Anaplastology - Advancements in Maxillofacial Prosthetics.

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Abstract

Objective: This article explores cutting-edge developments in maxillofacial prosthetics within the field of anaplastology. It delves into innovative techniques, materials, and technologies driving prosthetic rehabilitation, ultimately aimed at restoring confidence and improving the lives of individuals with facial defects.

Background: Anaplastology combines expertise from various fields like prosthodontics and medical art to offer comprehensive care. The article examines drawbacks in traditional surgical methods, like limited tissue and patient preferences, leading to prosthetic rehabilitation. It discusses prosthetic fabrication techniques like conventional methods, Computer-aided design/computer-assisted manufacture (CAD/CAM), and 3D printing, and explores material advancements for realistic aesthetics and durability.

Method: We extensively searched PubMed, Scopus, and Google Scholar using keywords like "anaplatology," "prosthetics," "ear prosthesis," "silicones," and "CAD/CAM," supplemented by manual searches of reference lists. Our inclusion criteria encompassed studies on mobility aids, governmental and non-governmental initiatives for the disabled, and challenges in assistive mobility solutions. We considered original research and review papers published between 1979 and 2023.

Conclusion: Creating prosthetic solutions for maxillofacial defects is complex, requiring the right materials and techniques for satisfactory results. Anaplastology bridges traditional methods and recent advancements, enabling the adoption of improved approaches that balance effectiveness, affordability, and simplicity.

Keywords: Anaplastology, CAD/CAM, ear prosthesis, high-density porous polythene, prosthetics, silicones.

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Introduction

Every individual has the right to present themselves in a way that reflects their humanity. Physical appearance influences self-confidence and forms the basis for personal recognition. The societal emphasis on external appearance makes repairing or concealing deformed body parts necessary. In various aspects of life, such as employment and marriage, the significance given to external appearance often outweighs the qualities of the mind and character. Therefore, restoring the beauty of damaged or deformed body parts can significantly enhance a patient's quality of life.[1]

Anaplastology is the field of science that deals with prosthetic rehabilitation of bodily defects of the human body that are visible and produce social awkwardness for an individual.[2] Prosthetics become an excellent choice when surgical reconstruction may not be ideal, as surgery may not always meet the patient's expectations.[1,3] Anaplastologists from diverse fields like prosthodontics, ocularists, orthotics, and medical art or illustration play a crucial role in this process.[1,4] Prosthodontists, specifically, dentists, specialize in providing care for patients with significant oral and maxillofacial defects involving areas such as the nose, eyes, and ears.[3,5]

Methodology

We extensively searched PubMed, Scopus, and Google Scholar using keywords like "Anaplatology," "prosthetics," "ear prosthesis," "silicones," and "CAD/CAM," supplemented by manual searches of reference lists. Our inclusion criteria encompassed studies on mobility aids, governmental and non-governmental initiatives for the disabled, and challenges in assistive mobility solutions. We considered original research and review papers published between 1979 and 2023. Titles, abstracts, and full-text papers were screened, with disagreements on study selection resolved through consensus among the authors.

Taking over autogenous reconstruction

The surgical reconstruction of defects may be constrained by factors such as limited tissue availability, compromised blood supply, and the patient's overall health. Consequently, patients' expectations regarding their physical appearance may not always be fully met.[6] Despite advancements in transplant procedures, it is crucial for surgeons not to overlook the potential for prosthetic restoration.[7] Facial prosthetics, however, are not commonly considered as a reconstructive option. This is largely due to a lack of familiarity among both surgeons and patients with their application.[8,9]

The role of maxillofacial prosthetists becomes crucial in situations where surgery reaches its limit. This is particularly evident in cases involving significant deformities, poor blood supply, as seen in post-radiated tissue, advanced age of the patient, poor health conditions, or when patients decline reconstructive surgery.[2,3] The choice between reconstructive surgery and prosthetic reconstruction is often guided by the surgeon's training and the prevailing practices in a given region. For instance, in the United States, most children with microtia undergo autogenous reconstruction techniques, while in Sweden, prosthetics are more commonly employed.[10,11]

Before selecting between these options, it's essential to recognize that optimal results from a prosthesis are achieved when the anatomy of the body part to be restored is absent. Reconstructive surgery is typically preferred when there are anatomical deformities or misplacements. However, achieving successful and realistic outcomes with a prosthesis relies on effective communication and close collaboration between anaplastologists and surgeons. Anaplastologists can outline various parameters detailing how they envision surgical site closure, enabling them to provide patients with a genuinely lifelike prosthesis.[1,6]

Retention of maxillofacial prostheses

One of the important factors for the long-term success of a prosthesis is Retention [12].

Different methods for the retention of a prosthesis include anatomical, mechanical, chemical, and surgical.

Anatomical retention is provided by the existing structures such as any undercut area in occlusal defect.[13] If an anatomical undercut can be used efficiently it can result in the least invasive and simplest type of retention.

Mechanical retention in prosthetics can be achieved through additional external support, such as spectacle frames, hair bands and magnets.[14] Magnets, commonly used in hybrid devices, play a role in these systems. Hybrid devices involve two prostheses, one intraoral and the other extraoral. They are individually adapted to specific defects and connect internally through magnets, providing mutual retention.[15]

Chemical retention is facilitated by adhesives, which, while easy to use, have drawbacks such as irritation, perspiration issues, and potential compromise of bond strength with any prosthesis movement.[14] In a study, the effectiveness of adhesives in securing a prosthesis was investigated using a silicone elastomer strip with Secure 2, a medical adhesive. The research found that bond strength was highest among individuals with consistently dry skin. Throughout the day, bond strength decreased gradually, up to 8 hours, but re-application of adhesive resulted in stronger bonds.[16].

The most reliable method of retention is surgical, achieved primarily through implants. At the cellular level, implants are secured through processes such as bio-integration, fibro-osseous integration, and osseointegration. Among these, osseointegration stands out as the most dependable, as the implant becomes fully integrated with the bone both structurally and functionally.[17]

Various techniques for the fabrication of prosthesis

In the conventional method wax pattern is fabricated for the prosthesis which is later used to create mold and this mold is used to pack the prosthetic material. For auricular prosthesis, either the contralateral ear is taken as a guide or any family member or relative with ear contours closely resembling that of the patient can act as a donor where the impression is taken and the wax pattern is fabricated from the impression. Necessary recontouring is done.[18]

The fabrication of ear prostheses commonly involves the use of Shaper or Tracer machines. These machines employ a metal shaper activated by hand, featuring cutting and tracing tools on an arm that moves in opposite directions as the master cast is shifted horizontally. This process produces a mirror image of the desired prosthesis.[18] Advanced techniques utilize CT scanning and MRI to obtain images of the existing structure. The prosthesis is then designed on a computer, and this design is printed using rapid prototyping or stereolithography. Rapid prototyping creates a mold layer by layer, allowing for the reproduction of undercuts and finer details.[19,20]

Thermojet printing, studied by Eggbeer et al. in 2006, is recognized for its ability to produce high-definition parts in suitable materials.[21] Stereolithography typically employs ultraviolet (UV) light to cure resin into the desired shape. It can also use UV light to fuse layers of metal/resin and laminate thin sheets to achieve the desired form.[22] Despite the skill of an Anaplastologist, using impression material on soft tissue can deform it, leading to inaccuracies. Advanced methods like 3D laser scanning and photography offer precise images of soft tissue. The 3dMD FaceTm system, commercially available in Atlanta, GA, evaluates the external surface of a patient in just 1.5 milliseconds. Using two stereo camera viewpoints, it forms a continuous point cloud, producing a wiring diagram for manufacturing 3D models.[23]

Ear prostheses are crafted using a 3D laser scanner to generate a digital 3D image of the healthy ear, which is then mirrored and replicated. This digital model is used by a rapid prototyping machine to produce a precise resin ear, ensuring accuracy while avoiding the potential distortions linked with traditional impression techniques.[18]

Materials

Throughout anaplastology's history, various materials such as porcelain, natural rubber, gelatin, and latex have been utilized.[24] Nevertheless, Methacrylates and Silicones are the prevalent materials in contemporary use. Methacrylates are chosen for their durability and hardness, whereas silicones provide a soft and flexible option that can be stretched to transparency at corners, seamlessly integrating with the surrounding skin for enhanced aesthetics.[13,25] The ongoing introduction of new materials continues to refine and improve aesthetic outcomes in the field.

Despite these advancements, weaknesses still exist in the physical properties of these materials, particularly in tearing resistance when used in thin layers, especially at the margins of defects or openings.[26] A survey found that room-temperature vulcanized silicone is the most frequently chosen material for crafting extra-oral maxillofacial prostheses. Moreover, silicone pigments for intrinsic coloring and silicon paste for extrinsic coloring are favored over artist's oil. The once-common practice of using dry earth and oil pigments for coloring has become less common in modern practice.[27]

Silicone is generally deemed more acceptable for external use due to its biocompatibility. However, occasional instances of allergic reactions have been reported, and in such cases, the material cannot be utilized even for external purposes.[26]

Requirements of material

Prosthetic materials must fulfill several key criteria, including biocompatibility, facilitating easy manipulation during fabrication, being cost-effective, and presenting a skin-like appearance and touch. Desirable characteristics in this regard encompass translucency, color stability, a skin-like texture, and a tactile sensation of softness. Additionally, the materials should demonstrate resistance to chemical and physical insults, including UV light, and possess sufficient strength to prevent tearing. It is noted that the use of colorants, adhesives, solvents, and cleansers has been reported to degrade both the static and dynamic mechanical properties of the material. The majority of discoloration and tearing tend to occur when patients remove the prosthesis or adhesive.[28-30]

Advances in material

Significant advancements have been made in prosthetic biomaterials, but a material closely resembling or duplicating skin has yet to be developed, highlighting the need for improved biomaterials in prosthetics. Experiments were carried out at the Charity Hospital of New Orleans to assess a new facial prosthetic material comprising low-cost Thermoplastic Chlorinated Polyethylene (CPE). This material demonstrated advantages over traditional silicone rubber, particularly in repair, relining, reconditioning, and overall prosthesis lifespan. It exhibited better edge strength, resistance to fungal growth, compatibility with various adhesives, and cost-effectiveness. The only reported drawback was the complexity and difficulty in processing the material. Introducing another innovative material, 3D-lite, which utilizes an open-weave polyester infused with a non-toxic resin, producing a lightweight and breathable prosthetic material.[2,31]

In 2015, Zardawi et al. examined the use of elastomers (SIL-25 and Matrix M-3428) in 3D-printed facial soft tissue prostheses. Elastomers were crucial in preventing powder disintegration in the fragile 3D-printed shapes. The study found that while immersion duration had no effect, applying 2-bar and 3-bar pressure for 20-25 minutes increased infiltration depth to about 4mm and 8mm, respectively.[32]

Taking a step ahead

With advancements in biomaterials and technology, Anaplastology has evolved beyond the basic restoration of missing or deformed body parts. The field has embraced innovative ideas, elevating its scope.

For Nasal Prostheses, functionality is as important as appearance. Cosmetic prostheses may not control airflow effectively, but by incorporating an intra-anatomy airway replication design, the prosthesis redirects airflow naturally, enhancing functionality and preventing displacement during activities like sneezing or coughing.[2,20] Cosmetic finger prostheses can be secured in place either by creating a suction effect between the stump and prosthesis or through mechanical methods like using rings or implants.[31]

For facial defects, retention is a challenge wherein, implant-retained prosthesis are important. Implant-retained prosthesis is a multi-staged procedure. Previously, giving an implant-retained facial prosthesis was a challenge.[33] However, various advances in technology at each stage like laser scanning, CAD-CAM etc. has significantly reduced the manual labor and increased the quality of treatment procedure and prosthesis as well.[34]

Given the various drawbacks linked to metal cranial implants such as higher thermal conductivity, susceptibility to infection, lower biocompatibility, and challenges in radiographic interpretation, alternative materials like acrylic resin, silicone, and polyethylene are commonly employed without complications. A recent advancement in implantable materials, high-density porous polyethylene (HDPE), has emerged as a superior option for calvarial reconstruction, presenting significant advantages compared to traditional methods.[2,34]

To prevent scar formation or contraction in burn patients, burn masks are commonly fabricated. Insignia, employing a 3D motion tracking laser scanner and computer-aided design software, produces a personalized mask without direct skin contact, eliminating any pain or discomfort for the patient. This clear plastic prosthesis applies direct pressure over the wound site, preventing excess collagen fiber formation and realigning them to a normal pattern. This minimizes the development of hypertrophic scars and flattens those already formed. Additionally, the burn mask acts as a protective barrier, shielding the wound from external forces that could hinder the healing process.[33,34]

Anaplastologic skills extend beyond restorative prostheses to include contributions to special effects, such as creating heads, aliens, and creatures for films and television.[2]

Conclusion

Prosthetic rehabilitation of maxillofacial defects is an intricate art, and the absence of an ideal material or suitable technique can result in unsatisfactory outcomes. Anaplastology, with its integrated approach to prosthetic management, stands between conventional techniques, recent advancements, and various therapeutic options. This midway position allows for the selection of further developments that offer improved results at an affordable cost and with a simple technique. Numerous research efforts are required to enhance silicone materials' physical properties, adherence, and biocompatibility or to develop new brands that can meet the evolving demands of aesthetics. The goal is to provide a "Life-Like" prosthesis that satisfies patients, preventing psychological and societal stigmas associated with maxillofacial defects.

References

1. Gaudin R, Raguse JD, Krause S, et al.: Quality of life and psychological evaluation of patients after anaplastology. J Craniomaxillofac Surg. 2023, 51:485-489.
2. Padmaja S: An insight into the future beckons of maxillofacial prosthodontics: Anaplastology. Journal of Dental Research and Review.
3. Kumar MS. 16: Maxillofacial prosthodontist: the god's apprentice. J Indian Prosthodont Soc. 2018, 18:80.
4. de Jong M, de Cubber J, de Roeck F, Lethaus B, Buurman D, Kessler P: Kunst verankerd in het gelaat [The art of facial prosthetics]. Ned Tijdschr Geneeskd. 2011, 155:3967.
5. Tanner PB, Mobley SR: External auricular & facial prosthetics: a collaborative effort of the reconstructive surgeon and Anaplastologist. Facial Plast Surg Clin North Am. 2006, 14:137-145. 10.1016/j.fsc.2006.01.003
6. Jablonski RY, Veale BJ, Coward TJ, et al.: Outcome measures in facial prosthesis research: A systematic review. J Prosthet Dent. 2021, 126:805-815. 10.1016/j.prosdent.2020.09.010
7. Klimczak J, Helman S, Kadakia S, et al.: Prosthetics in Facial Reconstruction. Craniomaxillofac Trauma Reconstr. 2018, 11:6-14.
8. Pingarron ML, Rey BJ: The current role of Anaplastology in maxillofacial surgery. Anaplastology. 2013, 3:123.
9. Akadiri OA: Evolution and trends in reconstructive facial surgery: an update. J Maxillofac Oral Surg. 2012, 11:466-472.
10. Tjellstrom A: Ossoeintegrated implants for replacement of absent or defective ear. clin plast surg. 1990, 17:355-366.
11. Tjellstrom A, Lindstrom J, Nyleno: The bone anchored auricular epithesis. Laryngoscope. 1981, 91:811.
12. Nazar SA, Nair VV, Harshakumar K, Ravichandran R: Retention in maxillofacial prosthetics: A review. Int J Appl Dent Sci. 2021, 7(2):568-573.
13. Karthikeyan I, Khatree M, Gaddale R, Pandraveti RR: A Review on prosthetic Rehabilitation of maxillofacial region. Journal of Scientific Dentistry. 2016, 6:(1):6-12. 10.5005/jsd-6-1-6
14. Thakkar P, Patel J, Sethuraman R, Nirmal N: Custom occular prosthesis: A palliative approach. Indian journal of palliative care. 2012, 18 (1):78-83.
15. Toso SM, Menzel K, Motzkus Y, et al.: Anaplastology in times of facial transplantation: still a reasonable treatment option?. J Craniomaxillofac Surg. 2015, 43:1049-1053.
16. Kiat SA, Gettleman L, Khan Z, Goldsmith LJ: Effect of adhesive retention of maxillofacial prosthesis. Part 2: Time and reapplication effects.. J Prosthet Dent. 2001, 85:438-441.
17. de Jong m, de cubber J, de Roeck F, et al.: The art of facial prosthetics. Nederlands tijdschrift voor geneeskunde. 2010, 155:3967.
18. Thotapalli S: Fabrication of mirror image prosthetics Ears- A short review. Anaplastology. 2013, 2(5):120.
19. Wolfaardt JF: Maxillofacial rehabilitation: prosthodontic and surgical considerations. Int J Oral Maxillofac Surg. 1998, 27:410.
20. Cheng AC, Morrison D, Cho RS, Archibald D: Vacuum formed matrix as a guide for fabrication of craniofacial implant tissue bar-retained auricular prosthesis. J Prosthet Dent. 1998, 79:711-714.
21. D Eggbeer, Pl Evans, R Bibb: A pilot study in the application of texture relief for digitally designed facial prosthesis.

Proc Inst Mech Eng H. 2006, 220(6):705-714.
22. Wolfaardt JF, Coss P: An Impression and cast construction technique for implant retained auricular prosthesis. J Prosthet Dent. 75:45-49.
23. Sabol JV, Grant GT, Liacouras P, Rouse S: Digital image capture & rapid prototyping of the maxillofacial defect. Int J Prosthodont. 2011, 20:310-314.
24. Federspil PA: Auricular prostheses. Adv Otorhinolaryngol. 2010, 68:65-80.
25. Richard C Cardoso, Patricia C Montgomery, Sudarat Kiat-Amnuay: Extraoral Maxillofacial Prosthetic Materials: Results of the 2020 International Survey. Int J Prosthodont. . 2023, 36(5):570-580.
26. Abdulhadi LM: The need is growing for a new replacing Biointegrated material. Anaplastology. 2013, 2:1:108.
27. Montgomery PC, Amnuay SK: Survey of currently used material for fabrication of extraoral maxillofacial prosthesis in North America, Europe, Asia & Australia. Int J Prosthodont. 2009, 19:482-490.
28. Sweeney WT, Fischer TE, Castleberry DJ, Cowperthwaite GF: Evaluation of improved maxillofacial prosthetic materials. J Prosthet Dent. 1972, 27:297-305.
29. Lemon JC, Chambers MS, Jacobsen ML, Powers JM: Color stability of facial Prosthesis. J Prosthet Dent. 1995, 74:613-618.
30. Koran A, Yu R, Powers JM, Craig RG: Color stability of a pigmented elastomer for maxillofacial appliances. J Dent Res. 1979, 58:1450-1454.
31. Lemon JC, Kiat-Amnuay S, Gettleman L, Martin J, Chambers MS: Facial prosthetic rehabilitation: Preprosthetic surgical techniques and biomaterials. Curr opin otolaryngol Head neck Surg. 2005, 13:255-262.
32. Zardawi FM, Kaido X, Noort R, Yates JM: Investigation of Elastomer Infiltration into 3D Printed Facial Soft Tissue Prostheses. Anaplastology. 2015, 4:1:139.
33. Beasley RW, de Beze GM: Prosthetic replacements for thumb. Hand Clin. 1992, 8:63-69.
34. Ciocca L, Fantini M, De Crescenzio F, Persiani F, Scotti R. New protocol for construction of eyeglasses-supported provisional nasal prosthesis using CAD/CAM techniques. J Rehabil Res Dev. 2010;47(7): 595–04.