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Neurovascular Supply of the Scalp in Hair Transplant Surgery: An Anatomical Study to Optimize Donor Site Harvesting.

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ABSTRACT

Background: Transplanting the hair is a good surgical procedure that can be used to treat hair loss; the success rates will mainly rely on whether the neurovascular status of the scalp is maintained. An in-depth knowledge of the vascular and neural anatomy is indispensable in order to make the most out of the donor site harvesting and reduce complications. Objective: To determine neurovascularity of the scalp and its importance to surgery in hair transplantation to maximize donor site harvesting.

Methods: This cross-sectional anatomical study was a descriptive study that was carried out within a period of six months in a tertiary care institution. The non-probability consecutive sampling was used in analyzing a total of 60 scalp units of surgical patients and cadaveric specimens. Cadaveric dissections and intraoperative observations were carried out to measure the supply of the arteries, venous drainage and sensory supply. The structured proforma was used as a method to record the data and SPSS version 26.0 was used to analyze the data and present the result in the form of frequencies, percentages and mean standard deviation.

Results: Large contributing arteries were always observed; the superficial temporal artery was always available and then the occipital and posterior ears arteries. There were differences in the vascular and neural structure in a group of specimens. Supraorbital and greater occipital nerves were mostly used to provide sensory innervation. Intraoperative observation revealed that there were different rates of bleeding and nerve preservation was done in most cases.

Conclusion: Scalp neurovascular anatomy is very important in understanding safe and effective donor site harvesting. Integrating anatomical knowledge in surgical practice can lead to increased graft survival, lesser complications and better clinical outcomes.

KEYWORDS: Hair transplantation, scalp anatomy, neurovascular supply, harvesting a donor site, follicular unit extraction, vascular anatomy, sensory innervation.

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INTRODUCTION

The health issue at the global level that has a great psychosocial effect is hair loss that impacts a considerable percentage of the adult population. Recent epidemiological statistics show that about 60.3% men and 46.7% females undergo some extent of hair loss emphasizing that it is a very broad burden of people. In patients who are not responding to any pharmacological treatment, hair transplantation has come out as the best and final mode of treatment, and it also has both cosmetic and psychological advantages to the patient {1}. Although its popularity is on the rise and it tends to be rather safe, there is a high dependency on the comprehensive knowledge of scalp anatomy and neurovascular structure to ensure the best possible outcomes of surgery. The scalp also has a very rich and redundant vascularity supplied by the internal carotid arteries and external carotid arteries. The supratrochlear, supraorbital, superficial temporal, posterior auricular, and occipital arteries are major contributors of the arteries and they have extensive anastomoses that provide strong perfusion in spite of surgical manipulation of the arteries {2}. It is this redundancy of the vascularity which leads to quick healing of the wound and also plays a role in the low rate of significant complications of hair transplantation surgery {3}. Nevertheless, any interference with such vessels may result in bleeding, compromised survival of transplants, or in extreme cases, tissue necrosis when there is interference with such vessels in case of donor harvesting {4}. It is also vital that the scalp has a complex sensory supply, mostly fed by the branches of the trigeminal nerve in the anterior area and cervical spinal nerves in the posterior part. These neural structures should be preserved to avoid the postoperative complications including numbness, dysesthesia, and chronic pain syndromes, which are detrimental

to the preservation of neural structures in surgery to avert nerve injury and its related consequences (2). Besides, recent research proposes that the state of microcirculatory dysfunction and neurovascular changes could determine the viability of hair follicles and success of transplantation {5}. Even though there is a very low complication rate reported to be as low as 0.10% when considering minor complications, technical mistakes during harvesting of the donor skin more so in the safe donor area still poses as a major concern {4). These problems emphasize the need to have accurate anatomical information that can reduce morbidity and improve the graft yield. Thus, the purpose of the study is to thoroughly examine the neurovascularity of the scalp in particular focus on its surgical utility in hair transplantation to maximize donor sites harvesting and achieve better clinical results.

METHODOLOGY

The present study was carried out as a descriptive cross-sectional study of anatomy study for six months. It was conducted in the Department of Anatomy in collaboration with the Department of Dermatology & Plastic Surgery of a teaching hospital of tertiary care. The study population included adult patients undergoing hair transplantation procedures and preserved cadaveric scalp specimens available for evaluation by dissection. A sample size of 60 scalp units was used, which was taken from previously published anatomical research that evaluated scalp vascular and neural patterns {1}. A non-probability consecutive sampling technique was applied to recruit eligible subjects during the study period. Adult patients aged between 20 and 60 years of age having follicular unit extraction (FUE) or follicular unit transplantation (FUT) were included. Cadaveric specimens with intact scalp anatomy were also included. Patients with a history of previous surgery of the scalp, trauma, congenital anomalies of the scalp, dermatological conditions of the scalp or systemic diseases with effects on wound healing were excluded. Cadaveric specimens with signs of decomposition or structural damage were also excluded. Data were collected by using a structured proforma. In surgical patients intraoperative observations were recorded, such as identification of branches of arteries, bleeding characters and preservation of neural structures during harvesting of the donor site. In cadaveric specimens, detailed anatomical dissections were carried out in order to determine the course, branching patterns, and relationships of major scalp arteries and sensory nerves. Measurements of vessel caliber and distances from anatomical landmarks were made by digital calipers to ensure accuracy and reproducibility. The major variables of study were arterial supply, venous drainage and sensory innervation patterns of the scalp and their anatomical variations. Secondary variables were intraoperative bleeding patterns and status of nerve preservation. Data analysis was done by the statistical package for the social science (SPSS) version 26.0 package. For quantitative variables, the mean and standard deviation were calculated and for qualitative variables, frequencies and percentages were presented. Ethical approval was received from the Institutional Review Board before the study was started. Written informed consent was obtained from all participating patients and confidentiality was strictly maintained. Cadaveric handling and dissection was performed under institutional ethical standards.

RESULTS

A total of 60 scalp units were analysed, including both surgical patients and cadaveric specimens, as described in the methodology. The mean age of surgical participants was 38.6 ± 9.4 years, with a male predominance (n = 42, 70%) compared to females (n = 18, 30%).

The distribution of arterial supply demonstrated that the superficial temporal artery was the most consistently identified vessel (n = 60, 100%), followed by the occipital artery (n = 56, 93.3%), posterior auricular artery (n = 48, 80%), supraorbital artery (n = 45, 75%), and supratrochlear artery (n = 41, 68.3%). Variations in arterial branching patterns were observed in 18 (30%) specimens (Table 1).

Venous drainage patterns were found to be consistent with arterial distribution in the majority of cases, with prominent superficial temporal and occipital venous channels observed in 54 (90%) and 50 (83.3%) cases respectively. Communication between venous systems was noted in 36 (60%) scalp units.

Sensory innervation analysis revealed that the supraorbital nerve was present in 58 (96.7%) cases, supratrochlear nerve in 52 (86.7%), greater occipital nerve in 55 (91.7%), and lesser occipital nerve in 47 (78.3%). Anatomical variations in nerve course were identified in 15 (25%) specimens (Table 2).

Intraoperative assessment showed mild bleeding in 34 (56.7%) cases, moderate bleeding in 20 (33.3%), and severe bleeding in 6 (10%) during donor harvesting. Nerve preservation was successfully achieved in 52 (86.7%) procedures, while minor transient sensory disturbances were noted in 8 (13.3%) cases (Figure 1).

Table 1: Distribution of Arterial Supply of the Scalp (n = 60)

Artery	Frequency (n)	Percentage (%)
Superficial Temporal	60	100%
Occipital	56	93.3%

Posterior Auricular	48	80%
Supraorbital	45	75%
Supratrochlear	41	68.3%
Arterial Variations	18	30%

Table 2: Distribution of Sensory Innervation of the Scalp (n = 60)

Nerve	**Frequency (n)**	**Percentage (%)**
Supraorbital Nerve	58	96.7%
Supratrochlear Nerve	52	86.7%
Greater Occipital Nerve	55	91.7%
Lesser Occipital Nerve	47	78.3%
Nerve Variations	15	25%

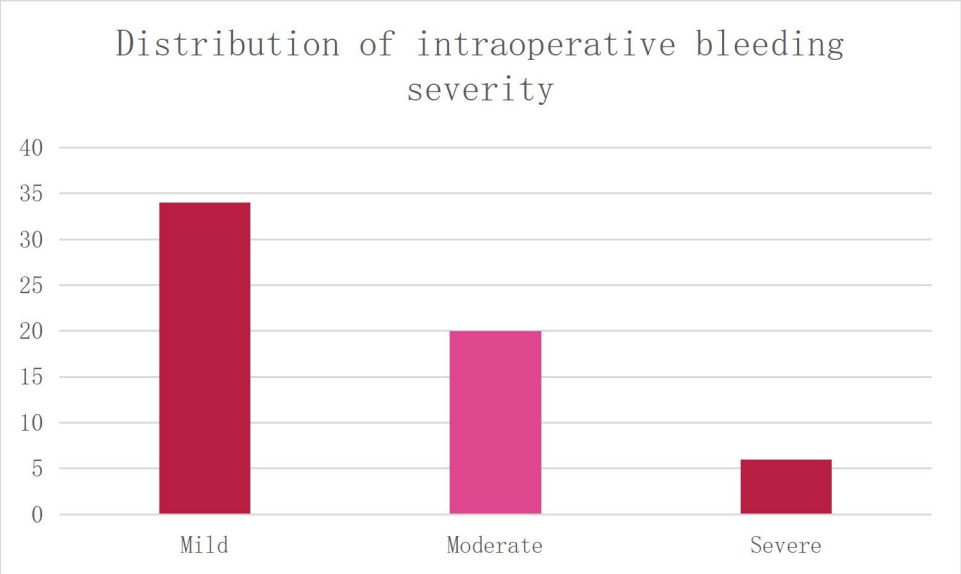

Figure 1: Distribution of intraoperative bleeding severity during donor site harvesting in hair transplantation procedures, categorized as mild, moderate, and severe based on clinical assessment of blood loss.

DISCUSSION

The current research examined the neurovascular anatomy of the scalp with particular relations to the donor site harvesting involved in the hair transplantation. The results imply the current literature of the fact that effective hair transplantation depends to the great extent on elaborate anatomical learning and maintenance of vascular integrity. Recent reviews point out that follicular unit extraction and transplantation procedures have changed dramatically since they have led to better results due to the development of the technique of fine surgical planning, as well as the increased knowledge of the scalp structure {6}. The

consistent finding of great arterial contributors in this study is consistent with previous anatomical and imaging-based studies which show that the vascular network is rich and redundant and supports graft survival and quick healing {7}. The measured variability in the pattern of branching of arteries can be compared to the recent reports of the inter-individual variability in perfusion of scalp based on the use of advanced methods of vascular mapping that have shown a substantial variation in inter-individual variability in scalp perfusion patterns {7}. These variabilities can affect intraoperative hemorrhage and survival of grafts. Experimental studies on laser Doppler flowmetry have also demonstrated that local ischemia and microvascular damage during graft implantation may negatively influence tissue viability underlining the significance of atraumatic surgical procedure {8}. These results give prominence on the clinical relevance of maintaining vascular integrity in donor harvesting. In the same language, the pattern of sensory innervation, which is presented in this study is in line with any known anatomical description, where the trigeminal and cervical nerves overlap in the scalp. These nerves must be preserved, because sensory disturbances that may occur after the procedures are known to be the complication associated with hair transplantation procedures {9}. Recent systematic reviews have stated that one of the most common adverse outcomes is the presence of donor-site complications such as pain and dysesthesia and again highlights the importance of a meticulous surgical technique {10}. In the context of biology, the follicular survival and regeneration depends greatly on sufficient vascular supply. According to emerging findings, growth factors like vascular endothelial growth factor (VEGF), insulin-like growth factor (IGF) and fibroblast growth factor (FGF) play crucial roles in ensuring the viability of the follicles and the angiogenesis in the grafts transplanted {11}. Also it has been demonstrated that mechanobiological and stem cell activation processes in the scalp microenvironment affects hair follicle regeneration and long term graft survival {12}. These mechanisms could partially be attributed to the positive results of well-vascularized areas of donor. The strengths of the work are in the fact that the intraoperative observations and the cadaveric dissection are used simultaneously, which gives the opportunity to study not only macro- but also micro-anatomy. Nevertheless, some restrictions must be admitted. The sampling size, which is rather small, and one-centered design could restrict the generalizability. Moreover, the study was descriptive, which did not allow evaluating cause-effect relations or longitudinal clinical outcomes. Clinically, the results support the significance of anatomical accuracy of knowledge as a way of reducing the complications in order to maximize the survival of the grafts. Further studies are needed in the future combining novel imaging modalities and quantitative measurement of the vascularity with the aim of improving the methods of donor site selection and surgical strategy.

CONCLUSION

The paper shows that the neurovascular topography of the scalp has a vital role in maximizing the availability of the donor site in hair transplantation. The availability of a rich but fluctuating vascular and neural net is an indication of the importance of careful surgical planning and technique to avoid damage to perfusion and reduce nerve damage. The knowledge of such anatomical patterns can help to increase the survival of grafts, decrease complications during the operation, and improve the results after the operation. The teaching of anatomy into clinical practice can help reduce the number of accidents and enhance patient satisfaction, besides informing future research to develop and optimize the practice of hair restoration surgeries and overall effectiveness.

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