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Clinical Utility of Bone Wax - A Post Market Clinical Follow Up Study

Murali Mohan S[1], Ramaswamy Anikode Subramanian[2], Mathangi Krishna Kumar[3]

[1]HOD Neurosurgery, Sagar Hospitals, Bengaluru, Karnataka, India
drmurali[at]drklinisch.com

[2]Professor and HOD, Pathology, PESIMSR, Kuppam, Karnataka, India
drramaswamy[at]drklinisch.com

[3]Consultant Anesthesiologist, Sagar Hospitals, Bengaluru, Karnataka, India
drrmathangi[at]drklinisch.com

Abstract: ***Bone wax is a century-old material used in surgical practice to control bleeding of disrupted bone surfaces by acting as a mechanical barrier. The current bone wax products are commonly packed in easy-to-open foil in the form of sterile sticks or plates. They have excellent malleability and smooth consistency, enabling cost-effective and easy handling approach for bleeding control. It has also been reported that the bone wax can at times cause complications including foreign body reaction and infection. This post market clinical follow up study was done to assess the clinical performance, safety and acceptability of the Waxocare® bone wax and to determine if any undesirable events occurred. A total of 31 subjects participated in the study among which 19 patients underwent cranial surgeries and 12 spine surgeries. All the subjects benefitted out of the surgeries where bone wax was used with excellent intended results. Additionally, no adverse events related to the use of bone wax were recorded in the study.***

Keywords: bone wax, surgery, hemostatic

1. Introduction

Bone when surgically incised or traumatically fractured, leads to osseous haemorrhage. This can be a difficult problem to control, especially in the highly vascular bones of the spine and sternum. Medical sterile bone wax is an essential material for haemostasis of bone during orthopaedic surgeries, thoracic surgeries and neurological surgeries. This material is commonly defined as a waxy substance used to mechanically control bleeding from bone fractures. Being strongly hydrophobic, it is not metabolised; therefore, it is minimally resorbed from the site of application and causes no effect on pH of the contacted body fluids [1].

Bone wax has no inherent haemostatic quality. It mainly acts as an impenetrable mechanical barrier at the wound site. Bone haemostasis results from the mechanical occlusion of Haversian canals in cortical bone and medullary spaces in cancellous bone. Bone wax has been in use in surgical practice as described above. Several studies have demonstrated the safety and effectiveness of bone wax [2].

Post-market clinical follow-up (PMCF) studies are performed on a device within its intended use/purpose(s) according to the instructions for use. A PMCF study examines how a device performs when used as intended, to gain verification of the clinical performance and to collect the safety information. The PMCF is recommended also due to there may be limitations to the clinical data available in the pre-market phase. Such limitations can be addressed in Post market clinical follow up studies. The extent of the data that will be gathered in the pre-market phase does not necessarily enable the manufacturer to detect rare complications or problems that only become apparent after wide-spread or long-term use of the device. Clinical data obtained from post-market surveillance and during PMCF studies are critical to update the clinical evaluation throughout the life-cycle of the device and to ensure the long-term safety and performance of devices after their placing on the market.

The primary objective of this post market clinical study was to assess the clinical performance, safety and acceptability of the Waxocare® bone Wax. The study also intended to determine if any undesirable events under normal condition of use occurred and identifies the presence of any new emergent risks, known and unknown residual risk.

2. Materials and Methods

The study was a prospective, single centre interventional study. Ethical approval from was obtained. The study was registered in Clinical Trial Registry India (CTRI).

The study population consisted of consenting adults in whom Waxocare® Bone Wax manufactured by Futura Surgicare Pvt Ltd, Bangalore, India was used to control bleeding from bone surfaces during the surgery. Subject requiring rapid osseous regeneration and fusion and those with known sensitivities or allergies to bees wax, pollen grains, paraffin wax and iso propyl palmitate were excluded.

Individually packed sterile bone wax available in a form of bone wax stick with a weight of 2.5 gms and sterilized by Gamma Radiation were used. End points used to determine the primary objective were as follows.

1) Qualitative determination of bleeding as graded by the operative surgeon as mild, moderate and severe.
2) Qualitative determination of the hemostatic action during application as graded by the surgeon as

complete, moderate, minimal, and failure for hemostatic action.
3) Occurrence of re-bleeding during the operation.
4) Wound infection or other complications within 15 days post procedure
5) Ease of use using Likert's scale (1-5)

The study was conducted in the hospital where the Principal Investigator (PI) performed the surgeries. The data was collected from the neurosurgeon who was the PI for the study who had used Waxocare® Bone Wax, manufactured by Futura Surgicare Pvt Ltd, Bangalore, India for the following indication viz., control of bleeding from bone surfaces.

The feedback from the surgeon regarding the safety and performance of Waxocare® Bone Wax was collected in the prescribed -PMCF format.

Safety assessments listed below were considered for all the subjects during the surgery.

The product was used as per the instructions provided by the manufacturer viz.,

Use Bone Wax sparingly.

Remove excess Bone Wax from the operative site.

Open the package just prior to use, to minimize the possibility of contamination and excessive drying.

Do not subject Bone Wax to excessive heat

Performance characteristics assessed during the PMCF study were biocompatibility, cohesion to bone, maintaining hemostasis, easy handling, flexibility, sterility, control of bleeding and wound sealing ability.
The entire duration of the study was four months. There was one follow up visit after the surgery. During the follow up visit, occurrence of re-bleeding was assessed. Any side effects reported were documented.

The PMCF data was evaluated through Clinical PMCF data summary and Clinical Case Study reports for each subject on whom Waxocare® Bone Wax was used.

Statistical Methods
With a confidence interval of 95% and expected positive response of 95% and adverse event of 2% the sample size of 31 was determined. Descriptive statistics were used.

3. Result

A total of 31 subjects participated in the PMCF Study out of which 55% (17) were male and 45% (14) were female. The Waxocare® Bone Wax was utilized in 19 cranial surgeries and 12 spine surgeries.

One subject (3%) was recruited from the age groups 10-20 and 71-80 respectively. Two subjects (6%) were recruited from age groups 21-30 and 81-90 respectively. Six subjects (20%) were recruited from age groups 31-40 and 41-50 respectively. Three subjects (10%) were recruited from the age groups 51-60 and remaining ten subjects (32%) were recruited from age groups 61-70.

The safety parameters and the rating given by the user for each of the clinical parameter are given in the table below (Table 1)

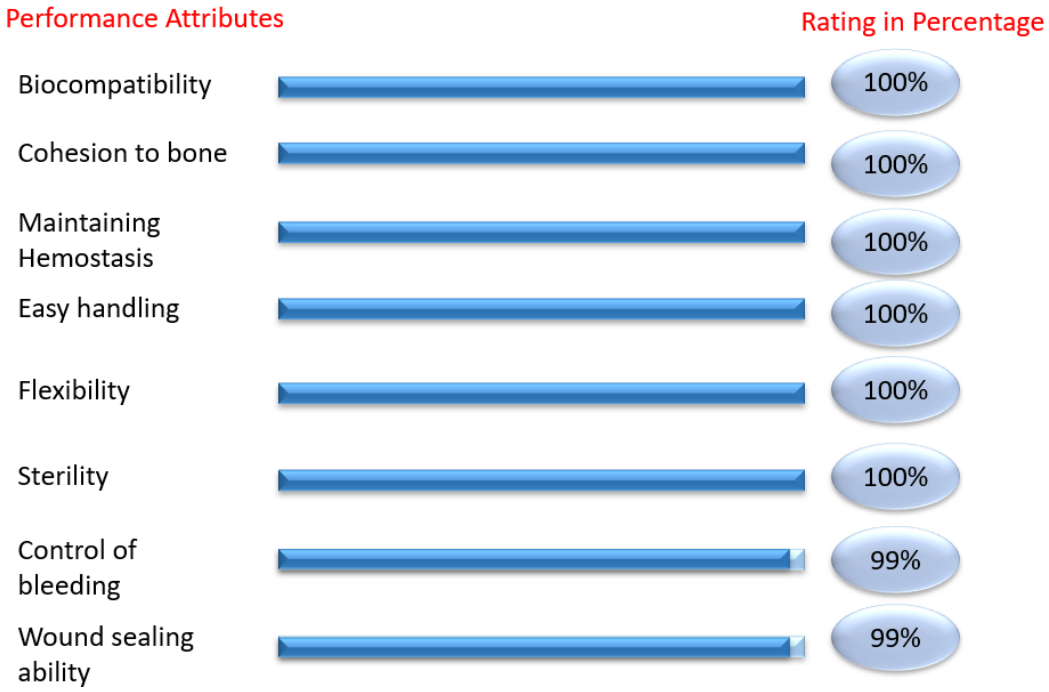
Table 1: Clinical evaluation of safety parameters

Clinical Safety parameters evaluated	*PI satisfaction from the Bone wax*
Discomfort from Bone Wax	None of the subjects had any discomfort from the use of Bone wax
Allergic reaction to the Bone Wax material	None of the subjects had any allergic reaction to the bone wax material
Inhibition of osteogenesis process	No inhibition of osteogenesis process noted
Inflammatory tissue reaction adjacent to the implantation site	Bone Wax didn't induce inflammatory tissue reaction adjacent to the implantation site to any of the subjects
Surgical Site Infection in subject	No surgical site infections were detected
Bone wax material appropriate for the Surgical site of this subject	Bone Wax material was appropriate for the Surgical site of the subjects under the study
Healing of surgical site	The surgical site of the subjects healed as expected
Irritation or pain in the implantation site	The subjects under the study doesn't face any kind of irritation or pain in the implantation site
Any contamination which led to the illness and injury to the subject	Bone Wax didn't cause any contamination
Prolong the hospital stay due to delayed bone healing	The subjects under the study didn't have to prolong the hospital stay due to delayed bone healing
Any sensitivity to pollen granules noted on the patient	There was no sensitivity to pollen granules noted on any of the subjects under study
Any wound dehiscence	There was no wound dehiscence observed on any of the subjects under study

All the subjects considered for PMCF study benefitted out of the surgeries where bone wax was used. Additionally, no adverse events related to the use of bone wax were recorded in the study.

The clinical performance of the product was evaluated by asking the surgeon to rate in the PMCF checklist for the performance categories. The scale was given on 1-5 where 1- is given as Poor and 5 as excellent. The overall rating for the performance attributes of Bone Wax was 99.7% as depicted in Table 2.

Table 2: Performance attributes as evaluated by the investigator.



In all the subjects except in one subject the surgeon strongly agreed that bone wax was easy to use and in one subject he agreed that bone wax was easy to use.

Occurrence of re-bleeding from operative site was noted for the subjects who came for their follow up visit after the study. From the follow up visit it was evident that none of the subjects had re-bleeding after the operation.

The known risks from the product which are identified from Risk Management as well as from published literature sources were included for analysis. In all the subjects, there were no new risks identified for the Waxocare® Bone Wax.

None of the subjects showed any wound infection or complication within 15 days of post procedure.

4. Discussion

Bone wax is a century-old material used to control bleeding of disrupted bone surfaces by acting as a mechanical barrier to seal the wound. The current bone wax products are commonly packed in easy-to-open foil in the form of sterile easy to use forms. Their excellent malleability, smooth consistency and easy handling approach make them a cost effective tool for bleeding control. The inert nature of bone wax can at times cause complications including foreign body reaction, infection promotion and bone healing inhibition.

The medical application history of bone wax can be traced back to the eighteenth century [3]. The classical and most widely used formulation was developed by Sir Victor Alexander Haden Horsley in 1885 [4]. The first documented evidence of the successful use of bone wax in clinical surgery appeared in 1892, when Rushton Parker used it to stop bleeding from the lateral sinus [5]. Since then, the term "Horsley's wax" was synonymous with bone wax although several formula modifications were developed [6].
After the evolution of over a century, the current commercial bone wax products still mainly consist of beeswax and softening agent such as vaseline or a mixture of paraffin wax and isopropyl palmitate. Bone wax in the market is categorized as Class 2 medical device by the US Food and Drug Administration (FDA) and is commonly supplied in easy-to-open foil package in the form of sterile sticks or plates. Bone wax is quite cheap. It has a shelf life of approximately five years if stored as per the manufacturer's instructions [2].

In practice, bone wax should be used immediately after removal from the package. It should be softened to the desired consistency before applying by moulding with the fingers or by immersing the unopened foil packet in a warm sterile solution. The material displays excellent malleability and smooth consistency and is capable of being smeared across the cut surface to plug the holes in the bone to stop bleeding physically.

Although bone wax has been in use since a long time, there are reported instances of various complications in literature [7-13].

Three cases in which retained bone wax after skull base surgery resulted in recalcitrant frontal sinusitis have been reported. Retained bone wax should be considered as possible etiology for postoperative recalcitrant sinusitis and imaging concerning for mucocele in the appropriate surgical setting. Judicious use of bone wax is recommended, if placed in a sinus with patent ostium. There were no such concerns noted among the patients in the present study [14].

A case in which foreign-body reaction to bone wax applied over femoral neck osteoplasty required reoperation has been reported in the literature. The present study did not have any such issues noted among the patients [15].

In a study on total of 1151 patients who underwent cardiac surgery postoperative sternal dehiscence was detected in 88 (1.6%) patients. The postoperative sternal dehiscence rate was 1.4% in patients without bone wax and 2.5% in patients with bone wax. It was concluded that bone wax may be associated with increased postoperative sternal dehiscence after cardiac surgery. No episodes of any bony dehiscence were noted in our study [16].

A study aimed to evaluate the efficacy of bone wax in reducing blood loss and transfusion rates after total knee arthroplasty was undertaken among 100 patients. The application of bone wax was found to be safe and effective for reducing total blood loss and maintaining higher hemoglobin levels [17].

Another study evaluated the effectiveness of bone wax in reducing blood loss and transfusion rates after total knee arthroplasty. The use of bone wax significantly reduced blood loss, decreased Hb levels, and the risk of transfusion [18]. The present study showed that bone wax was effective in reducing the blood loss by providing effective hemostasis.

The sterna of 18 consecutive cadavers who prior to death had undergone surgery with median sternotomy were examined. Macroscopically, bone wax was seen in 17 of 18 sterna. Acute inflammation was found in one, chronic inflammation and foreign body multinucleated giant cells were seen around the bone wax in 17 sterna. Bone wax is non-resorbable and induces chronic inflammation in the operated sternum up to 10 years after application [19].

Two cases of delayed migration and extrusion of bone wax through postauricular wounds due to foreign body reaction and granuloma formation following mastoid surgery have been reported [20]. Bone wax-related disc space foreign body granuloma following L4 total laminectomy, an extremely rare complication has also been reported [21].

5. Conclusion

This prospective PMCF study has proven the safety and performance of using the Waxocare® Bone Wax and resulted in no complications. Hence this study is enough to prove that Waxocare® Bone Wax is safe to use and results in no immediately known complications.

6. Future Scope

Further studies following up the use of the bone wax will throw more material on its continued safety in surgical practice.

Acknowledgement
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Author Profile

Dr Murali Mohan S is the Head of Neurosurgery at Sagar Hospitals, Bengaluru. Dr. Murali Mohan S is a senior consultant neurosurgeon from Bengaluru. Having completed his graduation from MS Ramaiah Medical College, RGUHS, He received his Neurosurgical training under Prof B Ramamurthi DSc (the father figure of Indian Neurosurgery) and team at the Post graduate Institute of Neurological Surgery, ALNC, VHS Hospital, Chennai. Dr. Murali has performed over five thousand Neurosurgical procedures.

Dr A S Ramaswamy is a Professor and Head of Department of Pathology at PES Institute of Medical Sciences and Research, Kuppam, Andhra Pradesh. Having completed his graduation from MS Ramaiah Medical College, Bengaluru he pursued his MD Pathology at JJM Medical College, Davangere. He is a trained assessor for ISO 15189:2012 for QAI. He has more than 45 publications in various national and international journals.

Dr Mathangi Krishna Kumar is a consultant anesthesiologist at Sagar Hospitals, Bengaluru. She is an MBBS, MD, PDF, DM (Neuroanaesthesia & Neurocritical care). She is an avid reader and interested in biomedical research.