BONE CHANGES IN THE ADULT ANOPHTHALMIC ORBIT INFLUENCING OCULOPLASTIC RECONSTRUCTIVE CONSIDERATIONS*

BY *Robert E. Kennedy*, MD

THE ANOPHTHALMIC ORBIT IS ALWAYS A COSMETIC BLEMISH TO THE PERSON who has had an enucleation. Over the years the prosthesis develops a progressive sunken appearance with recession of the upper lid sulcus and absence of the lid fold. This has been felt to be due to degeneration of the inactive extraocular muscles, orbital fat atrophy, and the tendency for normal senile enophthalmos. However, little attention has been given to the bony changes in the adult anophthalmic orbit following enucleation, which is the subject of this paper.

In the young animal, removal of an eye results in a slower rate of development of the orbit than in the fellow orbit. It may even lead to a contraction of the orbit with a resulting reduction in its capacity. This has been comprehensively reviewed and demonstrated in animal skulls in the rabbit,[1,2,3] the cat,[2] and the lamb.[4] The orbits have been studied by linear measurements in all three of these animals. The changes are in the magnitude of 30 per cent in the cat and lamb. Orbital volumetric determinations have been made in the rabbit and lamb. There is as much as a 35 per cent decrease in the lamb. Figure 1 demonstrates the lack of orbital development in the cat following early enucleation.

Most of the interest in this problem has centered around children who have had an early enucleation and are then confronted with subsequent restriction in orbital development. This restriction of development is dependent upon the age at the time of enucleation and whether an implant has been inserted. This problem has been comprehensively reviewed and demonstrated in the human by roentgenographic study.[2,5,6,7,8] Figure 2 shows the roentgenogram with small orbits with bilateral con-

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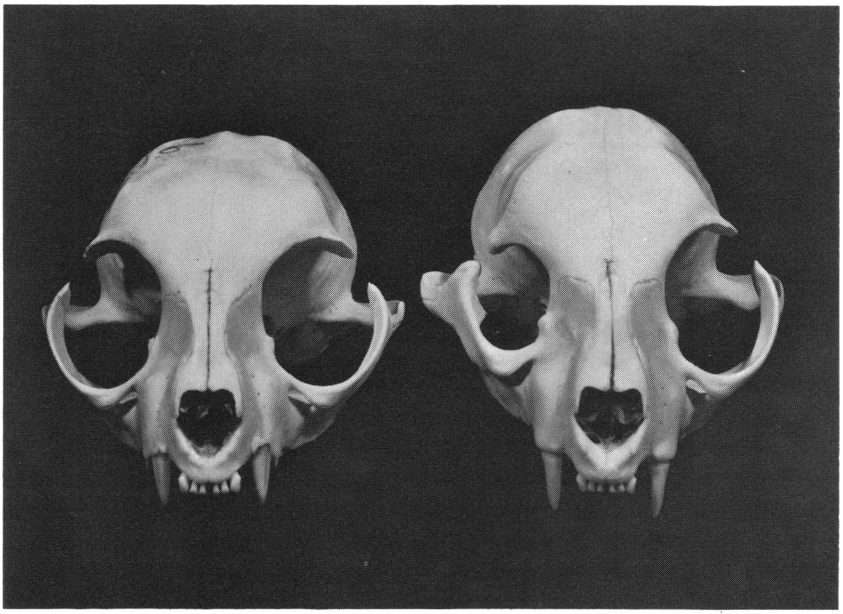


FIGURE 1
Two cat skulls from same litter. The right eye of the skull on the right was enucleated at two weeks showing the changes from normal when sacrificed at six months.

genital anophthalmos. Figure 3 shows the roentgenogram of a child with a smaller orbit on the side of a unilateral congenital anophthalmos.

The magnitude of the changes in the anophthalmic orbit recently has been shown more accurately and in more detail with the availability of two abnormal skulls, one with orbital changes with a phthisical globe and a skull with a unilateral anophthalmos, apparently congenital, which allowed volumetric determinations to be made directly from the bony skull for the first time[9] (Figure 4). Previously, linear measurements had shown up to a 15% reduction with loss of an eye and up to about 25% with congenital anophthalmos. These new studies suggested orbital volume decreases of approximately 20% following enucleation with an implant, 30% without an implant, and as much as 50 to 60% in congenital anophthalmos. It was impossible previously to demonstrate volume and orbital changes roentgenographically and correlate the measurements with dry skulls.[10]

In a brief report, Pfeiffer[6] made the following two sentence statement: "Enucleation of the adult eye also results eventually in a diminution of the size of the orbit. Contraction of the optic canal is also inevitable

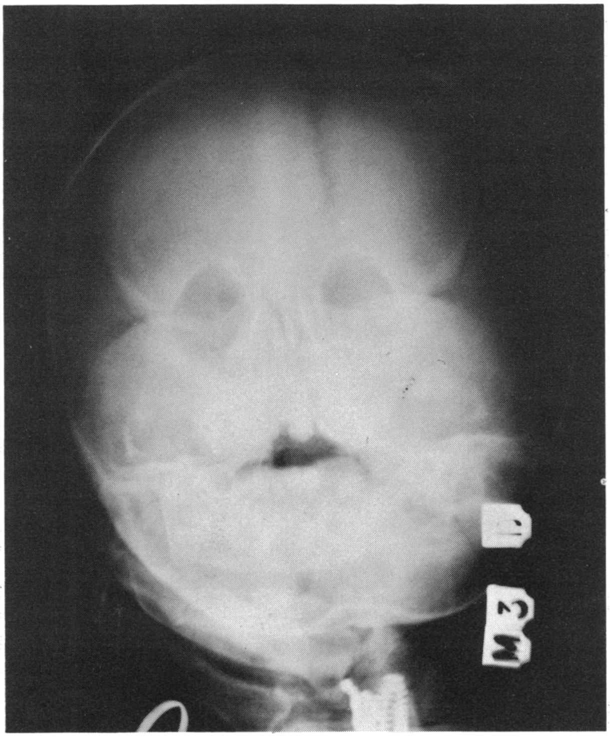


FIGURE 2
Human skull. Roentgenogram of bilateral congenital anophthalmic orbits.

following enucleation in the adult as in the child." He attributed these changes to the fact that if the content of the orbit is reduced, the former size or capacity need no longer be maintained. The space surrendered by the orbit is taken in part by the neighboring sinuses which become somewhat larger. Pfeiffer felt that changes were less marked when an implant was used.

The opinion expressed by Pfeiffer has been refuted to some extent by several authors. Spaeth[11] in his 1964 Bedell Lecture stated: "It is absurd to state that the small bony orbit of congenital microphthalmia or anophthalmia is dependent upon the eyeball defect. Each is primary and all combinations are seen." He doubted the relationship of the growth of the orbit being dependent upon the presence of the eyeball. Taylor[12] remarked: "With regard to the possibility of an implant making any

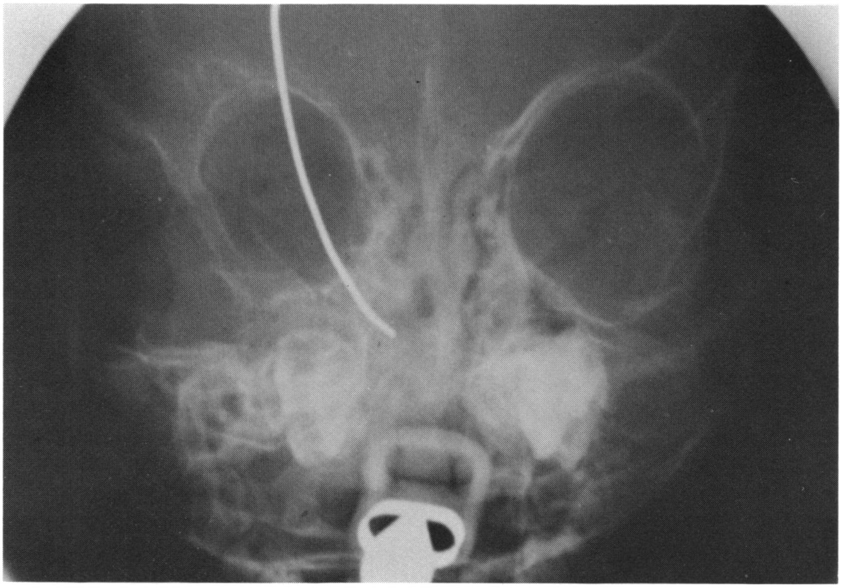


FIGURE 3
Human skull. Roentgenogram of unilateral congenital anophthalmic orbit made under anesthesia. The linear tube and mouthpiece are anesthetic equipment.

difference in the development of the orbit, I find it hard to believe that any inanimate object can have such an effect."

Sarnat and Schanedling[3] quote Pfeiffer as saying: "Removal of the eye arrests the development of the orbit and indeed leads to a contraction of it, or to a reduction of its capacity." They remark: "Our findings were to the contrary. The orbital size, although smaller than on the unoperated side, became progressively larger in growing animals with a longer post-operative survival period. In other words the orbit is not actually smaller, but is smaller relatively to the unoperated orbit." However, their work was with young rabbits which had undergone evisceration, enucleation, and exenteration. I believe the opinions of Pfeiffer are strongly supported by subsequent experimental findings, animal studies, and human roentgenographic and skull measurements.[2-9]

As people live longer and demand a better cosmetic result, a better understanding of the changes that actually do take place in the orbit is necessary. Therefore, while it is acknowledged that soft tissue changes do take place it should be recognized that there are actually bony changes also taking place, as so briefly mentioned by Pfeiffer 30 years ago. These

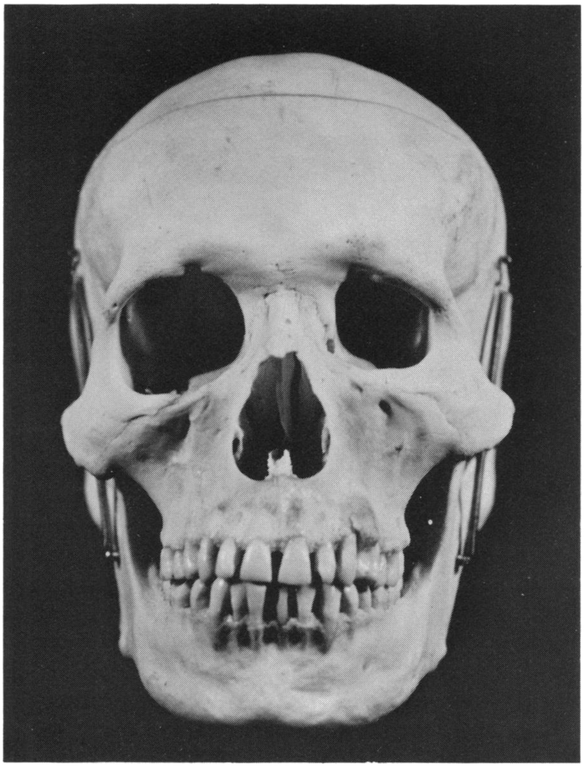


FIGURE 4

Human skull. Skull showing normal right orbit and markedly underdeveloped left orbit; probably congenital anophthalmos. The underdeveloped orbit shows constricted rim, rounded edges, and porosity of bone. This was previously published in *Trans Am Ophthalmol Soc* 70:278, 1972, and *Am J Ophthalmol* 76:294, 1973.

changes have not been elucidated and should be recognized, studied, and understood to give the best cosmetic result when the surgeon is confronted with the oculoplastic revision of a prosthesis, a lid sulcus, or of an orbit.

While the following changes have been seen in several people studied roentgenographically, one case will serve to illustrate the changes which are most apparent. These are represented by an 83-year-old lady who was first seen at age 41 and had an enucleation of her left eye for a malignant melanoma at age 42. No implant was inserted in the orbit and a prosthesis has been worn since that time. This has a sunken appearance with a sunken upper lid sulcus and no lid fold. The patient 41 years later is

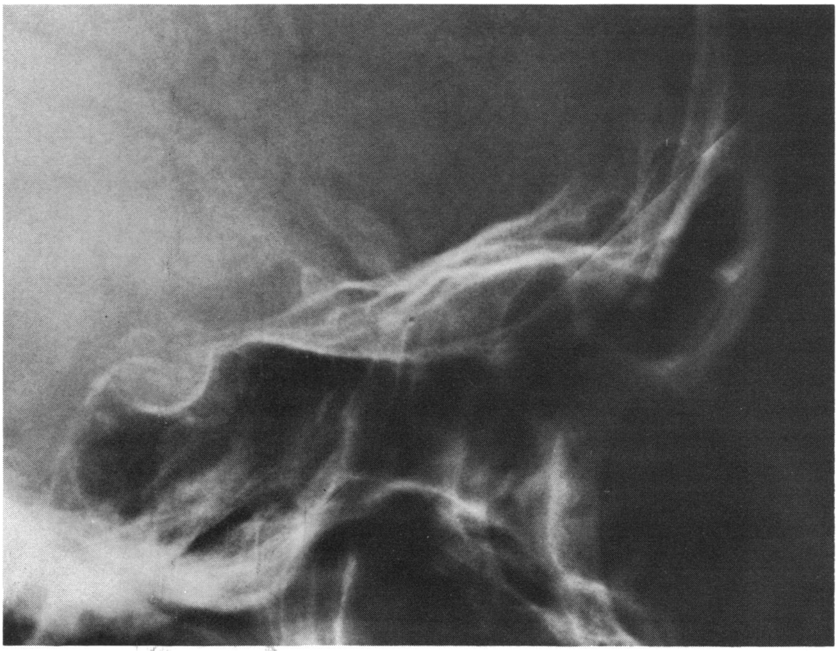


FIGURE 5
Left lateral skull view. Little change is demonstrated.

satisfied with her cosmetic appearance. Roentgenograms 38 years after her enucleation show changes in the left orbit in all of the film projections. Stereoscopic views and tomograms are even more striking. The lateral view (Figure 5) is least revealing. The optic foramina views (Figure 6) show the left optic foramen to be much smaller with scalloped edges. The orbital rim and other changes are evident. The Caldwell view (Figure 7) and the Water's view (Figure 8), together with line drawings of each with specific changes numbered, show the following.

The orbit is smaller in dimensions horizontally, vertically, and both diagonals. The walls of the orbit show porosity and thinning (Numbers 1, 2, and 5 in Figures 7 and 8). The linear dimensions show an average decrease of just over 10%, probably representing at least a 20% orbital volume reduction.

The orbital rims show irregularity, constriction, and a marked overhang of the rim of the orbit above compared to the roof of the orbit, seen well in Figures 6, 7, and 8. These projections also show the added bone rarefaction in addition to the soft tissue loss of density following the enucleation with no implant. The sphenoidal ridge line and the temporal line changes

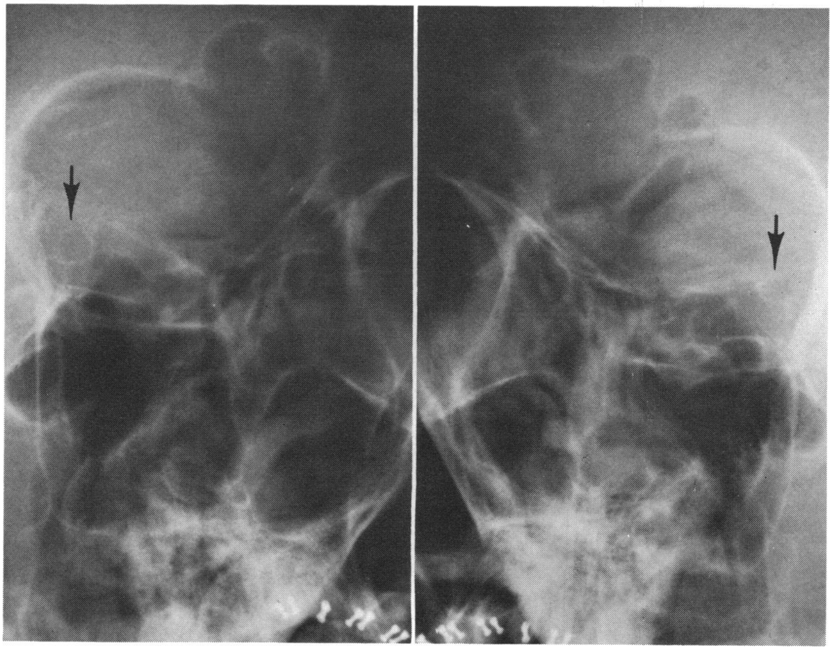
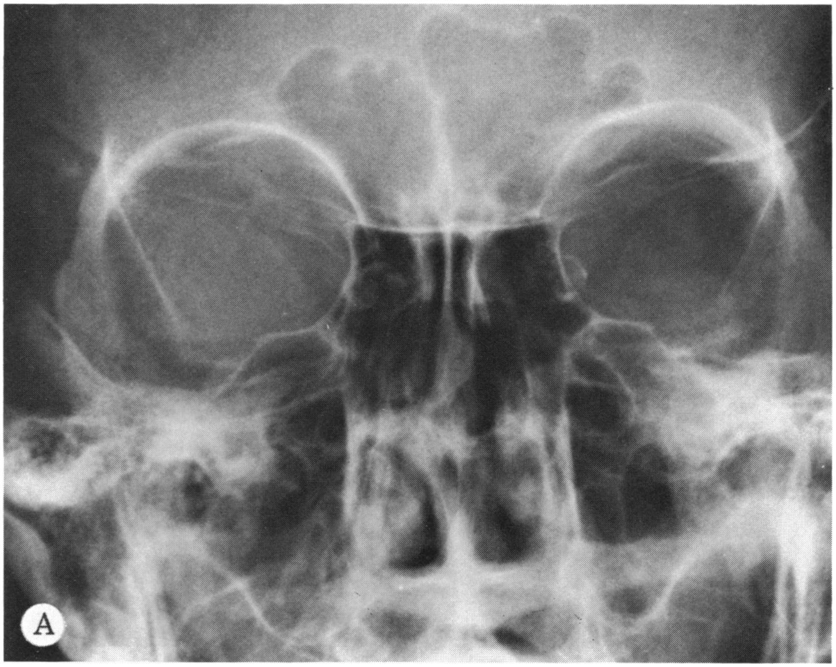


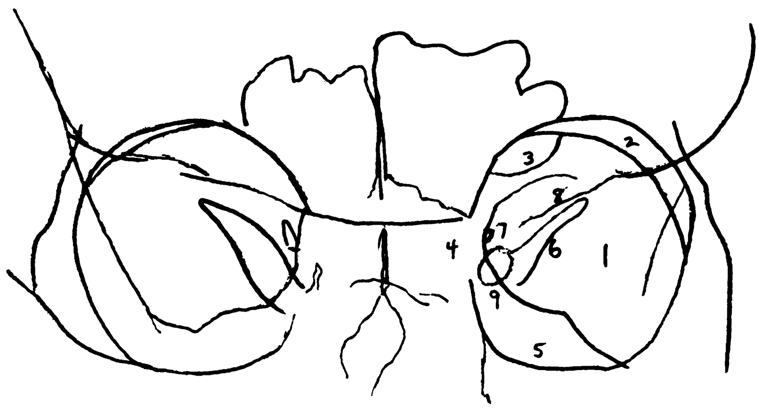
FIGURE 6
Optic foramina views. The left optic foramen (on the right) is smaller with scalloped edges.

can be compared (Numbers 8 and 10 in Figures 7 and 8). The optic foramina changes (Number 7 in Figure 7) show marked constriction with its scalloped edge changes also shown in Figure 6. The superior orbital fissures (Number 6 in Figures 7 and 8) which usually show an amazing similarity in size and shape, show very marked constriction, irregularity, and decrease in size on the left side. It is of interest that in this particular patient there is a calcific ring of sclerosis of the carotid artery within the cavernous sinus (Number 9 in Figure 7) which, of course, may not be evident as a routine manifestation. The neighboring sinuses encroach upon the orbit to alter its shape and reduce its volume (Numbers 3, 4, and 5 in Figures 7 and 8).

Figure 9 represents a patient with enucleation. This figure shows the extent of the cosmetic blemish of a sunken prosthesis and recessed upper lid sulcus which these patients must endure for life. These changes are all too often ignored by the ophthalmologist.

The oculoplastic ophthalmic surgeon attempts to correct the cosmetic blemish of the patients with an anophthalmic orbit by some type of surgical procedure. All of these procedures are aimed at increasing the orbital





B

FIGURE 7

A: Caldwell Projection. B: Line drawing from this roentgenogram. The numbers represent the orbit (1), the overhanging rim of orbit (2), the frontal sinus (3), the ethmoid air cells (4), the antrum (5), the superior orbital fissure (6), the optic foramen (7), the artery (9), and the linea innomunata, or temporal line (10). These are described in the text.

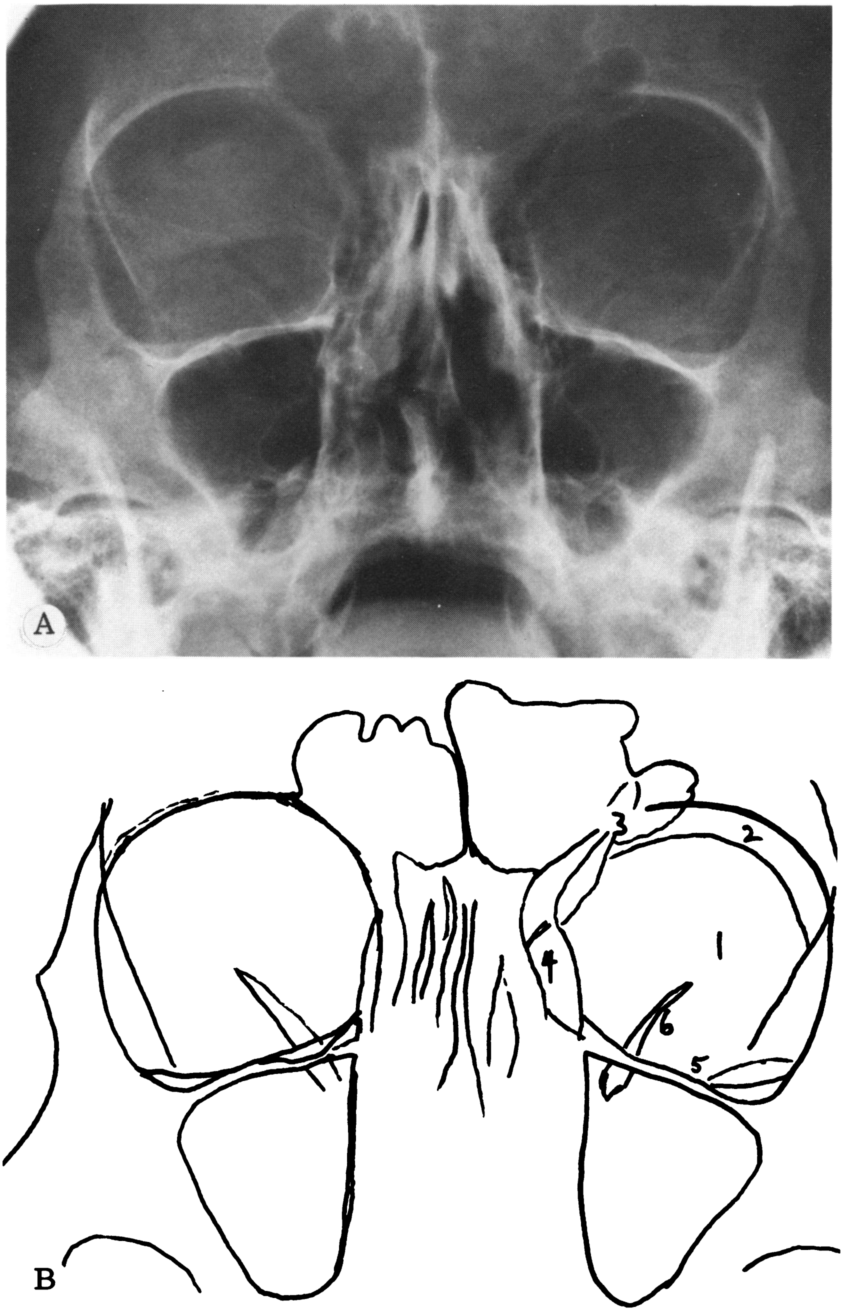


FIGURE 8
A: Water's projection. B: Line drawing from this roentgenogram. The numbers are the same as listed for Figure 7. The changes are described in the text.

FIGURE 9
A: Front view of patient with the enucleation-prosthesis defect with the sunken appearance and recession of the upper lid fold. B: Side view of same patient.

volume. Such procedures might include inserting an initial implant, or larger implant in Tenon's capsule, placing some type of synthetic device beneath the periorbita on the floor of the orbit, inserting glass beads toward the apex of the orbit to attempt to push the prosthesis forward to its previously more normal position, and the insertion of some type of synthetic or fascia lata implant in the upper lid sulcus which frequently becomes deepened and flattened with no lid fold. Socket reconstruction could involve wiring the orbital rim. Despite all of these procedures it is recognized that further progressive anophthalmos may take place.

Before understanding such procedures it is important to recognize the bony changes that may have taken place in addition to the soft tissue changes. It would be advisable to evaluate the orbit with roentgenograms. This is better performed stereoscopically and perhaps by tomograms. This becomes of greater significance the longer the interval following the enucleation. The importance of such an evaluation in infancy or childhood has already been pointed out.

SUMMARY

Decreased orbital development following enucleation is a well recognized condition in the young person and is lessened by orbital implantation at the time of inital surgery. Pfeiffer, some 30 years ago, suggested that bone changes as well as the soft tissue changes could also continue to take place in the adult resulting in added orbital changes. While this has been questioned, the findings originally reported by Pfeiffer are firmly substantiated by roentgenograms and documented in this report.

If there has been a significant interval of time following the enucleation, careful roentgenographic evaluation prior to cosmetic oculoplastic revision of the orbit should be done even in the adult.

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DISCUSSION

Dr A. D. Ruedemann, Jr. I would like to thank the author for the privilege of reading his paper prior to presentation. I would like to say at the outset that I would have no argument with his primary conclusion, that there are changes in the orbit following enucleation which have a notable effect of orbital dimensions and volume following enucleation and continuing over a period of time. The author has shown in previous papers that bone changes resulting in diminution of orbital volume occur in the infant, the juvenile, and in certain animals. He has shown in the present paper that there is evidence that the orbital volume also decreases in the adult following enucleation.

This amounts to the case of the collapsing orbit verses the case of the contracting socket. There are several points which should be considered in this regard and I would therefore refer to the references given by the author. The prime reference is that of R.L. Pfeiffer who presented a paper at the American Academy of Ophthalmology and Otolaryngology in 1945. The title was, "The Effect of Enucleation on the Orbit." The author stated that an organized study was undertaken to note: "The relationship of age at time of enucleation to the degree of change which comes about in the orbit" and secondly, "The influence of the use of the implant on these changes." The author noted that in his study, prostheses were used in all the cases. He noted that, "The orbit should contract after enucleation. It is consistent with the law of adaptation." He also noted that, "Enucleation of the adult eye also results in a diminution in the size of the orbit." It is interesting to me that the discussion of this paper was given by Doctor Frank E. Birch who had reintroduced the idea of evisceration with a retained cornea at the meeting of this Society in 1939.

Dr E.B. Spaeth at the Arthur J. Bedell Lecture of 1964 on the "Surgical Pathology of the Eyelids and the Orbit in Early Childhood," pointed out the frequently made statement that, "An enucleation necessary for good reasons in a young child should be delayed as long as possible so that the orbit will have stimulation for growth from the presence of an eyeball in a socket." Spaeth doubted that this relationship was necessary. However, Sarnat and Schanedling presented a paper in the American Journal of Ophthalmology in 1970 on a study performed on a series of rabbits. The authors performed evisceration, enucleation, and exenteration without implantation on these animals. The authors noted that there was a suggested direct relationship between the lack of orbital mass and subsequent lack of development of the orbit. The authors noted that after evisceration there was little difference in the postoperative volumes. The decrease in volume after evisceration was not as remarkable as that after enucleation, although in both instances no implant was involved. The small series invloving exenteration was even less significant in that they noted a lesser difference in orbital volumes with the longer postoperative period. It is possibly true that in this animal study there is inadequate data to properly evaluate orbital volume, or for that matter, the status of the orbital contents.

It appears that the most important point is achieving and maintaining a functioning orbit and contents. This is much more difficult in an orbit which has been subjected to multiple surgical procedures or other traumatic incidents. [Slide] In the first slide one looks at an orbit which has been enucleated without implantation. [Slide] With the passage of time there is an obvious reduction in the size of the orbit. If it were true that the orbital reduction in fact affected the tissues within, then one would not expect the resultant contraction of orbital contents with reduction of cul-de-sac. This is what happens in many, if not all, cases of enucleation, with or without implantation of globe. In the most simplistic fashion one would expect that if collapse of the orbital socket were involved then the problem of reduction of cul-de-sacs and orbital contents would be reduced. We used to think of maintenence of orbital volume as essential to maintenance of orbital function after an enucleation. In long standing cases, even with adequate implantation (namely an 18 or 20 mm ball) there is often a deep superior sulcus and a contraction of the cul-de-sacs. From the standpoint of cosmesis the problem evolves into correction of the deep superior sulcus following enucleation and the subsequent loss of cul-de-sac. The cul-de-sac is very often reduced more in the inferior fornix then the superior fornix, which means that the shell tends to ride superiorly and into the deep fornix evolving from the contracted socket.

There are several methods to correct a deep superior sulcus and a contracted cul-de-sac. The first and simplest is to extend the cul-de-sacs with scissors below to allow for a larger prosthesis. Secondly, orbital tissues may be forced superiorly by the implantation of a subperiosteal stent beneath the inferior orbital tissues thereby forcing orbital tissues superiorly. If this is not adequate, an implant may be placed subperiosteally in the superior and posterior orbital area using a plain silicone conformer beneath the subperiosteal tissue and extending above and behind the superior orbital tissues, forcing them forward. In conjunction, an extension of the superior fornix and inferior fornix is made by simple enlargement with scissors and forceps above and below. A large silicone conformer is placed in the cul-de-sacs and the lids are sewn together.

In the long-standing enucleation case, with or without the presence of a prosthesis, it seems to me that the prime consideration is not the problem of replacing orbital volume but of maintaining cul-de-sac so that the ocularist can utilize a properly functioning prosthetic device. Finally, I would point out that in those conditions in which the scleral and corneal tissues may be maintained by an evisceration, the resultant situation is one in which the orbital contents are maintained practically intact, as well as the mucous membrane surrounding the globe and the cul-de-sacs, allowing a reasonably normal orbit as well as mucous membrane surrounding the existent globe. This is what we call an evisceration and it is the best method of attaining a functional orbit and cul-de-sacs.

I wish to thank the author for the privilege of discussing his paper.

Thank you very much.

Dr Robert Kennedy. I was very interested in Dr Ruedemann's discussion and I thank him for his comments. We have enjoyed discussions and sometimes differences since residency days together 29 years ago.

I do not feel that we are talking about contracted sockets as Dr Ruedemann suggests, but rather about orbital changes. In the paper I have shown two young ladies who have had fairly recent enucleations. They probably had extensive surgery, possibly with hemorrhage into the orbit, resulting in orbital tissue atrophy and degeneration. This results in a prominent upper lid sulcus.

[Slide] This photograph is that of a man wearing a prosthesis who certainly does not have a contracted socket. He has worn this same prosthesis for 25 years and he has all the room in the world in his socket. There are no contracted socket changes over the years even though there is decreased orbital size by roentgenographic study. The prosthesis is markedly displaced downward. He has laxity of his lower lid and a prominent upper lid sulcus. He has other oculoplastic necessities, such as possibly changing the tension on the lower lid, or maybe something done to his orbit to improve the position of the prosthesis. A contracted socket is not his problem as he still wears the original prosthesis.

Over a period of 20 years, I have measured some anophthalmic patients by exophthalmometry and have found that the prosthesis does tend to recede over the years. I believe Doctor Joseph Hill of Toronto has also discussed this progressive recession of the prosthesis which tends to be almost physiological no matter what is done.

I do not feel there is scar tissue within the orbit which reduces orbital size and I do not feel that contracted socket per se is the point being made in the paper. The orbital changes which take place should do so as the result of the loss of the eye. Both Whitnall's *Anatomy of the Orbit* and Pfeiffer point out that the orbit should contract after enucleation which is consistent with the law of adaptation, which calls for an adjustment of the organ to the function it is called upon to perform. With the loss of the eye the orbital contents are reduced, the capacity is not needed, and the orbit can surrender part of its volume to expansion of surrounding sinuses, flattening of the orbital roof, optic canal contraction, etc.

However, regardless of whether you are talking about contracted sockets or changes in the orbital volume, good roentgenographic evaluation of the orbits is essential so that accurate measurements can be made and the degree of orbital changes determined. Careful study of the roentgenograms can save embarrassment in oculoplastic reparative work and yield better results.

Thank you.