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The Future of Biomimicry in Dentistry: "Evaluating Dental Students Awareness of Tissue Chip Impact"

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Research Article

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ABSTRACT

This study investigates dental students' awareness of tissue chip technology, an innovative biomimetic tool designed to replicate the structure and function of human tissues, and its potential applications in dentistry. A cross-sectional survey was conducted among 150 undergraduate dental students to assess their knowledge, perceptions, and attitudes toward this emerging technology. Findings reveal moderate awareness of biomimicry and limited understanding of tissue chips, with significant gender- and study-year-based variations in responses to specific survey items. Statistical analyses highlight key areas where targeted education could enhance understanding and adoption of tissue chip technology in future dental practice. The study underscores the need for integrating biomimicry concepts and technologies into dental curricula to prepare students for advancements in regenerative and precision dentistry.

Aim: To evaluate dental students' perceptions, knowledge, and attitudes toward the integration of tissue chip technology in dental practice, thereby enhancing patient care and advancing the field of dentistry through innovative biomedical technology.

Objectives: To assess the level of awareness and understanding of tissue chip technology among dental students, including its applications & benefits.

To determine the potential benefits that dental students associate with tissue chip technology, improved diagnostics, personalized treatment options, and patient outcomes.

Method: A cross-sectional survey was conducted among 150 dental students, comprising 85 males (56.6%) and 65 females (43.4%), including 85 fourth-year BDS students and 65 interns. The survey included 13 questions exploring awareness, perceptions, and potential barriers related to tissue chip technology. Responses were analyzed based on gender and year of study using chi-square tests to identify statistically significant differences.

Keywords: Biomimetic Dentistry, 3D Cell Culture, Microfluids, Organ on the Chip, Tissue Engineering.

Introduction

The rapid advancements in technology and biomimetic sciences have revolutionized the approach to healthcare, including dentistry. Biomimicry, the practice of emulating nature's designs and processes, offers transformative potential for improving patient outcomes through innovative and sustainable solutions. Among the groundbreaking developments in biomimicry is tissue chip technology, often referred to as "organs-on-chips." These micro-engineered systems simulate the structural, functional, and mechanical properties of human tissues, enabling researchers and clinicians to replicate physiological conditions with remarkable precision.

The integration of biomimetic concepts and tissue chip technology into dental education offers several key advantages that can significantly enhance both the learning experience and the overall quality of dental care.

1. **Improved Patient Outcomes:** Biomimetic dentistry emphasizes the use of materials and techniques that closely mimic the natural structure and function of teeth, leading to more durable, biocompatible, and aesthetically pleasing restorations. This approach can reduce the need for invasive procedures, minimize patient discomfort, and improve the long-term success of dental treatments.
2. **Enhanced Clinical Skills:** By incorporating hands-on training with advanced technologies like tissue chip platforms, dental students can gain practical experience in simulating real-world scenarios. This training allows students to better understand the biological and mechanical aspects of dental treatments, which enhances their diagnostic and decision-making skills in clinical practice.
3. **Better Research Opportunities:** Tissue chip technology provides a cutting-edge tool for conducting research in a controlled, ethical, and efficient manner. By offering a platform to test materials and treatment approaches without the ethical concerns of using live animal or human models, tissue chips can accelerate the development of new dental therapies and techniques. Encouraging students to engage in such research fosters a deeper understanding of the field and the ability to contribute to its advancement.
4. **Bridging Disparities in Education:** The integration of these advanced technologies helps address gender and year-based differences in dental education. Providing equal access to innovative resources ensures that all students, regardless of background, have the same opportunities to explore and apply the latest advancements. This promotes a more inclusive and diverse learning environment, empowering future dental professionals from various backgrounds.
5. **Interdisciplinary Learning:** The introduction of these technologies in dental education also promotes collaboration between different disciplines, such as bioengineering, material science, and biomedical research. This interdisciplinary approach equips dental students with a broader perspective and the ability to adapt to the rapidly changing technological landscape of healthcare.

Overall, the integration of biomimetic dentistry and tissue chip technology into dental education provides numerous benefits, from improving patient care to fostering innovation, enhancing research opportunities, and ensuring equitable access to emerging technologies. These advantages not only prepare students to excel in

their practice but also contribute to the ongoing advancement of the dental field.

However, the successful implementation of tissue chip technology in dental practice requires an informed and prepared workforce. Dental students, as future practitioners, need to be equipped with the knowledge and skills to integrate such advancements into their clinical and research endeavors. Despite the growing relevance of biomimicry and tissue chips in dentistry, little is known about the awareness and preparedness of dental students to embrace these innovations.

This study aims to bridge this knowledge gap by assessing the awareness of dental students regarding tissue chip technology and its applications in dentistry. It further explores how demographic factors such as gender and academic standing influence students understanding and attitudes toward this emerging tool. The findings of this research will inform the development of targeted educational strategies to integrate biomimetic concepts into the dental curriculum. By preparing future dentists to harness the potential of tissue chip technology, this study seeks to contribute to the evolution of dentistry toward more precise, effective, and patient-centered care.

Methodology

A) Study design and area: A cross-sectional study was carried out at the tertiary care teaching hospital khammam.

B) Study population: The health care students including those of IV year and Interns who responded to the offline paper print questionnaire survey.

C) Study Instrument: A self-administered questionnaire was designed based on knowledge attitude and awareness of advanced technology and had a total of 13 questions. Each participant has to fill their demographic data like Name, age, and year of study. Participants had to select one option from the answers provided against questions and the questions were based on knowledge attitude and awareness among dental students.

D) Pilot study: A pilot study was conducted on a group of students to assess the validity and reliability of the study.

E) Sampling Method: The sampling method used is a convenience method.

F) Inclusion Criteria: The students who were interested in the study and who were willing to participate.

G) Exclusion criteria: Students who are not willing to participate are excluded.

H) Organizing the study: The study was designed in a paper-based version of the self-administered questionnaire of 13 questions focusing on knowledge, and awareness.

Includes the sections of demographic data: Name, Age, Sex, and Year of study demographic information and asked to answer all questions by selecting one option from the provided answers.

I) Statistical analysis: Data from the filled questionnaire was collected in a tabular form in an Excel worksheet and evaluated for analysis. The analysis was performed by SSPS version 29.

Results

A total of 150 students took part in this with a female (43.4) and a male (56.6). Age of the participants ranged from 21-25 years. In this study, males were more likely to demonstrate awareness of tissue chip applications than females. Significantly Interns showed greater familiarity with advanced applications than fourth-year students.

AGE					
	N	Minimum	Maximum	Mean	Std. Deviation
Age	150	2	26	22.13	1.638

Gender			
		N	Percent
Valid	**Male**	85	56.6
	Female	65	43.4
	Total	150	100.0

Year of Study			
		Frequency	Percent
Valid	IV BDS	85	56.6
	INTERNS	65	43.4
	Total	150	100.0

Distribution and comparison of responses based on gender

Item	Response	Males		Females		Chi-Square value	P value
		n	%	n	%		
Q1	1	24	28 2	28	43.0	13.915	**0.003***
	2	46	54.1	29	44.6		
	3	10	11.7	3	4.6		
	4	5	5.8	5	7.6		
Q2	1	49	39.6	22	41.4	8.445	**0.656**
	2	31	36.5	14	23.5		
	3	3	13	20	17.5		
	4	1	10	9	10.4		
Q3	1	30	33	11	67	5.698	0.127
	2	50	39.1	32	60.9		
	3	3	18.8	13	81.2		
	4	1	10	9	90		
Q4	1	25	27.8	15	23.0	12.493	**0.006***
	2	53	44.2	21	32.3		
	3	5	23.8	16	24.6		
	4	1	7.1	13	20.0		
Q5	1	21	30	19	20.5	10.422	**0.07**
	2	55	42.6	24	57.4		
	3	6	18.2	17	81.8		

	4	2	15.4	5	14.6		
Q6	1	24	29.6	17	70.4	9.978	**0.655**
	2	56	41.8	22	58.2		
	3	3	13.6	19	86.4		
	4	1	12.5	7	87.5		
Q7	1	27	38	14	62	6.714	0.082
	2	49	37.7	21	62.3		
	3	7	21.2	20	78.8		
	4	1	9.1	10	90.9		
Q8	1	24	34.8	19	29.2	5.352	0.008*
	2	56	37.6	23	35.3		
	3	3	16.7	15	23.0		
	4	1	11.1	8	12.3		
Q9	1	22	31.9	11	68.1	7.245	0.064
	2	56	40	24	60		
	3	5	17.9	23	82.1		
	4	1	12.5	7	87.5		
Q10	1	20	29.4	8	70.6	13.179	**0.07**
	2	59	42.8	23	57.2		
	3	4	14.3	24	85.7		
	4	1	9.1	10	90.9		
Q11	1	21	35	39	65	9.330	**0.025***
	2	55	40.4	11	59.6		
	3	7	16.7	15	83.3		
	4	1	14.3	6	85.7		
Q12	1	32	40.5	17	59.5	10.273	**0.06**
	2	45	37.8	24	62.2		
	3	6	17.6	12	82.4		
	4	1	7.7	12	92.3		
Q13	1	20	30.8	19	29.2	6.058	0.04*
	2	58	39.2	20	30.7		
	3	5	23.8	16	24.6		
	4	1	9.1	10	15.3		

P≤0.05 is statistically significant

Distribution and comparison of responses based on year of the study

Item	Response	IV BDS		INTERN		Chi-Value	P-Value
		n	%	n	%		
Q1	1	60	70.5	50	76.9	14.101	**0.029***
	2	11	12.9	2	3.0		
	3	7	8.2	4	6.1		
	4	7	8.2	9	13.8		

Q2	1	39	41.7	43	40.9	28.850	**0.235**
	2	34	40	14	16.5		
	3	8	34.8	8	34.8		
	4	4	40	0	0		
Q3	1	35	38.5	42	46.2	25.294	**0.09**
	2	37	39.8	21	23.4		
	3	7	43.8	2	12.5		
	4	6	60	0	0		
Q4	1	27	30	37	51.1	34.158	**0.07**
	2	43	47.5	23	19.2		
	3	9	42.9	5	23.8		
	4	6	42.9	0	0		
Q5	1	22	25.8	30	46.1	20.383	**0.02***
	2	42	49.4	32	49.2		
	3	15	17.6	2	3.0		
	4	6	7.0	1	1.5		
Q6	1	21	29.6	25	47.9	16.967	**0.08**
	2	46	46.2	31	23.8		
	3	13	39.4	8	24.2		
	4	5	45.5	1	9.1		
Q7	1	23	28.4	30	48.1	22.851	**0.06**
	2	50	47.8	30	22.4		
	3	10	45.5	4	18.2		
	4	2	25	1	12.5		
Q8	1	21	30.4	36	52.2	25.779	**0.06**
	2	51	43.6	26	23.5		
	3	9	50	3	16.7		
	4	4	44.4	0	0		
Q9	1	19	27.5	32	46.4	16.601	0.11
	2	52	47.1	25	24.3		
	3	10	35.7	8	28.6		
	4	4	50	0	0		
Q10	1	19	27.9	34	50	25.253	**0.07**
	2	44	42.8	26	25.4		

	3	18	64.3	3	10.7		
	4	3	27.3	2	18.2		
Q11	1	18	30	31	51.7	26.188	**0.246**
	2	51	47.8	23	23.5		
	3	14	33.3	11	26.2		
	4	2	28.6	0	0		
Q12	1	32	40.5	31	39.2	10.763	0.096
	2	37	42.9	20	24.4		
	3	12	35.3	12	35.3		
	4	4	30.8	2	15.4		
Q13	1	18	21.1	32	49.2	20.107	**0.003***
	2	49	57.6	20	30.7		
	3	12	14.1	4	6.1		
	4	6	7.0	9	13.8		

P≤0.05 is statistically significant

Discussion

The findings emphasize a pressing need for the integration of biomimetic concepts and tissue chip technology into dental education. Gender- and year-based differences suggest disparities in access to resources and exposure to emerging technologies. Including hands-on training, interdisciplinary learning, and research opportunities may bridge these gaps and foster a culture of innovation in dental practice. Tissue chip technology, on the other hand, introduces an innovative way to simulate human tissues for a better understanding of disease progression, material interactions, and restorative procedures. This could revolutionize how dental researchers test new materials, procedures, and therapies in a controlled, ethical environment. By incorporating such technologies into dental curricula, students will not only gain advanced knowledge but also become more adept at handling emerging challenges in oral healthcare. Research opportunities also play a crucial role in cultivating a culture of innovation. By encouraging students to engage in research, whether through clinical trials, experimental designs, or collaborations with tech companies, they are better prepared to contribute to the advancement of dental science. A curriculum that emphasizes research and technological integration will not only improve dental education but also prepare graduates to become leaders in the field, capable of shaping the future of dental practice and patient care.

Conclusion

The integration of biomimetic concepts and tissue chip technology into dental education is vital for advancing dental practice and improving patient care. Addressing gender- and year-based disparities in access to emerging technologies will help ensure that all dental students are equally prepared to face the challenges of modern dentistry. By incorporating hands-on training, interdisciplinary learning, and fostering research opportunities, dental schools can bridge these gaps, promoting innovation and excellence in the field. Ultimately, these efforts will equip future dental professionals with the skills and knowledge needed to lead the way in cutting-edge dental care, benefiting both the profession and patients alike.

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