[11] A large case series involving 22 patients with esotropia, reviewed by Jethani et al. showed that ocular alignment following transplantation remained stable over a period of two years. Amitava et al.

successfully performed ocular alignment in three case series of individuals suffering from esotropia.[8]

In a case series of seven patients with large-angle exotropia, Sonali et al. reported satisfactory long-term stable results.[3] Tawfik et al. compare the outcomes of hang-back recession versus muscle transplantation in patients with large-angle esotropia and found muscle transplantation to be superior due to two major problems first, the muscle may creep forward with such a large recession on hang-back, second the restriction in ocular motility.

In contrast, muscle transplantation, has minimal motility restriction and no chance of rejection of the transplanted muscle.[7] Muscle elongation techniques such as marginal myotomies or adding silicone bands or nonabsorbable sutures have been successful in some cases, the major problem is that the expanded material may be sutured to the globe for insertion thereby resulting in disastrous extrusion. True muscle transplantation is a promising stable technique for managing large-angle strabismus.[12]

The success of strabismus surgery depends on several clinical factors, including visual acuity, preoperative deviation angle, axial length, refractive error, age of onset, age at surgery, surgical technique, surgical amount, stereopsis, and fusion.[13] The success rate is defined by multiple factors such as orthophoria or angle near close to 0°, binocular vision or stereopsis, elimination of diplopia, and patient satisfaction.[14]

The BCVA was unexpectedly improved in the first case for the LE from 1/60 to 20/250. However, due to the presence of amblyopia resulting from chronic strabismus, there are no alternative therapies available.[15] It is suspected that the improvement in BCVA is due to the alignment of the eye, following strabismus surgery. The result of the Worth Four Dot Test (WFDT) indicated that there was no improvement in stereo acuity or binocularity in all cases. This finding is consistent with a previous study, which suggests that achieving stereopsis function is more likely assuming strabismus surgery is performed during the first ten years of life. However, assuming binocularity is impaired during this age, the process of stereopsis maturation may be damaged, and this impairment cannot be completely reversible with treatment. Despite this, according to Chavasse's theory, correcting the alignment of the eyeballs can improve binocular vision function.[16] In a study by Mets MB, it was found that surgical correction of strabismus in adults led to improvement in binocular function as seen in 42% of the patients. Another study by Garabaghi D & Azadeh M, reported that some degree of stereopsis could be achieved in most cases, even after delayed alignment of eyes in patients with infantile or early childhood strabismus.[13]

The first and second cases showed no limitations in all gaze directions, which is consistent with a previous study. It was found that muscle transplantation effectively increases the muscle length without losing contractility.[12]

Meanwhile, in the third case, there is still a limitation in lateral gaze in both eyes, which may be due to the short follow-up period, the large preoperative angle, and the muscle laxity. In terms of postoperative angles, the first case achieved orthotropic, while the second and third cases showed 15XT and 30ET in the Hirschberg examination. Several studies have reported successful outcomes, with mean postoperative angles ranging from 12.3±9.9 ΔD[12], 10.8±7.683 ΔD.[7]

It was suggested that the procedure performed on the patients was for cosmetic purposes. The first patient expressed satisfaction with the outcome of the procedure after nine months post-surgery, while the second and third patients are still being monitored for their progress.

CONCLUSION

Muscle Transplantation is a suitable treatment option for unilateral large-angle strabismus, as it can result in satisfactory alignment and ocular motility. Additionally, this procedure offers a lower risk of scleral perforation, and shorter operating time, as it only requires a single-stage surgery. Moreover, it may provide long-term results. However, in bilateral/alternate cases and very large angle muscle transplantation may be considered but the result may be varied.

CONFLICT OF INTEREST

The author(s) declare(s) that there is no conflict of interest regarding the publication of this article

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REFERENCES

1. Nabie R. Three horizontal muscle surgery for large-angle esotropia: success rate and dose-effect ratio. Int J Ophthalmol. 2020 Apr 18;13(4):632–6.
2. Asafali F, Rajamani M, Periannan C, Michael S, Dandapani R. Concerns in the management of large-angle horizontal strabismus. TNOA J Ophthalmic Sci Res. 2020;58(3):186.
3. Rao S, Gupta A. True muscle transplantation surgery for large angle exotropia: A case series. Indian J Ophthalmol - Case Rep. 2021;1(3):577.
4. Satish Thomas & Sujata Guha (2010) Large-Angle Strabismus: Can a Single Surgical Procedure Achieve a Successful Outcome?, strabismus, 18:4, 129-136.

5. Shafik HM, Eldesouky MA, Tadross D. Lateral rectus muscle tendon elongation by an autograft from the resected medial rectus muscle as a monocular surgery for large-angle sensory exotropia. Clinical Ophthalmology 2020; 14 : 2135-42.
6. Ameri A, Akbari MR, Keshtkar Jaafari AR, et al. Medial rectus muscle elongation, a technique to treat very large angle esotropia. Graefes Arch Clin Exp Ophthalmol. 2015;253(7):1005–1011.
7. Tawfik AM, Ahmed MM, El Sayed SM. Single eye surgery by hang-back recession vs muscle transplantation in large-angle esotropia. Sci J Al-Azhar Med Fac Girls 2020;4:507-12.
8. Ganesh SC, Rao SG, Aziz AA, Narendran K. Bilateral true muscle transplantation for correction of very large angle exotropia. European Journal of Ophthalmology. October 2020.
9. Kanukollu VM, Sood G. Strabismus. In : Statpearls [Internet]. 2021 August 11. [cited 2021 december 25]. access from : https://www.ncbi.nlm.nih.gov/books/NBK560782/
10. Edelman PM. Functional Benefits of Adult Strabismus Surgery. Am Orthopt J. 2010 Jan;60(1):43–7.
11. Pineles SL, Chang MY, Holmes JM, Kekunnaya R, Özkan SB, Velez FG. Innovative techniques for the treatment of adult strabismus. J AAPOS. 2019 Jun;23(3):132-139.
12. Jethani, JN, Shah, N, Amin, S, et al. Stability and effects of muscle transplantation for very large angle esotropia: a study of 22 patients. Indian J Ophthalmol 2017; 65(7): 607–609.
13. Shrestha S, Manoranjan, Shrestha S. Surgical outcome of strabismus. Medical Journal of Shree Birendra Hospital. Desember 2013; 12(2):23-26
14. Alajbegovic-Halimic J, Jovanovic N, Halimic T. Success rate of strabismus surgery in adult patients. Acta Med Sal [Internet]. 2020 Jan 7 [cited 2021 Dec 25];49(2): 30-4.
15. Astle AT, McGraw PV, Webb BS. Can human amblyopia be treated in adulthood? Strabismus. 2011 Sep;19(3):99-109. doi: 10.3109/09273972.2011.600420. PMID: 21870913; PMCID: PMC3433677.
16. Eshaghi M, Arabi A, Banaie S, Shahraki T, Eshaghi S, Esfandiari H. Predictive factors of stereopsis outcomes following strabismus surgery. Therapeutic Advances in Ophthalmology. January 2021.
17. Quoc EB, Milleret C. Origins of strabismus and loss of binocular vision. Front. Integr. Neurosci 2014;8:1-19