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Digital evaluation of orbital development after self-inflating hydrogel expansion in Chinese children with congenital microphthalmia

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Summary *Background:* Assessment of the growth of bony orbit in children with blind microphthalmia is essential to its management. In this study, variables were measured to evaluate the development of the bony microphthalmic orbits after treatment with self-inflating hydrogel expanders.
Methods: This is a retrospective study with an interventional case series. Thirteen pediatric patients with congenital unilateral blind microphthalmia who had undergone tissue expansion with hydrogel expanders and computed tomography (CT) scanning before and after operation were included in the study. The orbital volume, depth, width, and height and retardation of the orbital rims before and after treatment were measured and analyzed using the iPlan Cranial Software.
Results: The mean age at the time of first implantation was 44 months (range, 3—113 months). Of the 13 patients, eleven received orbital expansion, while two received socket expansion. In the orbital expansion group, the mean microphthalmic/contralateral ratio (MCR) of orbital volume was 79.3% before surgery, which increased to 89.8% 3 years post operation ($P < 0.001$). The mean MCR of orbital width also increased from 88.8% to 91.8% ($P = 0.003$). The development of inferior and lateral rims showed the greatest retardation before treatment; the retardation of these two rims decreased significantly at the final measurement ($P = 0.004$). It is also noted that the development of the microphthalmic orbits was limited in the two patients who only underwent socket expansion.
Conclusions: The affected orbit enlarged in children with congenital blind microphthalmia

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following treatment with hydrogel expanders; this suggested that microphthalmia-associated orbital asymmetry can be treated with self-inflating hydrogel expanders.

Congenital anophthalmia and microphthalmia are rare conditions of the globe resulting from early embryonic development defect of the optic vesicle. True congenital anophthalmia is the complete absence of the eye; microphthalmia is much more common than anophthalmia and is defined as the presence of a small eye. Anophthalmia has a frequency of 0.18—0.4/10,000 births and microphthalmia around 1.5—19/10,000 births.[1—3] The condition described in this study is blind microphthalmia (visible tiny globe when opening the lid fissure).

The deficiency of volume of the globe can lead to hypoplasia of not only the soft tissue including eyelids and socket but also the bony structure surrounding the affected orbit. The principal manifestations of the microphthalmic eye are minified eyelids with abbreviated palpebral and bulbar conjunctivae and hypoplasia of the affected bony orbit, which can result in noticeable hemifacial deformity.[4] Treatment of congenital blind microphthalmia should be initiated early and directed toward improving cosmesis through stimulating the growth of both soft tissue and bony orbit.[5] Several methods had been reported, involving progressively enlarging static acrylic conformers to expand the socket, followed by orbital expansion with spherical orbital implants, dermis fat grafts, or inflatable saline expanders.[6—9] The newer hydrogel implants may provide more rapid expansion of the pediatric socket and orbit with minimally invasive surgical procedures,[10—13] although there is no consensus as to the best treatment.

The orbital volume is an important criterion in evaluating efficacy in congenital microphthalmia; it can be measured based on computed tomography (CT) or magnetic resonance imaging (MRI).[12,14,15] CT scan allows for imaging of the bone and three-dimensional (3D) reconstruction; the orbital volume could be calculated based on these scans and various linear measurements can be performed. However, the changes in orbital development after orbital expansion have been rarely reported. This study was carried out by measuring orbital volume and path lines before and after self-inflating hydrogel expansion in pediatric patients with congenital blind microphthalmia, to evaluate the development of the bony orbit, and to provide clinical evidence for the management of congenital microphthalmia with hydrogel expanders.

Methods

Study population

This study was carried out retrospectively in the pediatric patients with congenital unilateral blind microphthalmia between November 2008 and October 2010 in Beijing Tongren Hospital, China. We included 13 patients who had undergone tissue expansion with hydrogel expanders (spherical, hemispherical, and injectable pellets), and computed tomography (CT) scanning before and after operation. The information recorded included gender, patient age at expander implantation, and type of expander. Variables were measured based on the CT scans, including orbital volume, depth, width, and height and displacement of the orbital rims. The study received ethical approval from the Institutional Review Board of the Ethics Committee of Beijing Tongren Hospital, Capital Medical University.

Surgical procedure

All implants were made of a highly hydrophilic hydrogel consisting of N-vinyl pyrrolidone and methyl methacrylate (Osmed GmbH, Ilmenau, Germany). The hemisphere expander was used to expand the conjunctival socket in very young patients or patients with extremely small conjunctival sacs. It was sewn into the conjunctival space through preexisting anchoring holes (Figure 1A); temporary tarsorrhaphy by one central suture was carried out to avoid displacement. Then it was exchanged for the first prosthesis 1—2 months later. Spherical and injectable pellet expanders were used to expand the bony orbit in cases with obvious orbital asymmetry. The spherical expanders were implanted deep in the orbit through a transconjunctival approach (Figure 1B); injectable pellet expanders were implanted by the method described by Schittkowski and Guthoffb[11] (Figure 1C and D). The size of the spherical expanders and the amount of injectable pellets were decided according to volume deficit, which was assessed by injecting sterile saline solution or local anesthetic. After a prosthesis was fitted, sterile saline solution or local anesthetic was injected into the muscle cone until symmetry with the healthy side was achieved, the volume deficit was calculated as the amount of the injection. A prosthesis was fitted for each patient and gradually enlarged depending on the expansion of the conjunctival sac and growth of the soft tissue.

CT examination

Orbital CT scans were obtained before treatment and every year post operation using a 64-channel multidetector row CT scanner (Brilliance; Philips Healthcare, Cleveland, OH, USA), when possible. As high-quality images were not necessary for diagnosis and to assess the development of bony orbit, the CT scanning parameters were optimized to minimize radiation dose (100 Kv, 93.8 mAs, 16 $\times$ 0.625 mm detector collimation, with a pitch of 1.06, images were reconstructed on a 512 $\times$ 512 pixel matrix at a thickness of