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Scoping review of the development of artificial eyes throughout the years

Holly Chinnery, Simon B. N. Thompson, Siamak Noroozi, Bryce Dyer

ABSTRACT

Losing an eye following trauma can lead to profound psychosocial difficulties making it imperative for the wearer to be fitted with an aesthetically pleasing custom-made artificial eye. Despite recent technological advancements, current design and manufacturing processes have remained unchanged in over 55 years. With the aim of portraying current knowledge regarding the development of artificial eyes in order to aid future development, a scooping review was conducted. Six online search engines were used: Scopus, PubMed, MedLine Complete, Web of Science, Science Direct and Google Scholar. Thirty-eight articles met the inclusion criteria and underwent numerical and thematic analysis with three thematic themes emerging. History and the current process of artificial eyes has been well documented, however, the impact of wearing artificial eyes is sparse. On-going research and development into the design and manufacturing processes of artificial eyes and the psychosocial impact of wearing an artificial eye is needed.

Keywords: Artificial eyes, Eye loss, Historical and technological development of artificial eyes, Prosthetic eyes, Psychosocial impact of prosthetics

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INTRODUCTION

Human understanding of expressions and what they mean emerges very early in life. Confronted with and revealing a whole host of emotions when we look into one

another's eyes gives credence to the saying 'Our eyes are the windows to our soul'. Our eyes act as our navigational tools: we adjust and modify our behavior and act in accordance to our interpretations, whether that's related to our physical surrounding, social interactions or emotional contact. With many aspects of human functioning relying on our eyes, a loss of one or both can have a significant impact on a person.

The loss of an eye(s) can be caused by a congenital defect or be acquired. Examples include malignancies, intraocular and extraocular infections, trauma, orbital tumors and painful blind eyes [1]. Following the loss of an eye, patients are fitted with an artificial eye. Today's artificial eyes are a thin hard acrylic shell that covers the surface of the eye, fitting over an orbital implant and under the eyelids [1].

Research showed that the loss of an eye highlights medical, psychological, social, emotional, and physical difficulties [1–7]. From a medical perspective the loss of one eye results in a change from binocular vision to monocular vision leading to initial feelings of disorientation and clumsiness [4]. Although adjustments by turning the head can overcome the defects in depth perception, and field of vision some activities of daily living such as playing sports, driving and work requiring prolonged visual vigilance will continually be impacted.

Psychological adjustment to the loss of an eye comes with emotional acceptance in all areas of one's life including personal, professional and societal. In circumstances where a person has not adjusted to the loss, difficulties such as depression, anxiety, low self-esteem, low self-image and feelings of hopelessness may arise. This can lead to maladaptive coping mechanisms impacting social functioning and independence. Thus, in order to provide the best overall care, understanding and sensitivity to the loss is required [2].

Whilst research has documented the factors associated with the loss of an eye [3–6], knowledge surrounding the impact wearing artificial eyes is still in its infancy. Furthermore, despite its progression in related fields, such as prosthetic limbs, technological development regarding artificial eye design and manufacturing has stagnated. These two key facets are essential in identifying future research and development in order to create better outcomes for practitioners and artificial eye wearers alike.

In order to achieve this, a strong knowledge base needs to be created. Therefore, the objective of the scoping review is to portray current knowledge regarding the development of artificial eyes in order to aid future development.

METHOD

This review followed the five framework stages outlined by Arksey and O'Malley's (2005).

Stage 1: Identification of the research question

Based on two facets: development of artificial eyes remaining the same since the 1960s, and, peoples' needs evolving over time, led to the research question: 'What is known from the existing literature about the development of artificial eyes throughout the years?' It is envisioned that this review will be an aid in creating an understanding of where and if technology can provide the tools required by artificial eye wearers. To gain a rounded understanding of artificial eyes, a search strategy involving the historical and development of artificial eyes and what influences the development was deemed necessary.

Stage 2: Identifying relevant studies

In order to locate a wide variety of research relating to artificial eye development, no time span or language constraints were applied. A threefold search strategy was adopted: electronic databases, internet search and reference list search. The search was performed between August 6th and August 31st 2016 using six databases: PubMed; MedLine Complete; Web of Science; Science Direct and Google Scholar. The search strategy used terms to denote 'artificial eyes' (prosthetic eyes, ocular prosthesis) combined with a range of terms denoting its development (history, technology, impact, emotional wellbeing). The final stage of the search strategy was reference checking (Table 1).

Stage 3: Study selection

A total of 280 references were identified from the search strategy. An inclusion and exclusion criteria was developed and applied to all studies that represented a best fit with the research question. Articles relating to the historical and technological development of artificial eyes; needs of and the impact upon those wearing artificial eyes and participants who had undergone enucleation, exenteration and evisceration as a result of genetics, trauma, injury, infection and disease were included in the review. Furthermore, due to the scarcity of publications about the psychological impact of wearing artificial eyes, references were sought for those associated with facial disfigurement only (Table 2)

Articles regarding stock eyes, eye shells, implants and orbital prosthesis; those that assess the condition of and aftercare of artificial eyes and clinical/case reports were excluded. Reflecting time and budget constraints, the time span of articles was amended. With the change of material in the construction of artificial eyes occurring following the end of World War II, it was decided that all articles pre-dating 1950 would be removed from the search, enabling the remaining articles to reflect current methods utilized in its design.

The inclusion and exclusion criteria were applied to all 280 references using abstracts or the full articles where available. Of these, 121 were considered to meet the inclusion criteria. Full reports were obtained for 38 articles. The remaining 54 articles consisted of those that predated the exclusion criteria (17) and those unavailable through library sources (66). A full list of these articles can be found in the appendix.

Stage 4: Charting the data

A data charting form was created using the database programme Excel. All 38 articles were entered into the form that contained the following information: author(s), year of publication, study location; intervention type, duration of the intervention; study population; aim(s) of the study; methodology and key findings/results. These data formed the basis of the analysis.

Stage 5: Collating, summarizing and reporting the results

A scoping review aims to 'map' or identify literature in the field. This was done in two stages: firstly, basic numerical analysis and secondly, thematic analysis.

RESULTS

Numerical analysis

Geographical distribution of articles reviewing the development of artificial eyes

Figure 1 gives the number and proportion of research reports that looked at the development of artificial eyes. The majority of the articles were carried out in the USA (54%). In comparison, a far smaller proportion of articles were derived from the UK (18%). New Zealand accounted for 7% of the articles and Australia accounted for 4% of the articles. Articles from the rest of Europe and the world accounted for the rest.

Table 1: Number of studies of the development of artificial eyes found within different sources

Bibliographic Source	N	%
Electronic databases	229	82
Reference checking	30	11
Internet search	21	7

Table 2: Publications regarding the psychological impact of wearing artificial eyes and facial disfigurement

	Eye loss		Facial disfigurement	
	N	%	N	%
Included	3	27	8	73
Excluded	7	24	22	76

Categorizing the articles

The articles were related to the historical development, current process and the impact upon patients with artificial eyes and facial disfigurement. In order to reflect this heterogeneity, studies were grouped together.

Figure 2 shows the classification scheme used and the number of studies according to each intervention category. The majority of articles were narrative inquiries (39%) followed by historical reviews (26%) and questionnaires (22%). Literature reviews, interviews and interview and questionnaires made up the remaining typologies.

Types of research methods used to understand the development of artificial eyes

Table 3 reflects the number and proportion of studies according to type of research. The majority of studies (90%) used qualitative methods. Of these narrative inquiries compromised 39% of articles and historical reviews compromised 26% of articles. The remaining 35% of articles were a combination of quantitative and mixed methods research.

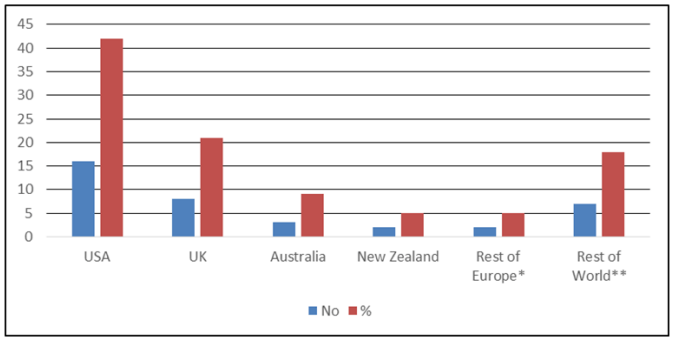

Figure 1: Distribution of articles reviewing the development of artificial eyes, by country (N = 38).
Note. * Portugal (1); Germany (1); ** Brazil (3); Nigeria (1); India (1); Turkey (1); Japan (1)

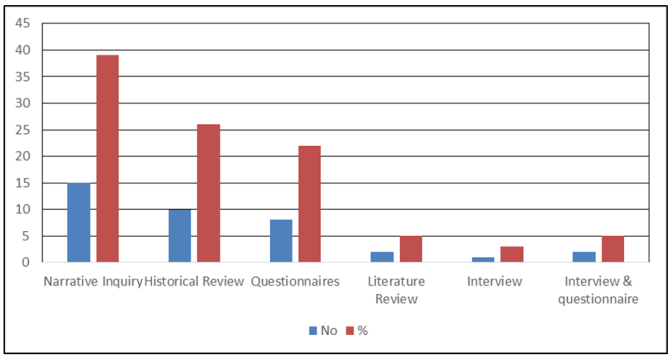

Figure 2: Number and proportion of studies according to typology (N = 38).

Table 3: Number and proportion of studies according to type of research (N = 38)

	N	%
Qualitative methods		
Narrative Inquiry	15	39
Historical Review	10	26
Literature Review	2	5
Interviews	1	3
Quantitative		
Questionnaires	9	22
Mixed methods		
Interview & Questionnaire	1	5

Geographical distribution of articles of artificial eye development according to research method

Table 4 gives the number and proportion of studies by country for each of the four typologies used. The majority of studies were narrative inquiries which were conducted in the USA (54%). In comparison, research in the UK has been more evenly spread: Narrative inquiry (60%); historical review (20%) and questionnaires (20%).

Summary of the characteristics of articles

The 38 studies of the development of artificial eyes were included in this review. The data shows that:

- The majority of articles were conducted in the USA and were qualitative in nature.
- Narrative Inquiries were most commonly studied, followed by historical reviews and then questionnaires.
- UK studies encompassed both qualitative and quantitative articles reviewing the historical development, current methods and the impact of artificial eyes and facial disfigurement.
- Articles related to specific techniques were mainly of single rather than multiple approaches.
- Few studies assessed the needs of the artificial eye wearer.

THEMATIC ANALYSIS

History of artificial eyes

Anecdotal reports and relics from ancient civilizations point to the first artificial eyes being made by the Egyptians in the 4th Dynasty (2613–2392 BC) and the ancient cultures of Babylon and Jericho [7–14].

The Egyptians, Greeks and Romans embellished important statues, mummies and animals with artificial eyes [10, 14, 15]. They were known as 'art eyes' and were made from precious stones such as earthenware, enamelled bronze, copper and gold. The orbit was filled with wax or plaster on top of which the precious stone was inserted to represent the iris of an eye [5, 9, 10, 11, 14, 16]. It is thought that these 'art eyes' were used for cosmetic purposes as a symbol of light and life in their religious beliefs [8, 9].

From the 26th Dynasty age to the Dark/Middle age (500–1500 AD) the making of artificial eyes was largely abandoned [10, 12]. It was not until the renaissance period (1400–1700 AD) that artificial eyes saw a resurgence [14].

The 16th century saw artificial eyes being fitted in the socket and experimentation with materials. Ambroise Paré, a French surgeon, described two types of artificial eyes: the 'Hypoblephara', which fitted underneath the eyelid, and the 'Ekblephara' which fitted externally: both of which were expensive, heavy, painful to wear and lacked the moist quality of a normal eye [7, 11].

Paré was also credited with evolving the making of artificial eyes from gold and silver to glass [5, 8–10, 12]. Glass eyes were made of lead or soda both of which were durable but caused severe tissue reactions and erosion limiting their lifespan to 9–24 months [5]. Despite these shortcomings, glass was better tolerated by the orbital

Table 4: Geographical distribution of studies according to methodology (N = 38)

	Narrative Inquiry	Historical Review	Literature Review	Questionnaire	Interview	Interview & questionnaire
	No %	No %	No %	No %	No %	No %
USA	8 53	7 70			1	
UK	3 20	1 10	1	4		
Australia		1 10			1	
New Zealand		1 10		1		
Rest Of Europe*	1*					1****
Rest of World**	3**			4***		

* Portugal (1)
** Brazil (1), India (2)
*** Nigeria (1), Turkey (1), Japan (1), Brazil (1)
**** Germany (1)

tissue [17]. and was seen as being able to eliminate the problems associated with metal artificial eyes (gold and silver) such as its weight and expense [11]. The use of glass saw their shape change from sphere to a shell form reducing irritation to the socket but putting patients at risk of bruising the conjunctival bed due to not being able to adequately replace lost orbital volume [12, 16, 18].

In 18th century, the importance of a custom-fit eye to the socket to overcome the above problems was being realized [12]. Experimenting with new materials and methods for making human glass eyes, Ludwig Müller-Uri, a German glassblower who produced dolls eyes that had good human-like qualities, developed cryolite glass which was hard and light and did not irritate the conjunctiva [3–10]. By providing support at the anterior of the socket, creating lightness of weight, replacing sharp edges with rounded edges and displacing soft tissues of the orbit around the prosthesis to fill volume thus eliminating a sunken appearance, the shape of the artificial eye changed to what is now known as the Snellen reform eye [11, 12, 19]. Despite the Snellen reform eye's vast improvements over the shell eye, they were uncomfortable in terms of pressure points causing irritation and discharge from large quantities of trapped tears and mucus partially due to being unable to achieve best fit due to the abstract nature of the Snellen reform eye and without the help of an impression [19].

Fragility, surface erosion, imperfect fit, superficial staining and spontaneous breakage of glass eyes led to investigation into other materials such as vulcanite and celluloid in the 19th Century [10, 17, 20].

With the turn of 20th century artificial eye services were becoming more regulated. During this time artificial eyes were made of glass and supplied in standard sizes and colors that could not be altered [21]. Vulnerability to socket secretions and rapid deterioration saw the fabrication of glass eyes using sand with a low oxide content being exclusively used until World War II (WWII) where it became unobtainable in Germany resulting in the United States temporarily relying on stock eyes to meet the need of the military and civilian population [8, 14, 16, 22]. In 1946, the Veterans Administration based in America, initiated the 'Plastic Artificial Eye Program' to train ocularist to make artificial eyes for a large number of disfigured and disabled veterans [4].

A polymerized form of methyl-methacrylate, acrylic resin is lightweight, easy to mould, fit and adjust, has good color permanence, is resistant to rough handling, easily fabricated, durable and provides an aesthetic appearance, thus making it the most suitable material that is still used today [6–8, 12]. The few disadvantages associated with plastic artificial eyes include not being fully scratch resistant, not capturing iris depth and color fading, are all related to poor restoration. With the right equipment and materials, these obstacles can be overcome [17]. Further developments in the design of artificial eyes came with the development of orbital implants in the 1980s.

Current design and manufacturing process of artificial eyes

Initially based on the shell and reform form used for glass eyes [16] acrylic artificial eyes also caused soreness due to ill fit, lack of mobility and lid distortion due to incorrect shape [9]. Research conducted by the United States Naval Dental and Medical Schools, identified that due to the individuality of each enucleated socket, artificial eyes need to be custom-made [8, 12, 14, 16, 21, 22, 23].

Although custom-made artificial eyes necessitates the work of a skilled artist making it a time consuming and costly process, they permit accurate coloring of the iris, veining and tinting of the sclera making it more cosmetically satisfactory to the patient [4]. Accurate fitting of the socket, minimizing tissue distortion, improved facial contours and increasing the degree of motility are achieved in custom made artificial eyes [4, 19, 23], allowing even distribution of volume and weight in the socket reducing long-term discomfort and producing better cosmetic outcomes [9, 14]. Furthermore, by providing close contact with the soft tissue, the artificial eye allows normal tear secretion, volume replacement, adequate orbital fat and absence of socket inflammation [7, 19, 24]. These advantages result in the artificial eye moving like a natural eye following almost simultaneously with the patient's natural eye [9].

In order to approximate the natural eye, accurate records of the posterior wall and its relation to the palpebral and the extent of the superior and inferior fornices of the palpebral is required in order to provide sufficient support [23]. Without sufficient support, the eyebrow can fall nasal-wards, the eyelid muscles can become weaker leading to entropion and the edge of the eyelids can become inverted [9]. Currently, this is achieved by a method known as the impression technique. The fabrication of an artificial eye using the impression method establishes the defect contour and the iris and sclera can be individually characterized offering better aesthetic and more precise outcomes [1, 6, 8, 19].

The initial impression technique in the mid 1940s reported partial success in fitting artificial eyes [19]. However, by pressing the paste (which was often heavy) into the socket to fill all spaces and smoothing out the conjunctiva folds and wrinkles often led to overfilling [19]. Furthermore, by only testing the wax mould of the impression for a short period of time, thus not giving enough time for the orbicularis muscle to reflex from the foreign object, a good fit was not always achieved [19, 25]. These techniques often caused discomfort and ignited fear in the patient as a result of the process, materials and equipment used [25].

Advancements in this method include the direct/external impression technique and the modified impression technique [6, 8, 25]. Whereas the former involves injecting low viscosity alginate or reversible

hydrocolloid material directly into the socket, the latter places a stemmed tray into the eye socket for the material to be inserted into. Variations to the modified impression technique include attaching a solid suction rod to an existing prosthesis and investing it in an irreversible hydrocolloid mould before replacing it with clear acrylic resin (custom ocular tray impression); applying ophthalmic alginate to a suitable stock eye which is inserted into the socket for a definitive impression (stock ocular tray modified technique); trimming/polishing a stock eye or using alginate or soft wax which is invested and processed (ocular prosthesis modification technique); and adapting baseplate was around half an appropriately sized steel ball to create a wax blank which is tested in a socket and adjusted as required (wax scleral blank technique) [1, 3–5, 7, 19, 21, 22, 24].

Despite these advancements, all impression techniques are unable to design the front of an artificial eye, thus is unable to manipulate the eyelids to their proper opening and shape [25].

Following an impression of the socket, a plaster mould is created using molten wax to produce a replica [5, 7]. Whilst the wax is being cured, the iris is produced. The iris disc is sized based on the observations of the natural eye and measuring the distance from the facial midline and pupillary light reflex allowing a guide for a centrally placed iris ensuring correct alignment [5]. Several methods such as paints, pigments and papers have been used: paper discs, ethyl-cellulose discs or directly on the acrylic resin sclera using water colors or oil paints [3, 4, 6]. Relying upon the artistic skills of the skilled technician led to the development of creating an iris using digital imaging.

Digital imaging involves taking a digital photograph of a patient's natural iris which is then compared to the natural iris. Adjustments are made to the color, brightness, contrast or hue using graphics software, if required [8]. Once aesthetically pleasing, the image is covered with three light coats of water resistant spray before attaching it to the ocular disc and then the wax pattern [8].

Digital imaging provides aesthetic quality as it closely replicates the natural iris with minimal color adjustment and modifications needed. Furthermore, this method is simple and practical as well as being less time consuming than the traditional method [6, 8]. However, special digital photography equipment and computer software is needed [8, 26] and the light instability of photographic dyes results in the colored iris fading quickly [4].

Following insertion of the iris into the wax pattern, it is cast in clear acrylic resin and cured under compression [5]. Once cooled, red cotton thread is adhered to the sclera using liquid monomer and polymer clear powder [3, 4, 6]. The artificial eye is then coated with a layer of clear acrylic resin before being cured under heat and pressure, cooled and polished [3, 5, 6, 21].

The current methods used in the fabrication of artificial eyes are labor intensive and time consuming with the end result being heavily dependent on the experience of the ocularist. The need for both functional and aesthetic consideration makes the fabrication of artificial eyes a challenging task in prosthetics.

Impact of artificial eyes and facial disfigurement

Due to the search of the impact of artificial eyes producing few results, the review was widened to include facial disfigurements.

Artificial eyes

The search strategy produced eleven articles related to the impact of artificial eyes that met the inclusion criteria. Of these, four full articles were obtained.

With literature primarily focusing on the before and after the loss of an eye, the long-term psychological impact of living with artificial eyes has received little attention [2, 28].

McBain et al. (2014) reported that 40% of artificial eye wearers take an average of two years to adjust to their prosthetic with clinical levels of anxiety, depression and appearance related distress being experienced [27, 28]. Research has shown that this is related to older age, having children and the belief that the prosthesis influences social and interpersonal relationships rather than the clinical aspects such as duration of prosthetic wear, age of acquisition, gender, current age or type of prosthesis [2, 27, 29]. Satisfaction with the shape, color, motility, comfort and fixation are often expressed by patients [27]. Primary concerns largely remain the same over time, with health of the remaining eye, ability to judge distance, receiving good advice and changes to appearance being at the forefront [28].

Identification of the factors linked to artificial eye wearers wellbeing are starting to be investigated. Hill et al. (2011) found the visibility of the condition rather than the extent, type and severity of the disfigurement increases levels of distress. Incorporating the emotional, psychosocial and economic impact on the artificial eye wearer, ensures better care for the patient decreasing levels of distress and increasing their confidence in the care received [23–27].

Facial disfigurement

Twenty-nine articles regarding the psychological impact of facial disfigurements were found during the search strategy. Of these, twenty-four met the inclusion criteria; eight of which full articles were obtained for.

The psychological care of patients with facial disfigurement is also overlooked despite patients having

lower levels of quality of life compared to controls [30–33]. High levels of anxiety and depression, maladaptive behaviors and reduced emotional wellbeing have been found in this population group [33] suggesting that psychological adjustment to the facial disfigurement is a key indicator of overall recovery [33]. Psychological adjustment has been shown to be worse for patients with acquired facial disfigurement than congenital facial disfigurement with females having significantly higher levels of anxiety compared with males [30, 33]. Reactions of other people to the disfigurement, location and maintenance of the prosthesis, impact of treatment and self-perception of their illness can affect patient's levels of adjustment leading to high levels of distress [30, 32, 33].

Patients with facial disfigurement report difficulties in social settings when meeting someone for the first time and in forming friendships leading to high levels of anxiety, low self-esteem and creating expectations about life chances [32, 34]. Reasons for this include focusing on information that supports their internal views. Providing social support that matches the patient's needs and challenging beliefs about the disfigurement can lead to successful outcomes such as acceptance [34, 35]. Self-acceptance comes from finding meaning of the distress whereby the patient looks beyond their physical disability. In turn, this makes them feel more accepted by others and increases their level of confidence and independence, reducing social distress, depression and anxiety [35, 36].

Measuring patient's quality of life can provide useful information regarding the health needs of these patients when planning prosthetic rehabilitation [30]. By understanding a patient's distress, the stigma they face and type of social support required, psychological growth can occur whereby the patient redefines themselves with positive support of others [37, 38].

DISCUSSION

The scoping review has 'mapped' literature documenting the development of artificial eyes throughout the years. Three themes were identified in the review with the current design and manufacturing process being the most referenced.

From their innovation in ancient Egypt, artificial eyes have undergone noteworthy advancement [11]. The 16th century saw a resurgence in the manufacturing and design process where artificial eyes were being fitted in the socket and experimentation with materials lead to the use of cryolite glass; changing the shape from a sphere to a shell form then later to the Snellen reform eye [6, 9]. Despite investigation with other materials, it was not until WWII that methyl-methacrylate replaced glass as the main material [4, 10]. Its advantages included being lightweight, easy to mould, fit and adjust, durability and having good color permanence [6, 17]. The few disadvantages associated with this material are largely related to poor restoration as a result of inadequate equipment and materials [20].

The advent of WWII also highlighted the importance of obtaining an accurate impression of the socket for optimal fit. With custom-made eyes came research into effective ways to fabricate an artificial eye [3, 6, 18]. Being created from dental material, the process of manufacturing methyl-methacrylate artificial eyes has largely followed the same procedures employed in manufacturing dentures [11]. Whilst adaptations have been made, this has largely been through trial and error by ocularist throughout the years [4, 13, 15].

Whilst the impression technique has gone through minimal changes, development of the artificial eye has occurred through digital photography of the iris. Although this method can be cost and time efficient, simple and practical [6, 21], special equipment is required which is not always able to provide fine details of structures.

Research into the psychological impact of artificial eyes and facial disfigurement has highlighted above average levels of clinical anxiety and depression, maladaptive behaviors and reduced emotional wellbeing. Patients internal views about their disfigurement and prosthesis affects their psychological adjustment [2], resulting in reduced self-acceptance which increases distress and perceived stigma. By understanding how the prosthesis affects the patient's quality of life, adequate support can be provided resulting in the patient's psychological growth [27].

STRENGTHS AND LIMITATIONS

Methodological issues

'Mapping' literature produces a vast amount of research, thus creates difficulty in deciding breadth over depth. However, the framework of a scoping review allows prioritization of certain aspects of the literature that is the best fit of the research question. The development and application of the inclusion and exclusion criteria after the search strategy allows for the most relevant articles to be included based on familiarity with literature.

Due to the nature of the scoping review, 74% of the articles were qualitative in nature, providing detailed background information and processes involved that quantitative studies would not be able to achieve. Most of the studies were narrative inquiries or historical reviews. Whilst the majority of articles were related to the current design and manufacturing of artificial eyes, there has been minimal changes in the technological development of artificial eyes. Variations of the impression technique have been developed through trial and error by the ocularists, rather than specific research. As this specialty area grows, quantitative studies should be undertaken that would further enhance our knowledge and lead us

closer to incorporating technological advancements into the design and manufacturing process.

The remaining 26% of articles used mixed methods or quantitative methods, all of which addressed the psychological impact of artificial eyes and facial disfigurement. Articles addressed quality of life, levels of distress and stigma in both population groups. Commonly used measures included the hospital anxiety and depression scale, quality of life core questionnaire, perceived stigmatization questionnaire and the social distress scale; focusing more on a patient's ability to cope rather than satisfaction with their situation. As a quantitative measure, questionnaires are not able to provide the whys and how of a patient's response. Only two articles administered interviews, one of which was combined with a questionnaire.

Whereas articles regarding the psychological impact of facial disfigurements had an adequate sample size, articles related to artificial eye impact had a small sample size. A possible reason for this is the small population of patients requiring artificial eyes. Articles related to the current design and manufacturing of artificial eyes largely focused on specific techniques developed by ocularists. Thus, the results are subjective in nature, have a lack of rigor, are unable to be generalized and difficult to replicate.

By not being discriminative in the location of publication, saw various techniques employed in the manufacturing and fitting process; some of which may not be applicable or used in other countries or services where different levels of standards exist. Through continuous research, recommendations and guidelines may be produced to create a standard of care for all wearers within and between countries.

Future research

This review has identified both positive and negative outcomes of the current form of artificial eyes and the impact it has on the patient, yet there is a lack of clear evidence to support any future technological development. Although the scoping review suffers from some methodological weaknesses, employing a systematic review would not rid it of them all, thus would not offer any more conclusive evidence.

The overwhelming advantages associated with acrylic resin may be reason for a lack of research into other materials that can be more beneficial, particularly biocompatible materials. The use of biocompatible materials has been used for the heart, ear, dental implants, prosthetic joints, ocular lenses, and maxillofacial reconstruction. Its use in artificial eyes is yet to be investigated. One type of biomaterial; artificial and natural polymers including poly (vinyl chloride), polyurethanes, collagen, elastin and silk; is worthy of extensive research.

Future research suggestions have been made for the psychological impact of artificial eyes on the wearer. By understanding the predictors, therapeutic treatment can be incorporated into the rehabilitation process improving the patient's psychological adjustment. Knowledge of these predictors will come from methodologies that get to the crux of the patient's experience. Therefore, future research needs to employ qualitative methods such as interviews, specifically those that are experience led. Not only can this help with patients psychological wellbeing, it may also create suggestions for the advancement of artificial eyes.

Key messages and recommendations

The overall aim of the scoping review is to understand the development of artificial eyes and its impact on the wearers in order to improve the current process. The list below sets out key messages and recommendations identified in the review.

Areas and questions for research

- Qualitative studies need to be undertaken in the psychological impact of artificial eye wearers, in particular, living with an artificial eye and the fitting of an artificial eye.
- With the current process being ocularist experience led, a quantitative study of the current design and manufacturing process is needed. This may contribute to developing uniformity between artificial eye services.
- There is a need to know more about the effectiveness of support networks of artificial eye wearers, such as family, friends, work colleagues, peers and acquaintances.
- Research needs undertaking into the relationship between different techniques in the design and manufacturing of artificial eyes and patient satisfaction/outcomes.
- Interventions need to be developed based on the psychological needs of artificial eye wearers.

Research design

- A wider range of research methods needs to be employed to increase the depth and breadth of data collected.
- Longitudinal studies to examine changes of need of artificial eye wearers in the short-term and long-term.
- Innovative approaches to the design and manufacturing of artificial eyes drawing on ocularists, patients and their families experience and expertise.

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Holly Chinnery – Substantial contribution to the conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published
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Guarantor
The corresponding author is the guarantor of submission.

Conflict of Interest
Authors declare no conflict of interest.

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REFERENCES

1. Manoj SS. Modified impression technique for fabrication of a custom made ocular prosthesis. Anaplastology 2014;3(2):129.
2. Ayanniyi AA. Emotional, Psychosocial and economic aspects of anophthalmos and artificial eye use. Int J Ophthalmol Visual Sci 2013;7(1).
3. Benson P. The fitting and fabrication of a custom resin artificial eye. J Prosthet Dent 1977 Nov;38(5):532–8.
4. Cerullo L. Plastic artificial eyes: Overview and technique. Adv Ophthalmic Plast Reconstr Surg 1990;8:25–45.
5. Deacon BS. Orbital implants and ocular prostheses: A comprehensive review. Journal of Ophthalmic Medical Technology 2008;4(2).
6. Goiato MC, Bannwart LC, Haddad MF, dos Santos DM, Pesqueira AA, Miyahara GI. Fabrication techniques for ocular prostheses: An overview. Orbit 2014 Jun;33(3):229–33.
7. Raizada K, Rani D. Ocular prosthesis. Cont Lens Anterior Eye 2007 Jul;30(3):152–62.
8. Artopoulou II, Montgomery PC, Wesley PJ, Lemon JC. Digital imaging in the fabrication of ocular prostheses. J Prosthet Dent 2006 Apr;95(4):327–30.
9. Dyer NA. The artificial eye. Aust J Ophthalmol 1980;8(4):325–27.
10. McCord CP. Artificial eyes: The early history of ocular prostheses. J Occup Med 1965 Feb;7:61–8.
11. Danz W Sr. Ancient and contemporary history of artificial eyes. Adv Ophthalmic Plast Reconstr Surg 1990;8:1–10.
12. Reisberg DJ, Habakuk SW. A history of facial and ocular prosthetics. Adv Ophthalmic Plast Reconstr Surg 1990;8:11–24.
13. Roman F. The history of artificial eyes. Br J Ophthalmol 1994 Mar;78(3):222.
14. Nuti Sobrinho A, Garcia de Lima E, Mattos MG, Watanabe I. A study of ocular prostheses. I. Manufacture and indications for use. Rev Fac Odontol Ribeiro Preto 1986 Jul-Dec;23(2):135–43.
15. Wilson RP. Artificial eyes in ancient Egypt. Surv Ophthalmol 1972 Mar–Apr;16(5):322–31.
16. Kelley JJ. History of ocular prostheses. Int Ophthalmol Clin 1970;10(4):713–9.
17. Erpf SF. Comparative features of plastic and/or glass in artificial-eye construction. AMA Arch Ophthalmol 1953 Dec;50(6):737–44.
18. Phillips W. The making and fitting of acrylic resin artificial eyes. Br J Physiol Opt 1950 Oct;7(4):217–24.
19. Allen L, Webster HE. Modified impression method of artificial eye fitting. Am J Ophthalmol 1969 Feb;67(2):189–218.
20. Charlesworth F. Fitting an artificial eye. Nurs Times 1966 Feb 11;62(6):172–4.
21. Bartlett SO, Moore DJ. Ocular prosthesis: A physiologic system. J Prosthet Dent 1973 Apr;29(4):450–9.
22. Schneider RL. Modified ocular prosthesis impression technique. J Prosthet Dent 1986 Apr;55(4):482–5.
23. Martin O, Clodius L. The history of the artificial eye. Ann Plast Surg 1979 Aug;3(2):168–71.
24. Mathews MF, Smith RM, Sutton AJ, Hudson R. The ocular impression: A review of the literature and presentation of an alternate technique. J Prosthodont 2000 Dec;9(4):210–6.
25. LeGrand JA Jr, Hughes MO. Empirical impression technique for artificial eye fitting. Adv Ophthalmic Plast Reconstr Surg 1990;8:118–25.
26. Goiato MC, Dos Santos DM, Moreno A, Filié Haddad M, Turcio KH. An alternate impression technique for ocular prostheses. J Prosthodont 2013 Jun;22(4):338–40.
27. McBain HB, Ezra DG, Rose GE, et al. The psychosocial impact of living with an ocular prosthesis. Orbit 2014 Feb;33(1):39–44.
28. Pine K, Sloan B, Stewart J, Jacobs RJ. Concerns of anophthalmic patients wearing artificial eyes. Clin Exp Ophthalmol 2011 Jan;39(1):47–52.
29. James H, Ellis JR, Foulds WS. A method of artificial eye manufacture. Br J Ophthalmol 1976 Feb;60(2):153–5.

30. Atay A, Peker K, Günay Y, Ebrinç S, Karayazgan B, Uysal Ö. Assessment of health-related quality of life in Turkish patients with facial prostheses. Health Qual Life Outcomes 2013 Jan 26;11:11.
31. Bonanno A, Esmaeli B. Facial disfigurement, stigma, and cancer: Interaction between patients and members of secondary groups. Sociological Spectrum 2012;32(2):138–56.
32. de Melo Filho MR, Rocha BA, de Oliveira Pires MB, et al. Quality of life and self-image in patients with head and neck cancer. Universitas Psychologica 2013;11(1):13–23.
33. Fu L, Bundy C, Sadiq SA. Psychological distress in people with disfigurement from facial palsy. Eye (Lond) 2011 Oct;25(10):1322–6.
34. Clarke A. Psychosocial aspects of facial disfigurement: Problems, management, and the role of a lay-led organization. Psychol Health Med 1999;4:127–42.
35. Deno M, Tashiro M, Miyashita M, et al. The mediating effects of social support and self-efficacy on the relationship between social distress and emotional distress in head and neck cancer outpatients with facial disfigurement. Psychooncology 2012 Feb;21(2):144–52.
36. Threader J, McCormack L. Cancer-related trauma, stigma and growth: The 'lived' experience of head and neck cancer. Eur J Cancer Care (Engl) 2016 Jan;25(1):157–69.
37. Masnari O, Schiestl C, Rössler J, et al. Stigmatization predicts psychological adjustment and quality of life in children and adolescents with a facial difference. J Pediatr Psychol 2013 Mar;38(2):162–72.
38. James H, Jenkinson E, Harrad R, et al. Appearance concerns in ophthalmic patients. Eye (Lond) 2011 Aug;25(8):1039–44.

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