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Preface

The publication process of the 'Inspiring Technologies and Innovations (INOTECH)' journal is continuing with the decision numbered 261 taken at the session of the Senate of Kastamonu University dated 2.12.2021 and numbered 26, and with the coordination of Kastamonu University Technology Transfer Office.

Our journal named 'Inspiring Technologies and Innovations (INOTECH) , which is a pioneer because it prioritizes R&D and innovation issues in multidisciplinary fields, is a peer-reviewed, open access, free publication policy and periodical research journal by Kastamonu University twice a year.

Aiming to develop in the way of presenting qualified works to national and international readers with the principle of scientific publishing, this first issue of our journal includes 5 original research and 1 review research articles from different disciplines and research fields.

We would like to thank all the academicians who contributed by sending their works, and all the referees who contributed in the evaluation process of these works;

We hope that the interest and support for our journal from the national and international community will increase.

Regards.

Prof. Dr. Kasım YENİGÜN

Chief Editor

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Content

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Research Article

The Relationship of Energy Management and Environmental Innovation: A Conceptual Evaluation

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ABSTRACT: Global warming and climate change are currently the most pressing challenges in the globe. Environmental pollution, greenhouse gas emissions, and wastes produced by the industrial sector at various stages of the production and consumption processes are the main contributors to this. As a result of additional harm to natural resources and the erosion of the balance, nations, corporations, and consumers face the possibility of not having a clean world where they can thrive and leave a legacy to future generations. It is necessary to develop R&D activities that support the recycling of natural resources, clean production and zero waste philosophy, technological advancement towards the use of renewable energy resources, and innovation in processes and operations in order to develop environmentally friendly production methods. This paper aims to analyze the connections between the ideas of energy management and eco-innovation and to explain their importance. The idea of energy management, the rise of environmental awareness concurrent with energy management, issues relating to energy use, and the connection between eco-innovation, energy management, and environment are all addressed within this framework.

KEYWORDS: Energy Efficiency, Energy Saving, Energy Management, Eco-Innovation

1. INTRODUCTION

The increase in production activities with the industrial revolution caused rapid consumption of natural resources and an explosion in population. The increase in population causes an increase in economic activities to fulfill the needs, which increases energy demand and consumption in turn. Energy is accepted as one of the main inputs and driving forces of economic growth and development, and it poses a problem for most countries in terms of supply and consumption since the first industrial revolution. Due to its vital role in economic activities, most countries have turned to the use of fossil fuels such as coal and oil for energy production. However, this type of energy is not sustainable, as it is non-renewable and not environment-friendly. The fact that the increase in energy demand is higher than the energy produced from fossil sources jeopardizes sustainable development by causing both an increase in energy prices and the devastation of the environment.

In today's life, globalization is expanding throughout the world, and the energy market is undergoing significant changes in various aspects, such as cross investments, re-organization of local markets, restructuring processes associated with the old energy industry, depending on new global policies, as well as international trade. The transformation progress in the energy markets affects the relationship structures between producers and consumers; and rises issues related to energy supply security (Harris, 2001). In this parallel, the levels of development and welfare become more dependent on energy, as it is not possible to produce and deliver goods and services to consumers without using energy. Any disruption in energy input will likely put the economy in a bottleneck (Ghosh, 2002). Usually, developed countries have the necessary technological infrastructure to replace their energy resources or to use their resources more efficiently, which is one of the crucial factors that enable those countries to cope more successfully with the global crises that may occur related to energy supply. On the other hand, the lack of these opportunities in developing countries causes them to be more severely affected by crises related to energy supply. In this context, it is vital to pay attention to crises that may occur in the global energy supply, especially for developing countries (Karagöl, Özgür, & Görüş, 2020).

The increase in fossil fuel-based energy demand causes global warming and climate change due to the continuous release of greenhouse gas emissions into the atmosphere. This situation endangers the sustainability and security of energy on a global scale (Akintande et al., 2020, p.1). The continuous use of non-renewable energy and the depletion of natural resources have increased the awareness of international organizations and country groups on global warming, and many countries have shifted their focus to renewable energy production methods. These production methods have lesser negative effects on the atmosphere and environmental quality compared to fossil fuels and non-renewable sources. In addition, global health problems, economic losses, climate change, and sustainability problems are the factors that contribute to encouraging the use of renewable energy (Wang and Wang, 2020, p.1). From this point of view, it is known that the concept of energy efficiency is at the center of national, economic, energy, and environmental issues, especially in developed countries. Moreover, the energy crises experienced in the past periods have been important encouraging factors that have played a role in focusing on energy-saving measures (Kurbatov and Naumenko, 2014). Because, in an environment where there is rapidly increasing competition with globalization both in the dimension of nations and companies, it is inevitable in a sensible mindset to use energy efficiently and to show interest in saving measures.

The purpose of this paper is to explain the vitality of energy management and eco-innovation, and examine the relationship between these two concepts. Thus, the development of environmental awareness in parallel with the issues related to energy consumption was reviewed before the evaluation of the relationship between eco-innovation and energy management.

2. MATERIALS

2.1. Environmental Awareness in Parallel with Energy Consumption-Related Problems

Since the first industrial revolution, took place in the eighteenth and nineteenth centuries, energy demand has increased, especially in Western countries, depending on the increase in industrialization movements. The spread of these movements in many other countries, especially in China, has gradually increased the global dependence on the use of energy resources, making it an indispensable factor in economies. Even today, non-renewable and high carbon-emitting fossil fuels, led by oil, natural gas, and coal, continue to be the most used energy sources. In this current situation, countries that take the ever-increasing energy demand into account have increased their interest and sensitivity in energy efficiency and obtaining alternative energy sources, and have carried out various studies (Karadaş, Koşaroğlu, and Salihoğlu, 2017).

The first significant formations of today's contemporary, systematic environmental awareness approach gained momentum in the second half of the twentieth century. Profound studies were initiated in the 1960s, a period when the development race, economic concerns, and the search for power overshadowed the significance of human health and natural balance for a long time (Tıraş, 2012; Korotenko, 2018; Lin and Niu, 2018). In this period, the worldwide production rate increased several times more compared to previous periods, and in this direction, the balance between nature and humankind's economic concerns began to deteriorate rapidly, and nature's self-renewal rate fell behind. With the realization of this situation, noteworthy studies that advocate environmental awareness and human health have started. For example, in 1962, in his work titled “Silent Spring”, Rochel Carson drew attention to the damage done to human health and nature by explaining the harmful effects of pesticides used in agriculture. By the 1970s, environmental destruction had reached a global dimension, leading to an increase in sensitivities on this issue. One of the first important steps was the report called "Limits to Growth", which the Club of Rome asked some of the leading intellectuals of the time to prepare in 1972. In the prepared report, attention was drawn to the dependence between economic development and the natural environment (Shave, 2012).

2.2. Energy Management

The concept of energy management refers to all the measurements and activities that include managerial and technical processes, which are implemented in a planned manner in order to minimize energy consumption in any structure (Fiedler and Mircea, 2012). Energy management (Lee, Teng, Fan, Yang, and Horng, 2011), which concerns different disciplines such as engineering, finance, management, and architecture, contains two important concepts, Energy Saving and Energy Efficiency, which are often confused with each other. When it comes to energy saving, it means that energy-consuming tools and equipment are turned off when they are not actively used, or that energy is consumed less in a way that affects living conditions. Solutions such as preventing electrical resistance losses and reducing the ambient temperature in heating can be given as examples of savings. On

the other hand, Energy Efficiency is the same quality and level of output with lower energy input. Thermal insulation applications in buildings, the use of efficient machines in the industry, and the preference for energy-efficient light bulbs for lighting are some examples of ensuring energy efficiency (Topal and Özoğlu, 2018). The implementation process of Energy Management is a dynamic process that contributes to the production of new knowledge and ideas and is beneficial in almost every field due to economic, social, and environmental factors (Kannan and Boie, 2003). Figure 1 summarizes the process of energy management:

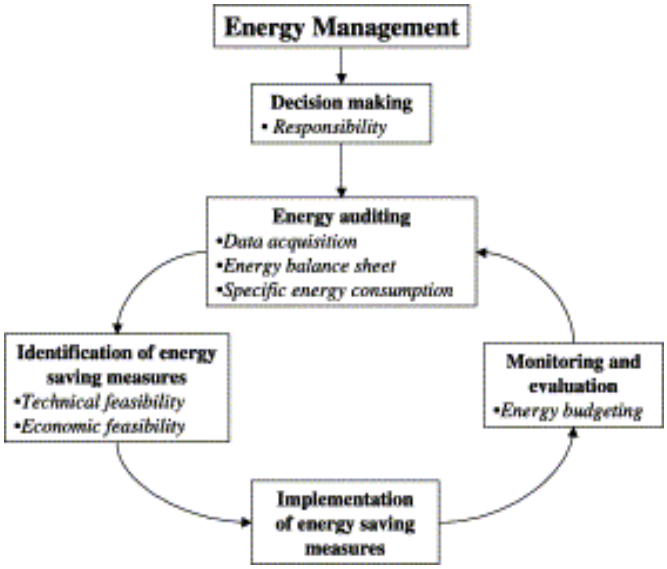

Figure 1. Energy Management Process (Kannan, R. & Boie W. (2003). Energy management practices in SME – case study of a bakery in Germany)

As it is clear in Figure 3.1, it is crucial that the decision-maker managers take responsibility in this regard and be determined to take the necessary steps as the first step in energy management practices. The lack of senior management in energy management, which should be continuous, can lead to inadequate or unsustainable practices. In this context, based on the willingness and determination of the top management of the organization in energy management practices, first of all, the existing energy map of the organization should be created. It is important to collect data on energy consumption, to reveal the area covered by the expense item, and to determine the most energy consumer units in the building. As a result of these determinations, ways to use energy more efficiently and economically without any reduction in work efficiency are investigated, and it is determined whether there is any waste. At this point, the feasibility of the planned solutions in terms of technical and economic suitability should be made. A decision should be made on whether to make a new investment, and it should be clarified in which areas and to what extent the improvements will be made. In the next stage, it is vital to determine energy-saving measurements in order to record the effect of energy-saving solutions to be implemented. After the implementation of the planned solutions, it is crucial to monitor the results to understand the realization of expectations. According to the results obtained, energy budgeting should be done for the next period, and then it should be returned to the examination of energy consumption items. In a sustainable and effective energy management strategy, this phased cycle should be carried out continuously, and the detected problems should be resolved as quickly as possible.

In a study conducted by Introna, Cesarotti, Benedetti, Biagiotti, and Rotunno (2014), it has been suggested that Energy Management was only applied in a few sectors where energy was used intensively before 1973, and it was an unheard concept by the majority. In addition, businesses developed more comprehensive approaches to combat increasing energy costs, entering a period in which awareness of greenhouse gas emissions increased significantly, as a result, the Kyoto Protocol was negotiated and, as a result, the measurement criteria and incentives of member countries on energy efficiency in the European Union. It has been stated that the popularity of Energy Management applications has increased rapidly, with the enactment of the 2006/32/CE regulation, which is required to clearly state the energy performance and targets, and also emphasizes the development and dissemination of goods and services that increase energy performance.

2.3. Eco-Innovation

3.3 Eco-Innovation

While innovation activities increase the welfare level of people with socio-economic benefits, they also contribute to sustainability by creating new resources. Eco-innovation, one of the typologies of innovation, is essential in terms of contribution to sustainability. According to Hemmelskamp (1997), eco-innovation is defined as innovation made to reduce the environmental impact of production methods (Hemmelskamp, 1997). While eco-innovations are classified in managerial, process, product, or marketing areas (OECD, 2009), they are also classified as pollution control and clean technologies (Rennings, 2000). However, the determinants and motivation sources of eco-innovation may be different compared to other innovation types. OECD (1997) emphasized the socio-economic benefit of innovation (TUBITAK, 1997).

Eco-innovation studies emerge as a developing field by benefiting from many different disciplines. These fields are evolutionary economics, theories of technological change, industrial economics, systems analysis, sociology, political science, business management, etc. It is a concept that can encompass many areas such as (Carrillo, Gonzalez & Könnöla, 2010). From a managerial point of view, the first definition of eco-innovation was given in the study of Fussler and James (1996). He stated that eco-innovation creates important contributions both for the consumer and for the business; that these contributions can be presented to all stakeholders through products, services, and processes by minimizing the effects on the environment (Bartlett & Trifilova, 2010). The concept of eco-innovation also appears in the literature as green innovation and eco-innovation (Schiederig, Tietze & Herstatt, 2012). The advanced version of the concept of eco-innovation, including the protection of future generations and the protection of our planet, also appears as sustainable innovation (Ruzzier, 2016). Therefore, it is possible to come across these concepts as concepts used interchangeably in the literature.

According to Rennings (2000), eco-innovations have three different features compared to other innovations. First, eco-innovations can take place in the technological, managerial, social, or institutional realm. Eco-innovations can be realized by both businesses and non-profit organizations and do not have to be sold on the market. Although eco-innovation is a multidisciplinary field, it encompasses both environmental economics and innovation economics. While environmental economics evaluates environmental policies, innovation economics tries to explain the factors affecting innovation decisions. While eco-innovations produce positive externalities, they create negative external costs from an environmental economics perspective. The third feature of eco-innovation, "double externality", can be solved by harmonizing both disciplines.

While Andersen (2002) stated that eco-innovation activities opened a new chapter in the markets and had high potential, OECD (2009) mentioned two important and privileged features of eco-innovation. Firstly, the impact of eco-innovation on the environment was evaluated. The second feature emphasized that eco-innovations will cause changes in socio-cultural norms and businesses (OECD, 2009). According to Helström, evaluating eco-innovation only with its reducing effect on environmental effects is a view that narrows the importance of this concept. Eco-innovations also have aspects that affect the quality of human life (Hellström, 2007). Therefore, the definitions related to eco-innovation, doesn't provide a full scope with solid lines, but it is clear that six different dimensions of eco-innovation emerge. The dimensions are listed as follows (OECD, 2009):

1. The innovation object is product, process, service, and method,

2. Market orientation to meet the needs and to be more competitive in the market,

3. Reducing negative environmental impacts (optimal = zero impact),

4. Paying attention to the entire life cycle of products (reducing raw material consumption,

5. Willingness to reduce cost and environmental impacts,

6. Establishment of a unique environmental standard.

The eco-innovation typology created by OECD based on eco-innovation definitions can be analyzed as the target, the mechanism, and the effect of innovation. Accordingly, it is possible to describe the target of eco-innovation as products, processes, marketing methods, businesses, and institutions. However, while processes and products need technological development, eco-innovations in areas such as managerial and marketing come with change and are not dependent on

technological development. The eco-innovation mechanism is again about whether it requires technological progress or not. These are minor or incremental modifications, redesign, development of alternatives, or the creation of new processes and products. Finally, the innovation effect is the last link of the typology. Accordingly, the impact of eco-innovations on the life cycle or other environmental areas and the target of eco-innovation have been determined as the effect created by the interaction arising from its mechanism in the socio-technical field (OECD, 2009). Eco-innovations are of strategic importance for sustainable production. Figure 2 summarizes the typology of eco-innovation.

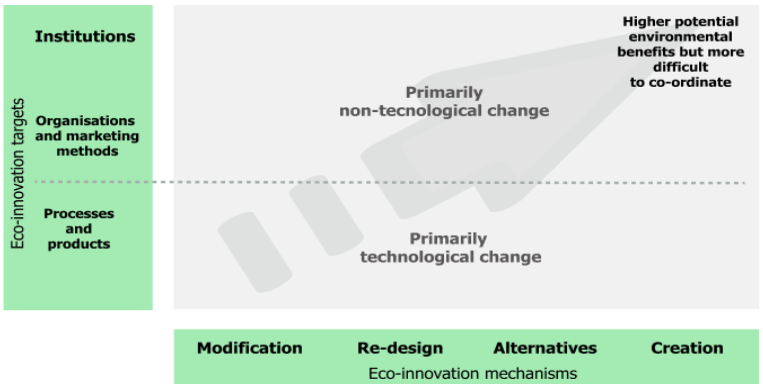

Figure 2. Summary of the typology of eco-innovation.

3. RESULTS and DISCUSSION

Environmental pollution and damage caused by the intense use of fossil fuels underline the need for businesses to redesign their raw material, supply chain, and production strategies. Industrial enterprises should increase their R&D investments in order to make their operations environmentally friendly with energy management and Eco-Innovation practices. The establishment of green supply chains at both national and global levels has become a necessity today in order to ensure sustainability on a global scale. Businesses need to establish sustainable supply chains by establishing an ecosystem cycle from producer to consumer and from consumer to producer through green operations. If it is; The cooperation of country administrations at the global level necessitates more planned and regular progress with state subsidies and legal regulations, encouraging businesses, and taking faster and healthier measures. Although making R&D investments to develop applications for eco-innovation and energy management may seem costly at first to businesses, it is obvious that the return on investment will provide high benefits in both financial, social, and environmental dimensions in the future. For this reason, country governments have an important role in encouraging R&D investments in order to improve the Eco-Innovation and technology infrastructure of enterprises.

Studies show that energy management, which encompasses saving and efficiency applications, is an inherent part of Eco-Innovation. For instance, Kuo and Smith (2018) mentioned that companies in various sectors, from footwear to automotive, usually focus on energy management practices in their innovative improvements, as energy is one of their primary inputs. Furthermore, Janahi, Durugbo, and Al-Jayyousi (2021) assert that "energy intensity and efficiency" is one of the major research topics within eco-innovation literature. They also claim that energy pricing and costing strategy, green knowledge sharing and sourcing strategy, and energy structures and systems strategy are some of the essential components that firms can formulate applicable targets for eco-innovation strategies to improve their sustainability.

Eco-Innovation is of great importance for ensuring the sustainability of our world and improving its livability. For this reason, each study from micro to macro is valuable. In order to carry out these studies, civil society and governments should consider eco-innovative steps as an agenda item. Although the various global economic crises negatively affected Eco-Innovation studies, it is expected that research and development (R&D) budgets to increase in the following periods as the focus turns to responsible investment for the economy. It is noteworthy that the countries at the forefront of Eco-Innovation are also those that value R&D both intellectually and materially, and they are at the forefront of the human development index, have large economies, and have well-established legal infrastructure. It is vital to establish a system that will produce solutions by re-evaluating the processes that ensure the minimization of environmental damage by efficient use of resources (input) and the final product (output); within the framework of optimum resource use to ensure sustainable development.

4. CONCLUSIONS

One of the most essential and urgent issues in the world today is global warming and climate change. The leading factors that cause this are environmental pollution, greenhouse gas emissions, and wastes that occur at the stage from the production process to consumption caused by the industrial sector. Countries, businesses, and consumers are faced with the threat of not having a clean world where they can survive and leave a legacy to future generations as a result of further damage to natural resources and the deterioration of the balance. Developing environmentally friendly production methods requires the development of R&D activities that contribute to the recycling of natural resources, clean production and zero waste philosophy, technological progress towards the use of renewable energy resources, and innovation in processes and operations.

It is of great importance for the future of all countries that the concept of energy management, which has other benefits such as saving energy, preventing environmental pollution, and providing quality and comfort, is popularized and brought to life in practice. Ensuring the continuity of the studies and enacting the law on this subject as soon as possible will provide great convenience. Subsequently, energy management covers efficiency and saving measures, and it is one of the main components of eco-innovation. The implementation of eco-innovation is impossible without taking energy management into account.

The examination of the linkage between energy management and eco-innovation concepts is becoming one of the promising areas. Future research could focus on the attitudes and decision-making processes of firms regarding eco-innovation, and how to influence them to invest in eco-innovative initiatives, as it is clear that the primary tendency of businesses is increasing profitability; but not protecting nature.

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Research Article

Comparative Study on Refrigerators Sold in Turkey

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ABSTRACT: As modernization continues, the lifestyle in domestic settings had become more entwined in the usage of gadgets and appliances. Among the appliances, refrigerators have grown to become one of the most useful in food storage in most countries. It has already become among the key features of any kitchen and hence, an integral part of the home appliances market. This paper presents a comparison of some refrigerators commercially sold in Turkey. The parameters included were brand, type of refrigerator, capacity, price and star ratings. Based on the Pearson correlation price was more strongly positively related to capacity $p<0.001$, than to defrosting type $p<0.01$, or to door type $p<0.01$. Free frost types are more likely to be of higher prices than direct cool types. The double door type is more likely to be of higher prices than the single. Furthermore, ANOVA on brand and defrosting type has shown that there is a significant difference among the five brands of refrigerator on defrosting type, $p<0.01$. Post-host testing revealed significant differences between group of BRAND1 and BRAND3, having more of free frost type of defrosting than BRAND5, BRAND4, and BRAND2. However, ANOVA on brand and price and ANOVA on brand and star ratings revealed that there are no differences among the five brands of refrigerators on price and on star rating which means that price and star rating are more dependent on capacity, door type and defrosting type regardless of the brand of the refrigerators.

KEYWORDS: Refrigerator, Star rating, Defrosting type, Door type, Energy efficiency

1. INTRODUCTION

Controlled-temperature storage of refrigerators does not only answer the need of ordinary producers and consumers in domestic settings but also of people in the science industries [1]. Usually in domestic settings, keeping the food in a low-temperature environment can prolong its shelf life. In the science industries, the ability to control the temperature of storage is vital to the storage of a specimen, like vaccines in pharmaceutical settings. Worldwide sales of refrigerator appliances have continuously increased in recent years. According to data [2] from among five groups of appliances, refrigerator appliances ranked second to have the greatest increase in worldwide retail sales with 84.5 bn USD in 2015, to 95 bn USD in 2021.

The quality of performance of refrigeration systems has been identified as one of the important field of research since the consumption of electrical and thermal energies in the residential building sector is growing fast. Refrigeration industry is responsible for 20 % of the total electrical energy consumed around the world [3]. The main idea behind determining the performance of a refrigerator is based on how much work input is needed to transfer the heat from a cold refrigerated space into the warm environment outside [4], [5]. Developing effective technologies at an expensive cost is impossible because competition in the market for these products is challenging and the resulting significant pricing pressure. Manufacturers have therefore turned to various inexpensive ways to increase the energy efficiency of domestic refrigerators [6].

Although the specific materials and full designs of refrigerators may not entirely be known, obvious parameters could be taken into consideration. In this study, some models of refrigerators from five brands commercially sold in Turkey are compared by using these parameters.

2. REVIEW of RELATED LITERATURE

As more people moved into expanding cities and further away from food sources, the need to keep perishable food cold throughout transit and at home increased. Throughout the 19th century, there was an upsurge in the demand for fresh food. Eventually, this has led to the mass production of the refrigerator in 1918 [7].

The purpose of refrigerator's system is to remove heat from its compartment inside. The most popular method in doing this is compression method, wherein refrigerant's heat is removed via evaporation [8]. The refrigerant repeatedly changes phase from liquid to vapor (gas) and back again as shown in Figure 1. These liquid and vapor phase changes are due to changes in pressure and temperature. The components of the refrigerator responsible for this are the compressor and the evaporation valve. In order to move heat-filled refrigerant vapor from the evaporator (a low-pressure location) into the compressor, it must first create suction. A running compressor causes low pressure in the evaporator because it continuously removes refrigerant from it. Also, the compressor compresses the amount of refrigerant that is drawn in during suction, raising the refrigerant's temperature and pressure. Meanwhile, the pressure of the liquid refrigerant entering the evaporator from the metering device drops suddenly. The enormous pressure difference between the metering device and the evaporator decreases the liquid refrigerant's boiling point. When liquid refrigerant enters the evaporator, some of it quickly boils into vapor and absorbs heat since the temperature is so low [5]. Different kinds of materials in the major components and other parts of refrigerator are used by manufacturers for several reasons. Among these is to select suitable materials from an aesthetical and functional perspective. These materials have different characteristics, like different conductivity and specific heat capacities [9].

Meanwhile, the trouble of getting rid of moisture has led to the accumulation of ice on evaporator fins and thus interferes with proper refrigeration. According to the work of Althouse et al. [8], the presence of moisture in the air that circulates through the evaporator coil can lead to the accumulation of ice on the evaporator fins, which interferes with proper refrigeration. They explained that the moisture problem can arise from several sources, including air leaks, improper installation, or failure to adequately remove moisture from the air. In particular, the systems that operate in warm and humid environments are more susceptible to moisture problems. To combat this issue, the authors suggest several approaches, including installing moisture-removing equipment, such as desiccants, in the system. They also recommend regularly checking for air leaks and ensuring proper insulation of the system's components. Failure to address moisture issues can lead to decreased efficiency and increased energy consumption, as well as potentially damaging the system's components. Furthermore, if ice accumulation becomes severe, it can obstruct airflow and lead to system failure. That is, the importance of effective moisture control in refrigeration systems and offer practical solutions for ensuring proper functioning of the system.

The issue of ice accumulation in refrigerators has been a long-standing problem that has affected the efficiency and lifespan of refrigeration systems. However, with the emergence of defrosting type refrigerators, this issue has been significantly mitigated [10]. The automatic defrost feature is designed to regulate the temperature of the refrigerator and prevent the accumulation of ice on the evaporator coils, which improves the overall efficiency of the system. This has made defrosting type refrigerators a popular choice for users who value convenience and efficiency in their kitchen appliances.

Materials used and the design itself [11] of each model contribute to how energy efficient would be the refrigerator. The efficiency is gauged by using star rating standards. According to the Bureau of Energy Efficiency [12], Table 1 and 2 are the star rating guidelines for direct cool and for frost free type of refrigerator, respectively.

Table 1. Star Rating for Direct Cool Refrigerator [12]

Star Rating	CEC Criteria
1 star	$(0.264 \times V_{adj\_tot\_dc} + 221) \leq \text{CEC} < (0.33 \times V_{adj\_tot\_dc} + 277)$
2 star	$(0.211 \times V_{adj\_tot\_dc} + 177) \leq \text{CEC} < (0.264 \times V_{adj\_tot\_dc} + 221)$
3 star	$(0.169 \times V_{adj\_tot\_dc} + 141) \leq \text{CEC} < (0.211 \times V_{adj\_tot\_dc} + 177)$
4 star	$(0.135 \times V_{adj\_tot\_nf} + 113) \leq \text{CEC} < (0.169 \times V_{adj\_tot\_dc} + 141)$
5 star	$\text{CEC} < (0.146 \times V_{adj\_tot\_dc} + 311$

Notes:
1. CEC stands for Comparative Energy Consumption
2. Storage Volume for direct cool ($V_{adj\_tot\_dc}$) = Total Adjusted fresh food storage volume + $1.31 \times$ freezer storage

Table 2. Star Rating for Fross Free Refrigerator [12]

Star Rating	CEC Criteria
1 star	$(0.286 \times V_{adj\_tot\_nf} + 249) \leq \text{CEC} < (0.357 \times V_{adj\_tot\_nf} + 311)$
2 star	$(0.228 \times V_{adj\_tot\_nf} + 199) \leq \text{CEC} < (0.286 \times V_{adj\_tot\_nf} + 249)$
3 star	$(0.183 \times V_{adj\_tot\_nf} + 159) \leq \text{CEC} < (0.228 \times V_{adj\_tot\_nf} + 199)$
4 star	$(0.146 \times V_{adj\_tot\_nf} + 127) \leq \text{CEC} < (0.183 \times V_{adj\_tot\_nf} + 159)$
5 star	$\text{CEC} < (0.146 \times V_{adj\_tot\_nf} + 311$

Notes: Total Adjusted Storage Volume for no frost ($V_{adj\_tot\_nf}$) = fresh food storage volume + 1.62 × freezer storage

When a refrigerator is turned on, the refrigerant flow cycle continues until the inside compartment reaches a wanted low temperature (set by the user). Its thermostat detects this and turns off the system. Although the inside compartment is insulated and sealed by its door, unwanted heat can still enter and eventually would warm the compartment slowly. This warming up is detected and then refrigerator would automatically turn on again. This repeated cycle of turning on and off of power could also affect the performance of refrigerator. Many researchers nowadays explore the integration of multiple phase change materials (PCMs) into the refrigerator system to address this concern. PCMs are materials that can absorb and release large amounts of energy as they change phase, such as from solid to liquid or liquid to gas.

A study by Ben Taher et al. [13] reveals that the integration of PCMs in the walls of the refrigerator can effectively reduce temperature fluctuations, enhance cooling efficiency, and significantly decrease the overall energy consumption of the refrigerator. Their numerical simulations indicate that the use of multiple PCMs with various melting temperatures is more effective in regulating the temperature inside the refrigerator than using a single PCM.

A research review by Omara et al. [14] provides an overview of the key concepts for improving the performance of refrigerators and freezers by utilizing phase change materials PCMs. The study reveals that the integration of PCMs in the refrigerator walls, doors, and shelves can significantly enhance the energy efficiency, reduce temperature fluctuations, and extend the storage life of perishable goods. The authors also discuss various types of PCMs, such as organic and inorganic, and their different melting temperatures and thermal properties. The review emphasizes that the appropriate selection of PCM type and location is critical for achieving the desired performance enhancement. The most common PCMs used in domestic refrigeration systems are water and eutectic PCMs solutions. They concluded that many research studies have concentrated in incorporation of PCM at the evaporator and compartment but few studies have been carried out at the condenser section. They also concluded that eutectic PCMs demonstrate better system performance than water.

G. Sonnenrein et al. [15] integrated a polymer-bound PCM with a phase change temperature of 9 °C into the compartment of fresh food in a commercial refrigerator to meet the new global refrigerator standard IEC 62552:2015. Their experimental result showed that the cooling capacity improved by 66 % and the temperature rise time rise up to 145 % without negatively impacting energy consumption. This could help manufacturers meet these new standards and improve the overall performance of refrigerators.

Y. Yusufoglu et al. [16] explored the use of phase change materials (PCMs) in household refrigerators to improve their energy efficiency and temperature stability. They conducted experiments on two models of refrigerator using several types of PCMs to determine which combination would have lowest electical power usage. PCM packages were prepared to fit on the evaporator tubes. The study found that using 0.95 kg of PCM could result to 9.4 % energy saving and that increasing the area of condenser could increase the effect of integrated PCM. They concluded that the effectiveness of PCMs in refrigerators is dependent on factors such as the melting temperature of the PCM and the thickness of the PCM layer.

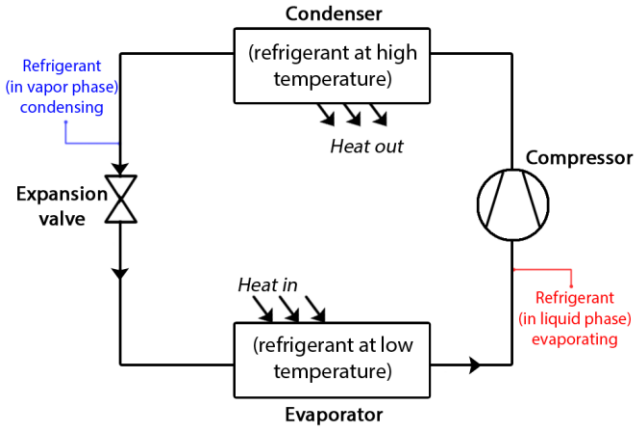

Figure 1. Flow of refrigerant through the major components of a refrigerator.

K. Azzouz et al. [17] conducted numerical simulations of a system with PCM of various designs and operating conditions. Their result has demonstrated that including a PCM leads to an improved conduction of heat from the evaporator to the PCM, as well as the convective heat transfer to the air. This allows a higher evaporating temperature. Nonetheless, response of refrigerator is also dependent on the thermal load. With PCM in the simulated model, coefficient of performance could be improved by 5-15 % which also means increases the energy efficiency of the system.

The research findings hold considerable potential for improving the energy efficiency of refrigerators, which will ultimately result in lower energy costs and reduced environmental impacts.

3. METHODOLOGY

This paper explores the comparison of some refrigerators from five brands, coded as: BRAND1, BRAND2, BRAND3, BRAND4, and BRAND5. The variables considered are brand, capacity, defrosting type, refrigerator door type, and star rating. The capacity of the refrigerator in this study ranges from 190 liters to 450 liters.

The data listed in Table 3 below is gathered from https://gadgets360.com [18]. Figure 2 shows the capacity (L) distribution of considered models. This website can generate a list to compare refrigerators, air coolers, air purifiers, and other electronic devices.

These data were encoded into the Statistical Package for Social Sciences (SPSS). The variables need to be classified as nominal, scale or ordinal in the SPSS. And it is appropriately classified in Table 4 below. For the variable defrosting type, there are only two types, namely: direct cool and frost free which were labeled in SPSS as “1” and “2,” repectively. Similarly, variable door type is of two types, namely: single and double which were also labeled as “1” and “2,” repectively. The variable star rating, it is ordinal with the number 5 rating as the best in performance [19].

Table 3. Data of refrigerators of the five brands

Brand	Capacity (L)	Price (in TL)	Defrosting Type	Door Type	Star Rating
BRAND1	347	8918.8	Frost free	Double	2
BRAND1	290	6817.8	Frost Free	Double	3
BRAND1	263	6157.8	Frost Free	Double	3
BRAND1	367	9017.8	Frost Free	Double	3
BRAND2	335	8797.8	Frost free	Double	3
BRAND2	260	6223.8	Frost free	Double	3
BRAND2	190	3407.8	Direct Cool	Single	5
BRAND2	190	3497.78	Direct Cool	Single	2
BRAND2	235	3957.8	Direct Cool	Single	2
BRAND2	335	8797.8	Frost Free	Double	3
BRAND2	260	5973	Frost Free	Double	3
BRAND3	335	9900	Frost free	Double	2

Table 3. Continued

Brand	Capacity (L)	Price (in TL)	Defrosting Type	Door Type	Star Rating
BRAND3	307	7037.8	Frost Free	Double	3
BRAND3	270	6358	Frost Free	Double	3
BRAND3	450	13755.94	Frost Free	Double	3
BRAND3	282	8360	Frost Free	Double	5
BRAND3	307	6971.8	Frost Free	Double	3
BRAND3	270	5893.8	Frost Free	Double	3
BRAND3	270	6266.48	Frost Free	Double	3
BRAND3	270	6424	Frost Free	Double	3
BRAND3	270	6357.78	Frost Free	Double	3
BRAND4	340	9372	Frost free	Double	3
BRAND4	324	7788	Frost Free	Double	2
BRAND4	192	3212	Direct cool	Single	3
BRAND4	244	5761.8	Frost Free	Double	3
BRAND4	192	2791.8	Direct Cool	Single	1
BRAND4	192	2970	Direct Cool	Single	2
BRAND4	192	3165.8	Direct Cool	Single	3
BRAND4	192	3014	Direct Cool	Single	2
BRAND4	192	3077.8	Direct Cool	Single	3
BRAND5	340	9311.5	Frost free	Double	4
BRAND5	200	3297.8	Direct Cool	Single	4
BRAND5	190	3429.8	Direct Cool	Single	3
BRAND5	245	4727.8	Direct Cool	Single	3
BRAND5	215	4298.8	Direct Cool	Single	4

Ordinary consumers are usually concerned about the price of refrigerators. Hence, analysis of the correlation among the parameters price, capacity, defrosting type and door type of refrigerator is done via the Pearson product-moment correlation test.

Individual One-Way Analysis of Variance (ANOVA) was also used to determine whether or not there are significant differences among the refrigerators in terms of prices, capacity and star rating.

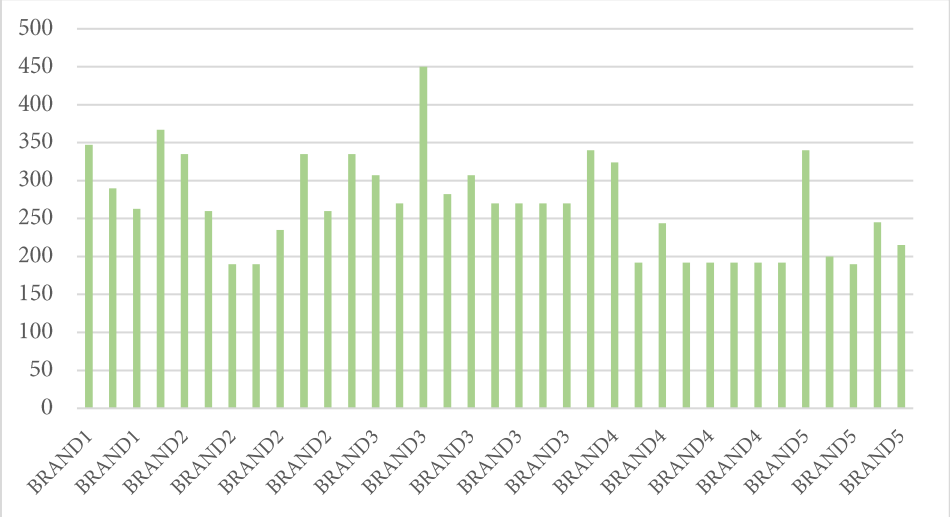

Figure 2. The capacity (L) distribution of considered models from the five brands of refrigerator

Table 4. Classification of variables

Variable	Classification
Brand	Nominal
Capacity	Scale
Price	Scale
Defrosting Type	Nominal
Door Type	Nominal
Star Rating	Ordinal

4. RESULTS

A Pearson product-moment correlation was conducted to examine the relationships between defrosting type and door type of refrigerator. Price was more strongly positively related to capacity, $r(33) = 0.98, p < 0.001$, than to defrosting type, $r(33) = 0.807, p < 0.01$, or to door type, $r(33) = 0.568, p < 0.01$. A complete list is presented in Table 5, a scatter plot of capacity and price is in Figure 3, and a scatter plot of capacity and price per brand is in Figure 4. Figure 5 shows a matrix plot of the four variables. These findings indicate that capacity explains much more of the variability in the price of the refrigerator than does defrosting type. The effect size ($r^2 = 0.96$) for capacity indicate the level of capacity that the brand manufacturer accounted for a large portion (96%) of the variability in the price.

Table 5. Correlation for Price

	Capacity	Defrosting Type	Refrigerator Door Type
Price	0.98**	0.807**	0.568**
Capacity		0.794**	0.583**
Defrosting Type			0.838**
Refigerator Door Type			
Notes:	**Correlation is statistically significant at the 0.01 level		

There was no significant difference among the five brands of refrigerator on prices, $F(4,30) = 2.923, p > 0.05, \eta_p^2 = 0.28$. Furthermore, post hoc testing revealed no significant differences among brands BRAND1 ($M = 7728.05, SD = 1457.80$), BRAND2 ($M = 5807.97, SD = 2330.92$), BRAND3 ($M = 7732.56, SD = 2437.13$), BRAND4 ($M = 4572.58, SD = 2475.40$), and BRAND5 ($M = 5013.14, SD = 2475.73$).

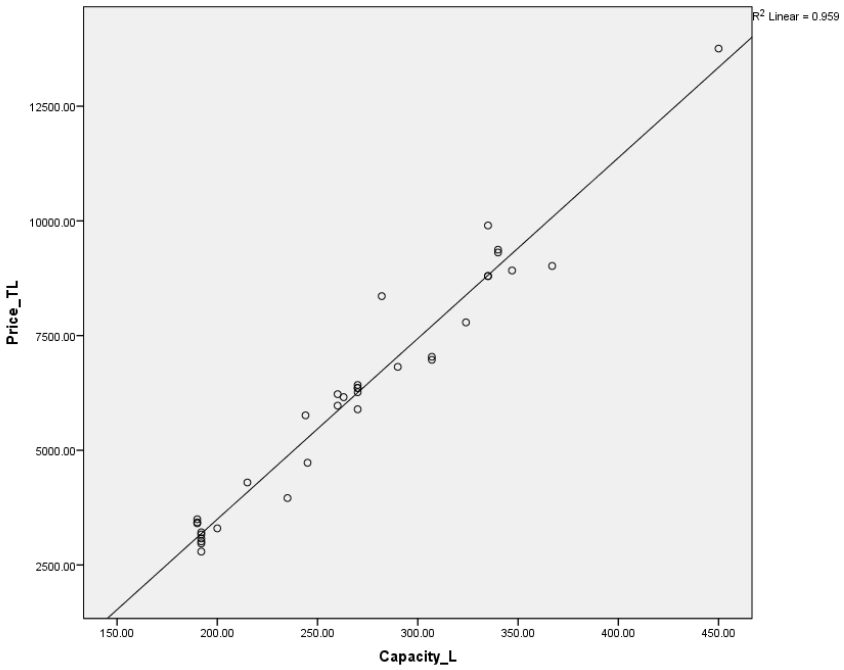

Figure 3. Scatter plot of Price (TL) and Capacity (L)

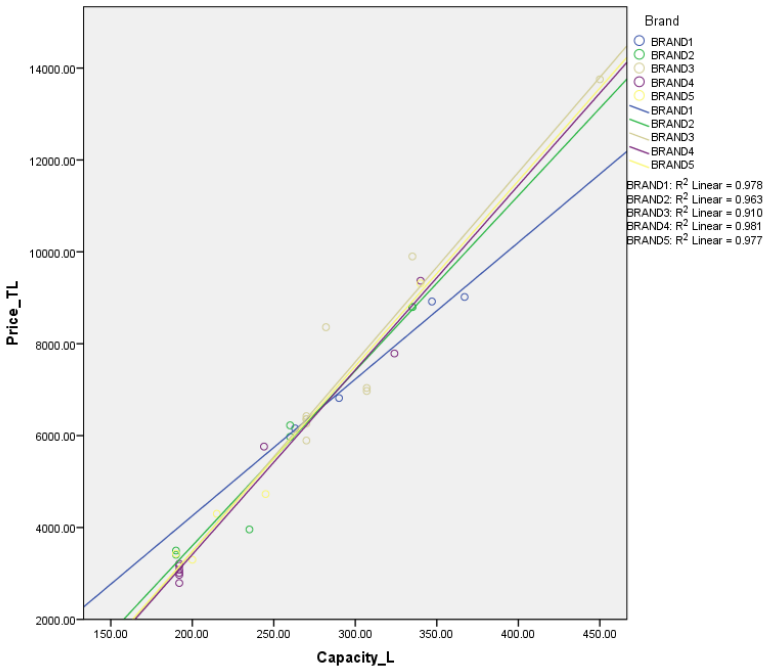

Figure 4. Scatter plot of Price (TL) and Capacity (L) per brand

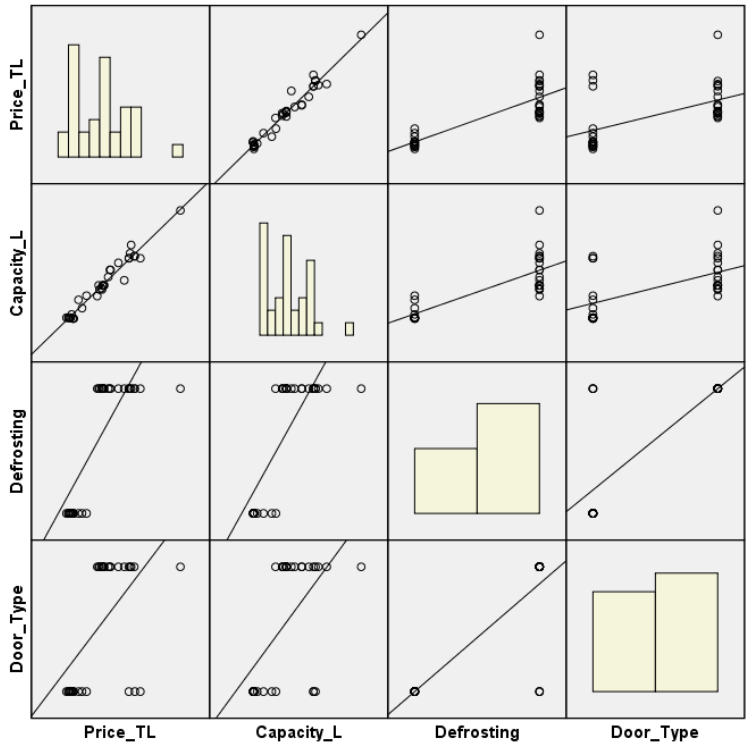

Figure 5. Matrix scatter plot of Price (TL), Capacity (L), Defrosting Type and Door Type.

There is a significant difference among the five brands of refrigerator on defrosting type, $F(4,30) = 22.561$, $p < 0.01$, $\eta_p^2 = 0.45$. Games-Howell post-host testing revealed significant differences between the group of BRAND1 ($M = 2.00$, $SD = 0$), and BRAND3 ($M = 2.0$, $SD = 0$), having more of Free frost type of defrosting than BRAND5 ($M = 1.20$, $SD = 0.5$), BRAND4 ($M = 1.33$, $SD = 0.5$), and BRAND2 ($M = 1.33$, $SD = 0.5$).

There is no significant difference among the five brands of refrigerator on star rating, $F(4,30) = 2.115$, $p < 0.10$, $\eta_p^2 = 0.22$. Furthermore, post host-testing revealed no significant differences among the brands BRAND1 ($M = 2.75$, $SD = 0.5$), BRAND2

($M = 3.00, SD = 1.00$), BRAND3 ($M = 3.10, SD = 0.74$), BRAND4 ($M = 2.44, SD = 0.73$), and BRAND5 ($M = 3.60, SD = 0.55$).

5. CONCLUSION

Therefore, it has been shown that based on Pearson product-moment correlation price was more strongly positively related to capacity, $r(33) = 0.98$, $p < 0.001$, than to defrosting type, $r(33) = 0.807$, $p < 0.01$, or to door type, $r(33) = 0.568$, $p < 0.01$. Since the free frost defrosting type was labeled as 2 and direct cool as 1, this means that the free frost type is more likely to be of higher prices than direct cool. Also, since the double door type was labeled as 2 and single as 1, this means that the double door type is more likely to be of higher prices than single. And this result coincides with what is usually observed in the market.

Furthermore, ANOVA on brand and defrosting type has shown that there is a significant difference among the five brands of refrigerator on defrosting type, $F(4,30) = 22.561$, $p < 0.01$, $\eta_p^2 = 0.45$. Post host-testing revealed significant differences between the group of BRAND1 ($M = 2.00, SD = 0$), and BRAND3 ($M = 2.0, SD = 0$), having more Free frost type of defrosting than BRAND5 ($M = 1.20$, $SD = 0.5$), BRAND4 ($M = 1.33$, $SD = 0.5$), and BRAND2 ($M = 1.33$, $SD = 0.5$). However, ANOVA on brand and price and ANOVA on brand and star rating revealed that there are no differences among the five brands of refrigerator on price and on star rating which means that price and star rating are more dependent on capacity, door type, and defrosting type regardless of the brand of the refrigerators.

6. Declaration of Ethical Standards

The authors declare no conflict of interest.

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Research Article

Innovations in Monitoring of Recurrent Laryngeal Nerve in Thyroidectomy Surgeries

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ABSTRACT: One of the most common complications in thyroidectomy operations is recurrent laryngeal nerve damage. Intraoperative neural monitoring has an important contribution to reduce these complications. In our study, we briefly reviewed the innovations related to this method in recent years. According to the results of our study, innovations in intraoperative neural monitoring and anesthesia in thyroidectomy and some surgeries performed in areas close to the recurrent laryngeal nerve have led to this practice being more effective and cost-effective.

KEYWORDS: Thyroidectomy Surgery, Recurrence Laryngeal Nerve, Monitoring.

1. INTRODUCTION

One of the most common complications in thyroidectomy surgeries is recurrent laryngeal nerve (RLN) injury [1]. Intraoperative neuromuscular monitoring (IONM) method used in these cases to reduce RLN damage rates is significantly effective, and important innovations have been introduced in this regard in recent years. In our study, we will briefly review the important ones among these innovations.

In a study conducted by Duong et al. with the data obtained from the national database, they reported that IONM was performed in 4269 out of 6942 thyroidectomy cases, and severe RLN injury was statistically significantly less common in patients who underwent IONM [2]. IONM method is very effective in reducing morbidity, since RLN damage is common in operations such as esophagectomy, cervical discectomy, lymph node dissection performed in the neck region apart from thyroidectomy operations:

In a prospective study by Çomşalı et al., it was reported that in 166 neck dissection cases, more lymph node dissection could be performed in the IONM group, and recurrence damage was less common [3]. In a meta-analysis conducted by Chen et al., it was reported that performing IONM in patients undergoing esophagectomy is beneficial in preventing RLN damage and pneumonia, and is a method that enables the removal of more lymph nodes in cancer patients [4].

In a study by Niljianskul et al., it was shown that performing IONM with an EMG endotracheal tube in anterior cervical discectomy and fusion surgeries may reduce the risk of RLN injury [5]. In a retrospective study conducted by Türk et al., monitoring was performed with thyroid cartilage needle (TCN) electrodes in 775 cases out of 885 IONM cases, and with endotracheal tube surface electrodes (ETS) in 110 cases. All amplitudes were high in the IONM system in both methods, however it has been reported that TCN electrodes are 20 times cheaper than ETS electrodes, so they should be preferred [6].

In a study by Peng et al., EMG recordings were made with modified arytenoid muscle electrodes in 122 cases, and it was reported that this method is easy to apply, effective and reliable for IONM[7].In a study by Lee et al., they compared the method of applying adhesive skin electrodes in IONM with an EMG endotracheal tube in 39 cases of thyroidectomy with the risk of RLN damage, and reported that although the signal amplitudes were statistically significantly lower, the adhesive skin electrodes could be used safely for IONM during thyroidectomy[8].

In a prospective clinical study, the authors divided 50 patients who underwent total thyroidectomy into 2 groups. In the first group, they only performed optical magnification (OM) to see the RLN in the operation area better, and they applied IONM in

the other group. As a result of the study, no statistically significant difference was found between the two groups in terms of RLN injury. The authors reported that applying both methods together is the most appropriate method [9].

In a study by Fu et al., they reported that performing thyroidectomy with IONM with the sternocleidomastoid intermuscular approach is more suitable for the absence of RLN damage than the anterior cervical approach, and also provides better cosmetic results due to not cutting the anterior cervical muscles [10].

Sometimes false signal loss may occur when performing IONM during thyroidectomy operations. In their study, Kong et al. reported that when direct RLN stimulation is performed with portable devices, it can be revealed more accurately whether the signal loss is true or false compared to IONM [11]. In a recent study, the effects of continuous or intermittent IONM in thyroidectomy operations were investigated. According to the results obtained in the study, both methods have been shown to be effective in preventing RLN damage in thyroidectomy and parathyroidectomy operations [12].

Using adhesive skin electrodes for IONM is an effective method. In the animal experiment and clinical studies by Shin et al., a study was conducted on where the adhesive skin electrodes should be attached in order to obtain the best results. According to the results obtained in the study, it has been shown that sticking the adhesive electrodes right next to the thyroid cartilage gives the best results for monitoring [13].

In a clinical study conducted by Baychorov et al., it was reported that the combined use of IONM and percutaneous larynx ultrasonography methods is the most effective method to prevent and evaluate RLN paralysis in thyroidectomy operations [14].

Hassan et al. developed a protocol called Abu Dhabi Neural Mapping (ADNM) in order to identify nonrecurrent laryngeal nerves and prevent hoarseness in minimally invasive thyroidectomy surgeries, and reported that the application of this protocol in operations is effective [15]. In a study by Tseng et al., the reliability of the quantum molecular resonance device was tested while performing continuous IONM during thyroidectomy in pigs, and it was reported that these devices should be used with care to avoid RLN injury [16].

In a study by Ling et al., direct transcrycothyroid electromyographic monitoring was performed for IONM in 50 thyroidectomy cases, unilateral RLN palsy was observed in only 10 cases, and it was reported that this method was effective and feasible for IONM in thyroidectomy surgeries [17].

In recent years, some innovations regarding anesthesia techniques have been reported during thyroidectomy operations performed with IONM:

In a study conducted by Kriege et al., methods such as videoryngoscopy and conventional direct laryngoscopy were compared to control the surface electrodes in order to prevent the decrease of intraoperative nerve signal quality in patients who underwent thyroidectomy and IONM, and videoryngoscopy was shown to be more effective [18].

In a study by Hsieh et al. reported that IONM in thyroidectomy operations decreases complication rates, but two important issues should be considered during anesthesia. First, they reported that the surface electrodes should contact the endotracheal tube sufficiently during monitoring, so that neuromonitoring signals can be received regularly, and secondly, routine neuromuscular blocking is required in order to provide sufficient signal stimulations [19]. In a controlled clinical study conducted by Oh et al., 20 of 40 thyroidectomy cases who underwent IONM were given neostigmine immediately after tracheal intubation, while the other group was given only saline. According to the results obtained in the study, neuromuscular blockade for IONM was immediately reversible in the neostigmine group [20].

In a study by Li et al., 40 thyroidectomy cases who underwent IONM were divided into 2 groups, and positive EMG signal durations were compared by giving profofol-based total intravenous anesthesia (TIVA) to the first group and combined intravenous and sevoflurane-based anesthesia to the other group. According to the results obtained in the study, it was shown that the duration of positive EMG signal emergence was longer in the group given combined intravenous and sevoflurane anesthesia compared to the TIVA group [21].

In a study by Li et al., it was shown that IONM reduces the risk of RLN palsy, but that neuromuscular blocking drugs used during the operation can endanger EMG responses, and when cisatracurium at a dose of 2xED95 is used for this purpose, better intubation conditions can be achieved than 1xED95, and the IONM process is not impaired [22] .

In a study conducted by Graceffa et al., in patients who underwent IONM during thyroidectomy, signal return was statistically significantly higher in patients who were given a single dose of steroid and escin, compared to those who were not given EMG signal loss [23].

4. CONCLUSIONS

According to the results of our mini-review, the application of IONM in other operations performed in the neck region close to the RLN, such as thyroidectomy, reduces the rates of RLN damage. Innovations in IONM in recent years have allowed IONM to be implemented more effectively and cost-effectively.

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