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REVIEW ARTICLE

History of intranasal splints

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Abstract

Objective: Intranasal splints have long been utilised as a post-operative adjunct in septoplasty, intended to reduce the risk of adhesions and haematoma formation, and to maintain alignment during healing.

Methods: A Medline literature review of the history and evolution of intranasal splint materials and designs was performed. Advantages and disadvantages of various splints are discussed.

Results: Intranasal splints fashioned from X-ray film were first reported in 1955. Since then, a variety of materials have been utilised, including polyethylene coffee cup lids, samarium cobalt magnets and dental utility wax. Most contemporary splints are produced from silicon rubber or polytetrafluoroethylene (Teflon). Designs have varied in thickness, flexibility, shape, absorption and the inclusion of built-in airway tubes. Future directions in splint materials and designs are discussed.

Conclusion: Intranasal splints have steadily evolved since 1955, with numerous novel innovations. Despite their simplicity, they play an important role in nasal surgery and will continue to evolve over time.

Key words: Polytetrafluoroethylene; Polyethylene; Splints

Introduction

Intranasal splints have long been utilised as an adjunct in a range of operations on the nasal septum. Traditionally, they have been used with the intention of preventing adhesions, haematoma formation and perforation, and to facilitate mucosal healing and support tissue alignment.[1] Although their utilisation varies between surgeons, and possible side effects include pain, discomfort and infection,[2,3] they remain a popular peri-operative adjunct. Their utility has also seen them used in the management of epistaxis, as an alternative to nasal packing.[4]

The history of the intranasal splint in the literature dates back to at least 1955.[5] Since then, many advances have been made on the original concept, to reduce pain and discomfort, reduce obstruction, improve ease of insertion, and improve efficacy. In this paper, we review the literature and summarise the history of intranasal splints.

Materials and methods

A review of the English literature via Medline, from 1946 to 2017, was performed. We reviewed the different materials utilised, and their various shapes and forms, assessing the advantages and disadvantages of each historical innovation that has led to the products in use today. In reviewing current practice, we consider common splints and discuss concepts for future development.

Results

X-ray film

The earliest documented description of intranasal splints was by Salinger and Cohen in 1955, in their article entitled 'Surgery of the difficult septum'.[5] The authors discussed a method of septoplasty that incorporated intranasal splints for the first time. This involved placing two strips of hand-cut X-ray film into the nose and securing them with two mattress sutures through and through to hold the septum firmly in between. The technique aimed to prevent the liberated septal cartilage from falling backwards and overriding the bony septum, and, importantly, to ensure healing in the midline. The nose was then packed, lateral to the X-ray film, for additional support, and a copper mould was applied as an external nasal splint. The splints were left in situ for at least 7 days.[5] This original concept of using a temporary sturdy device attached to the septum to facilitate stabilisation provided the impetus for future developments.

Coffee cup lids

In the following decade, Wright (1969) reported the novel use of polyethylene coffee cup lids,[6,7] again hand-cut, to splint the healing septum. The effectiveness of polyethylene as a biomaterial stemmed from its inherent properties. Specifically, it is inert,

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non-biodegradable and non-adherent; these are characteristics that have seen polyethylene used in other surgical applications such as joint prostheses.[8]

Polytetrafluoroethylene

Other authors proposed new materials, such as polytetrafluoroethylene (Teflon)[9] – a fluorocarbon polymer with characteristics similar to polyethylene. Outside the medical field, Teflon, with its low-friction properties, has been utilised in various industrial applications such as bearings and gears. Furthermore, its extreme non-reactivity and high temperature rating has also seen it used in industrial pipelines and as a liner in hose assemblies. These properties allowed Teflon splints to be advantageous in terms of comfort, whilst remaining physiologically inert.

Since that time, there have been several revisions of the Teflon splint, including the Reuter polytetrafluoroethylene splint.[10] However, the concept remains the same: the use of a relatively inert, light and elastic material aimed at providing structural support and minimising adhesions.

In recent years, Teflon splints have been trialled as a method to manage recurrent, refractory epistaxis, with provisional results demonstrating effectiveness and tolerability.[11]

Incorporating nasal airways

In 1977, Doyle *et al*. proposed a pre-formed polyethylene intranasal splint (thus avoiding the inconvenience of having to manually shape the splint), which consisted of two broad segments with a connecting isthmus and a breathing tube on either side.[7] The function of the isthmus was to provide anterior stabilisation (thus requiring only one posteriorly placed suture). It also acted to prevent potentially fatal aspiration in the event of suture dislodgement (a rare event which, to our knowledge, has only been reported once in the literature[12]). The edges were also rounded and beaded to prevent intranasal lacerations. The entire device was left in situ for a total of 7–10 days. The advantage of polyethylene was that the breathing tube rarely obstructed with secretions, as mucus did not readily adhere to the material.[7] In the event that the breathing tubes did become blocked with mucus, they could be easily cleaned by douching or aspiration.

Magnetic splints

All the designs up until the 1980s required the inserted splint to be sutured to the septum. In 1982, Goode employed magnets as a means for maintaining septal pressure and securing the splints in position.[4] Two pieces of silicon rubber were used, each containing three samarium cobalt magnets, with string ties attached to the anterior ends. Following splint insertion, the anterior ties were knotted to prevent posterior displacement. A section of tape or gauze was inserted between the ties and columella to prevent notching.

Goode trialled magnetic splints on 30 patients and found them to be effective and well tolerated, and soon extended their use beyond septal and turbinate surgery.[4] Goode trialled the magnetic splints to hold septal grafts in place, and even successfully used them to manage anterior epistaxis as an alternative to gauze packing. He noted that the splints were advantageous over packing post-septoplasty as they were more comfortable, allowed breathing and provided uniform pressure – properties that are all transferrable to managing anterior bleeds.[4]

However, the use of magnets strong enough to resist displacement carried the risk of ischaemia and perforation formation, a phenomenon reported in multiple case studies involving magnetic foreign bodies.[13,14] Accordingly, the popularity of this technique was relatively short-lived.

Dental wax

Nayak *et al*. described the use of dental utility wax as a splint material in 1995.[15] They reported that the material was inexpensive, malleable and easily shaped. The authors stated that it was effective in minimising intranasal adhesions, and reduced the incidence of headache compared to conventional packing. However, its main limitation was the increased incidence of post-nasal drip, presumably due to irritation or wax breakdown.

Absorbable splints

The majority of historical designs featured non-absorbable materials, which require removal at follow up. A novel concept was that of absorbable splints, aimed at reducing the need for follow up for splint removal. This is a potential advantage in smaller and rural facilities, where specialist visits are infrequent or where patients may have to travel considerable distances for review. This would also have the added advantage of removing the pain and discomfort associated with splint removal.

One proposal suggested the use of collagen as a biodegradable material, prepared into a gelatine substrate such as Gelfilm (Pfizer, Kalamazoo, Michigan, USA). This would potentially have the advantage of being biocompatible, and would also allow for impregnation with substances such as antibiotics or gluteraldehydes to control the rate of splint dissolution. Although a patent was initially approved and assigned, it later expired, and the concept was not pursued.[16]

Absorbable packing materials

The development of dissolvable intranasal dressings, such as polyurethane foam (Nasopore; Polyganics, Groningen, the Netherlands), and, more recently, carboxymethylcellulose (NasaStent; Smith & Nephew, London, UK), resulted in an alternative to the traditional splint. These packing materials have been reported to reduce adhesions and nasal discharge.[17] Product information reports that polyurethane foam breaks down over 3–4 days to polyamine, whilst

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carboxymethylcellulose converts to a hydrocolloid gel. As such, they are only effective in the early post-operative period. Similarly, most non-absorbable dressings are removed on day 0 or 1 post-operatively. Thus, the usage of an intranasal splint, which typically remains in situ for one to two weeks, has the advantage of being able to provide more consistent structural support and prevent complications for a prolonged period post-operatively, compared to an absorbable dressing.

Internal splints

The interest in absorbable splints led to the use of materials that could be incorporated into the septal wound as an 'internal' splint. Boenisch and Mink (2000) reported the use of polydioxanone foil in both animal (rabbit) models and human patients.[18] Extracorporeal septoplasty was performed, with suturing of polydioxanone foil to the excised cartilage, before securing the foil-cartilage complex within the raised septal flaps. Histological analysis showed that resorption of the material commenced at 15 weeks, and was complete by 25 weeks, with minimal tissue reactivity and scarring.[18]

Internal nasal valve preservation

An ideal splint is one that minimises pain and discomfort, and allows for adequate nasal airflow in the post-operative period, whilst preventing intranasal adhesions and supporting the healing tissues. The Guastella– Mantovani septal valve splint was an innovation aimed at preserving the nasal valve area.[19] Specifically, the anterior end of a Teflon splint was curved to maintain the physiological angle of the internal nasal valve. By reinforcing support in this region, functionally important for airflow, the authors proposed that the risk of adhesion formation would be reduced, and optimal nasal breathing preserved.

Modern splints

Splints come in a variety of shapes, sizes and fits, with additional features depending on the type of procedure performed or patient factors. For example, the Doyle Open Lumen Splint (Boston Medical, Shrewsbury, Massachusetts, USA) is a silicon splint that was designed to address the issue of potential luminal obstruction by a hypertrophied turbinate. It features a curved open lumen design that wraps around the inferior aspect of the turbinate in an attempt to maintain natural airflow.

The Spacer Splint (Summit Medical, Saint Paul, Minnesota, USA) is another example of a modern splint with adaptive features. It has a curved trough that extends from the body of the splint, and wraps around the inferior free edge of the middle turbinate. This aims to prevent lateralisation of the middle turbinate, and thus avoid contact and adhesion formation with the lateral nasal wall.

Some devices, such as the Doyle Combo Splint (Boston Medical), have even included padding around the splint that expands with the introduction of fluid. This is intended to reduce irritation from the splint edge and function as well-tolerated nasal packing, whilst allowing for air passage through the enclosed lumen.

Discussion

Current practice

In the current era, there is much variation in practice with regard to post-operative splints and packing. Commonly used intranasal splint materials include silicon rubber, plastic and Teflon. A survey of 301 UK ENT consultants in 1992 revealed that 52.5 per cent used intranasal splints routinely in nasal surgery, predominantly for adhesion prevention, with pre-shaped silicon rubber splints being the most popular (75 per cent of splint users).[20]

Controversy still exists as to the efficacy of intranasal splints in preventing syncytia formation and ensuring healing of the septum in alignment. At least five randomised controlled trials suggest that conventional splints increase post-operative discomfort, without significantly reducing adhesion rates.[3] Cook *et al*. (1992) studied adhesion formation following septal surgery, as well as septal position and airway patency, and found no significant difference between the splint and no-splint groups for any of the outcomes.[21] However, a study by Jung *et al*. (2011) found the use of thin Silastic splints to be just as well tolerated as having no splint in situ at one week, and to have improved comfort and mucosal status comparatively at two weeks.[1] This supports the results of a previous study by Campbell *et al*. (1987), who reported that splints were highly effective in preventing adhesion formation; these authors even highlighted the potential for their routine use, but found that patients could experience significant discomfort.[22]

Similarly, controversy also surrounds the effectiveness of splints in reducing the incidence of post-operative septal haematoma. Although conventional wisdom has proposed that splints may prevent haematoma formation by providing pressure on the healing septum, studies comparing trans-septal suture closure and intranasal splints have shown no significant difference in the incidence of post-operative haematoma.[23,24]

Interestingly, Salinger and Cohen's original description of an intranasal splint derived from X-ray film has received mention in the literature in the last two decades. Killic and Akbas (2001) described the use of bleached X-ray film as a low-cost and readily available alternative to Silastic splints.[25] This was reiterated by Gryskiewicz, who, in a Letter to the Editor published in 2001, commended the usefulness and resourcefulness of X-ray splints in developing countries.[26] He did, however, also make note of one particularly serious adverse event, where the brittle X-ray film cracked, migrated posteriorly, and lodged into the mucosa, causing significant pain and distress to the patient.[26]

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Gryskiewicz proposed that where splinting was required, Silastic splints were preferable as they were easier to remove if they migrated posteriorly.

Future concepts

The future of the intranasal splint lies in optimising comfort and breathability, whilst preventing adhesion formation, and allowing easy insertion and removal. As such, the ideal future splint should incorporate comfortable packing and splinting in one device, permit breathing, and should breakdown at the one to two week mark.

Conclusion

The intranasal splint is one of rhinology's common adjuncts. It has undergone numerous revisions throughout its past. However, the intranasal splint can be poorly tolerated by patients and can cause discomfort, particularly during removal. It is anticipated that these limitations will diminish with continued evolution.

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