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Development of Spherical Swab for Medical Applications: Part 1

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Introduction

The currently used cotton gauze pads are comprised of multiple layers of woven fabric secured together in a rectangular or square shape (Figure 1). These pads are used to wipe blood or other body fluids from incisions or wounds. An ideal surgical swab should have higher absorbency, better wicking, high wet strength with a soft feel and should provide easy swipe during surgery. In addition, the swab should have low linting (fibre migration), non-toxic and should create low bio-medical waste. The currently used woven gauze pads have following disadvantages:-

- lower absorbency, so multiple layers and larger dimensions (45X45, 30X30, 22.5X22.5 sq. cm) are used leading to higher bio-medical waste;
- not easy to fold edges of multiple layers of smaller dimensions (e.g. 5X5, 7.5X7.5 sq.cm) which may lead to infections due to edges;
- currently, smaller dimensions are being used by holding in a clipper scissor folded in a spherical shape;
- larger dimensions (45X45, 30X30, 22.5X22.5 sq. cm) are being used for neuro, ophthalmic or keyhole surgeries creating high level of bio-medical waste, although smaller dimensions can be used for these surgeries.

A joint clinical and laboratory study conducted at *East Glamorgan General Hospital, UK and Surgical Material Testing Laboratory, UK* has established that the nonwoven swab has practical and economic advantages over traditional cotton gauze owing to their ability to retain fluid and is manufactured using less expensive raw materials[1]. It has also been demonstrated that the nonwoven swabs are more absorbent than that of traditional cotton gauze both on a gram/gram basis and in terms of total absorbency of the swabs. On comparison in terms of softness, conformability, ability to pad or pack, resistance to snagging, shredding and ease of counting when wet, the nonwoven swab is as effective as traditional gauze. Additionally, the manufacturing of nonwoven swab is simpler than that of traditional gauze which involves spinning, weaving and chemical processing. In terms of bio-medical waste, nonwoven swabs generate a lesser amount of dump owing to higher absorbency than that of traditional gauze.

1. S. Thomas, H. Shukla, M.H. Lewis, *The Journal of the Royal College of Surgeons of Edinburgh*, Vol. 37(3), p 191-193, 1992.

Although having aforementioned benefits, the nonwoven swabs are not widely used, especially in the smaller dimensions (e.g. 5.0X5.0, 7.5X7.5 or 10X10 sq. cm) owing to the absence of commercially viable folding technique to keep all edges of the smaller sized nonwovens inside. We have developed a very unique way of folding nonwoven edges (Figure 2&3) which is further being automated to manufacture these spherical nonwoven swabs on bulk scale. The provisional patent application has already been filed for our uniquely designed spherical nonwoven swab with the application number 274/DEL/2011. This part of the paper focuses on the initial comparative study between woven and nonwoven swabs while the commercial viability and clinical trials will be the subject of the second part of the paper.

Figure 1 Available gauze pad

Figure 2 Spherical nonwoven swab

Materials & Method

The spunlace nonwoven materials were purchased through *Alpha Foams, Pune* for this project. Both nonwoven and woven swabs (Table 1) were tested and compared for the following parameters as per INDA's standard WSP 10.1 (05):

- liquid absorbency;
- liquid absorptive capacity;
- liquid wicking rate (capillarity).

Table 1. Sample specifications

Sl. No.	Sample
1	SP1 (100% Viscose NW*)
2	SP2 (Viscose/Polyester, 50/50 NW)
3	SP3 (Viscose/Polyester, 70/30 NW)
4	SP4 (100% Polyester NW)
5	Woven Gauze (100% Cotton)

NW*- Nonwoven

Results and Discussion

The 'Liquid Absorptive Capacity (LAC %)' in % was calculated for nonwoven samples in comparison with woven cotton gauze pads. The Graph 1 shows that SP3 has highest LAC% values followed by SP1, SP2 and SP4 whereas WG shows the lowest of all. In the LAC% formula mentioned below, M_k= mass in gram of the dry test specimens and M_n= mass in gram of the wet test specimens at the end of the test.

$$LAC\% = \frac{M_n - M_k}{M_k} X100$$

Table 2 shows performance comparison of spherical swabs in comparison with woven gauze pads. The following points were observed:

- higher absorbency of nonwoven swab in comparison with woven gauze on gram/gram basis;
- faster wicking in nonwovens;
- low linting (fibre migration) in case of nonwoven swab;
- lower fibre content is required to absorb equivalent amount of water, so reduction in bio-medical waste while using nonwovens;
- can be used for neurosurgery, ophthalmic and other surgeries where precise pointed structure is required;
- spherical swab can be manufactured in different dimension, i.e. 1/2, 1 or 2 inches.

Graph 1. '*Liquid Absorptive Capacity'* of nonwovens and woven gauze

Table 2. Performance comparison of nonwoven swabs and woven gauze pads

Particulars	Unit	Woven Gauze	Nonwoven Swab
Water Absorbency/g of Material	g	4.5	8.5
Size/Piece	cm^2	10X10-12P	19X19
Swab Weight/Piece	g	3.27	1.80
Water Absorbency/Piece	g	14.7	14.7
Piece Comparison	Piece	1	1
Fibre Content To Absorb 14.72g Of Water	g	3.27	1.78

As shown in the Figure 3 & 4, a prototype machine for slitting and formation of three-dimensional spherical structure has been developed. A further work is being carried out to set-up a continuous assembly to manufacture three-dimensional nonwoven swabs on bulk scale.

Initial market research showed that there was requirement of spherical swabs in three different sizes such as smaller swabs (1/2 inch diameter) for eye clinics whereas medium (3/4 inch diameter) and larger swabs (1 inch diameter) were required for wound management and cosmetic applications. We intend to incorporate a control panel in the currently designed prototype which would allow production of nonwoven swabs in the small, medium and large sizes as per the requirement.

Figure 3. Nonwoven slitting machine

(Machine working width – 12 inches; speed range – 5 metres/minute to 50 metres / minute)

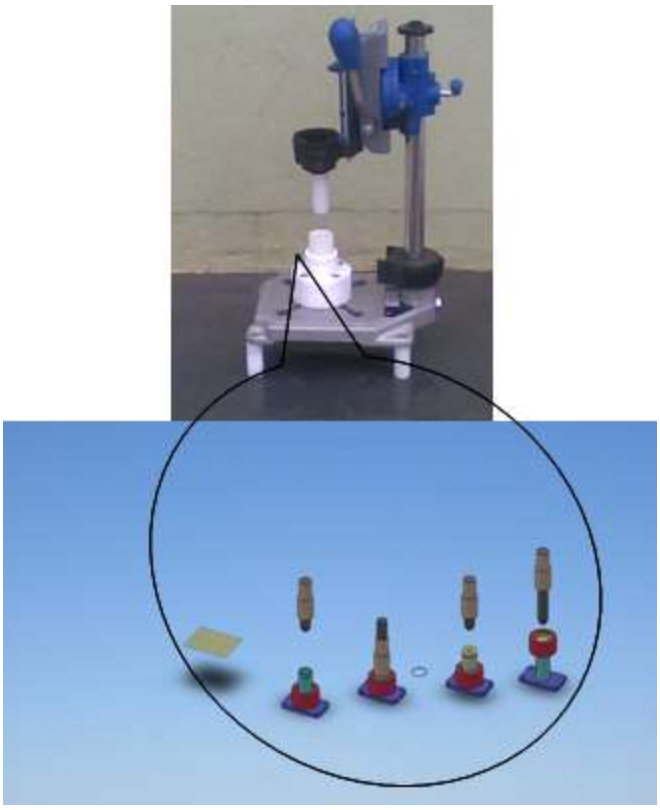

Figure 4. Prototype machine and design automation to manufacture spherical structure (Provisional patent application number 274/DEL/2011)

Market Size and Competition

The initial findings suggest that there is a huge requirement of this newly developed product in the operation theatres, for dental applications and by the medical staffs involved in the management of wound, such as removing wound exudates, cleaning or application of medicaments both in Indian and overseas market. Additionally, owing to the low fibre migration, these products are also preferred in place of cotton-balls for cosmetic applications. Currently, hand rolled solid ball of cotton and woven cotton gauze pads are being used in the Indian market. Most of them are manually manufactured and are usually prepared within the department from the sterile cotton roll or using woven cotton fabric. There are local sterile cotton converters who provide the cotton balls and woven plied gauze (usually manual). As an estimate, over *20 million pieces (per month)* are required for the domestic market. Internationally, the feedback received from the company's manufacturing the '*First-Aid Kits'*, the requirement could be of *500 million pieces (per month)* for exports. Our competitors are suppliers of woven gauze pads. However, none of these are supplying gauze pads in the spherical structure especially in the smaller dimensions.

Conclusions and Further Work

The newly designed spherical nonwoven swabs have following benefits:-

- ✓ Higher absorbency on gram/gram basis;
- ✓ Fast wicking and extremely low linting;
- ✓ Reduction in bio-medical waste;
- ✓ Used for neurosurgery, ophthalmic and other surgeries where precise pointed structure is required;

Further work is being done to develop fully automated machine for bulk production of spherical nonwoven swabs. Additionally, we intend to incorporate a control panel in the machine which would allow production of nonwoven swabs in small, medium and large sizes. It is also our intention to further develop this product as '*fibrous macro-packs*' as the spherical swab structure can be easily filled with various functional particles (e.g. haemostatic beads, super-absorbent polymer beads) which can be used in agriculture and horticulture applications.

About Authors

Mr. Sudarsan Rajagopalan has over ten years of experience in medical textiles with special interest in Biomedical implants which are being used for Cardiology and Cardiovascular surgeries. He holds a bachelor's degree in textile engineering and an M.B.A in marketing and finance.

Dr. Nandan Kumar has completed a PhD and Masters Degree in textile technology at the University of Leeds, U.K. He has worked with companies based in U.K. to develop technical textile products for automotive, industrial and personal protection market.

Mr. Sankamesh Ramaswamy has gained a Masters degree at the University of Leeds, U.K in studying liquid transport in composite nonwoven hygiene materials. He has worked with Nonwoven companies in UK for over four years in the design, development and manufacture of both single-use and durable nonwoven materials.