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Breast Cancer: Molecular Mechanisms, Risk Factors, Diagnostic Advances, and Current Therapeutic Strategies

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ABSTRACT

Breast cancer is a heterogeneous malignancy with diverse molecular alterations, multiple risk factors and variable clinical outcomes. This review provides a summary of recent evidence on the molecular mechanisms, risk factors, diagnostic approaches for breast cancer. Breast cancer is a consequence of the interaction of inherited genetic susceptibility, hormonal influences, genomic instability, epigenetic changes and dysregulation of signalling pathways such as estrogen receptor, HER2, PI3K–AKT–mTOR and cell-cycle regulatory pathways. The standard diagnostic methods are clinical examination, imaging, histopathological and immunohistochemical assessment of estrogen receptor, progesterone receptor, HER2 and Ki-67. Molecular testing can identify clinically relevant alterations that may guide treatment selection. Current treatment options include surgery, radiotherapy, chemotherapy, endocrine therapy, HER2-directed agents, CDK4/6 inhibitors, PARP inhibitors, and antibody-drug conjugates. These advances notwithstanding, tumour heterogeneity, acquired treatment resistance, adverse effects, and disparities in access to modern cancer care remain important challenges. It is important to incorporate molecular mechanisms with clinical, pathological and diagnostic information for the improvement of breast cancer classification, risk assessment and selection of treatment.

INTRODUCTION

Cancer is characterised as a disease that arises from a breakdown in cell division pathways, which leads to the aberrant and uncontrollable proliferation of a group of cells (Arnold et al., 2022). Breast cancer (BC) is the most frequent cancer among women and the second most common cause of cancer-related deaths globally (Zhang et al., 2022). It is a complicated and widespread disease. The most frequent malignancy in women is breast cancer. In 2018, there were around 630 thousand deaths worldwide and more than a million new cases. Furthermore, it is predicted that by 2040, the number of new cases of breast cancer will rise by more than 46% (Zhang et al., 2022).

In 2020, the incidence rate of breast cancer overtook that of lung cancer worldwide, accounting for 23% of all cancer cases and 14% of cancer-related deaths (Werner, 2023). In the United States, there were 48,530 cases of ductal carcinoma in situ and 276,480 cases of invasive breast cancer in 2020, along with about 42,170 deaths from breast cancer (Hendrick et al., 2021). Breast cancer develops when normal breast cells experience genetic abnormalities that cause neoplasia, or unchecked growth. Cancer cells can invade nearby tissues and spread to distant organs if they are not discovered early, making treatment more difficult and raising the risk of death (Siegel et al., 2022). Gender, age, genetic traits (including a family history of BC), race, and the timing of menarche or menopause are some of the risk factors for breast cancer that fall into the category of non-modifiable factors. Alcohol use, obesity, food, radiation exposure, immunodeficiency, and the use of drugs like oral contraceptives are examples of modifiable risk factors, which are usually related to lifestyle (Khan et al., 2025). Furthermore, compared to older women with lower BMIs, those with higher BMIs are more likely to develop the illness (Li et al., 2023).

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The disease is typified by the unchecked proliferation of altered cells that go through natural selection-driven evolution (Brown et al., 2023). Cells are typically strictly regulated to determine whether they divide, differentiate into different cell types, or die (Glaviano et al., 2025). Cells proliferate uncontrollably in the event that this regulatory system fails, creating a massive bulk and gaining the capacity to spread. Genetic mutations in DNA, the majority of which are acquired spontaneously as a result of environmental influences, are often the cause of cancer (Singh & Roghini, 2023).

Two important gene types are affected by these mutations: tumour suppressor genes, which result in their inactivation, and oncogenes, which result in their activation. The cell cycle is accelerated by this disturbance, which also results in a loss of control over the cell cycle and compromises the process of programd cell death, or apoptosis (Brown et al., 2023). According to recent figures, there will be over 20 million new instances of cancer and 9.7 million deaths worldwide in 2022, making cancer the second highest cause of death worldwide (Bray et al., 2024). Cancer is today one of the biggest global health issues. Furthermore, due to factors like population growth, ageing, and the prevalence of lifestylerelated risk factors like smoking, obesity, and physical inactivity, the World Health Organization predicts that the global cancer burden will increase to over 35 million new cases annually by 2050 (Bray et al., 2024). Tumours have a number of important characteristics (Brown et al., 2023):

Breas cancer

The unchecked, aberrant development of breast tissue cells and their capacity to penetrate healthy tissues and invade locally are the hallmarks of breast cancer (BC), a malignant tumour (Cuthrell & Tzenios, 2023). Although the main tumour starts in breast tissue, it may migrate to the lymph nodes if it becomes invasive (Cuthrell & Tzenios, 2023). Both sexes are susceptible to breast cancer, although women are more vulnerable because of the growth of their breasts and lifetime exposure to estrogen (Zhang et al., 2023). In terms of biological and histological traits, clinical results, and responsiveness to treatment, breast cancer is a very diverse disease. The emergence of several subtypes brought about by genetic, epigenetic, and transcriptome changes is a manifestation of this heterogeneity; these variables have contributed to the steadily increasing incidence of breast cancer (Zhang et al., 2023).

Epidemiology

Due to its high incidence and fatality rates, breast cancer is a major global health concern. Between 2008 and 2017, the number of new cases increased by 6%, reaching 11.7% of all cancer cases in 2020, a year that witnessed 2.3 million new cases and about 685,000 fatalities. By 2050, experts predict that there will be about 3.2 million additional cases year (Vinogradova et al., 2020). There were 234,087 instances of breast cancer in the US, 55,439 in the UK, 56,162 in France, 71,888 in Germany, and 66,101 in Japan in 2018 (Bray et al., 2018; Sharma, 2021). The World Health Organization/International Agency for Research on Cancer's Global Cancer Observatory (GLOBOCAN 2022) reports that 2.3 million new cases and 666,103 deaths among women were reported in 2022 (Bray et al., 2018; Filho et al., 2025; Kim et al., 2025; Zhang et al., 2025). China (357,161), the United States (274,375), India (192,020), Brazil (94,728), and Japan (91,916) had the greatest absolute case numbers, but France had the highest standardised incidence rate (105.4/100,000), followed by Cyprus, Belgium, the Netherlands, and Australia. In terms of mortality, Fiji had the highest standardised mortality rate (38.9/100,000), whereas India had the highest number of deaths (98,337), followed by China, the US, Indonesia, and Brazil (Filho et al., 2025; Kim et al., 2025; Zhang et al., 2025). In Iraq specifically, the incidence rate of breast cancer increased from 52.00/100,000 in 2000 to 91.66/100,000 in 2019. It accounts for almost one-third of all cancer cases reported in Iraq in 2019, making it the country's top cause of death for women. Among the top ten malignancies in 2019, breast cancer had the highest incidence rate and proportion (34.08% and 35.95/100,000, respectively); it also had the highest mortality rate (22.58% and 6.22/100,000, respectively) (Al-Hashimi, 2021).

Breast

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In particular, the incidence of breast cancer in Iraq increased from 52.00/100,000 in 2000 to 91.66/100,000 in 2019. It accounts for almost one-third of all cancer cases reported in Iraq in 2019, making it the country's biggest cause of death for women. Among the top ten malignancies in 2019, breast cancer had the highest percentage and incidence rate (34.08% and 35.95/100,000, respectively); it also had the highest percentage and fatality rate (22.58% and 6.22/100,000, respectively) (Al-Hashimi, 2021).

Types of Breast Cancer

Malignant tumours can multiply unregulated by the body; they usually grow locally and get bigger. They can also create their own blood arteries and absorb nutrients from the body. They can also go into the lymphatic and circulatory systems, where they can spread to other areas of the body and establish themselves, resulting in more symptoms. There are various forms of malignant breast tumours (Cuthrell & Tzenios, 2023):

Non-invasive ductal carcinoma

Cells in this kind of cancer grow abnormally inside the milk ducts or lobules, but they do not spread outside of them. These structures' cells have the ability to develop into malignant cells without spreading outside the lobules or ducts; when cancerous cells build up inside the ducts, the ducts widen and become clogged. Although it can occasionally appear as a breast lump, this variety typically manifests as tiny, irregular microscopic calcifications that can be seen on mammography (Tsai et al., 2025).

Non-invasive lobular carcinoma

About 10% of instances of breast cancer are of this type, which is the least prevalent and starts in the glands without spreading outside of them. Women are most likely to have it during menopause (Fendereski et al., 2022).

Infiltrating or Invasive IDC, or ductal carcinoma

Also known as infiltrating ductal carcinoma, this type of breast cancer is the most prevalent, accounting for around 80% of all occurrences. Within the milk ducts, the cancer cells proliferate, penetrate the ductal wall, and disperse throughout the surrounding fatty breast tissue. They can then spread through the circulation and lymphatic system to other areas of the body. When this kind of breast cancer is examined under a microscope, different subtypes of cancer cells are revealed (Kaur et al., 2022).

Invasive (or Infiltrating) Lobular Carcinoma (ILC)

About 10% of all cases of malignant breast cancer are of this form of invasive breast cancer, which is less common than ductal carcinomas. It starts in the breast's lobules, which are the glands that produce milk. Postmenopausal women are more likely to develop invasive lobular cancer (Thomas et al., 2023).

Breast Cancer Symptoms

The development of breast lumps is the main indicator of breast cancer; more than 80% of cases are discovered when a woman feels tumours or lumps in her breast. Breast cancer may be indicated by lumps in the axillary (armpit) lymph nodes (Effiong et al., 2022). Aside from lumps or tumours, other signs include thickening of the breast tissue (feeling different from surrounding tissue), differences in the size of the two breasts, changes in the nipple's colour or form, and changes in the breast skin (such as puckering or dimpling). Other symptoms include swelling under the arm or around the collarbone, severe discomfort in the breast or under the arm (though most malignant tumours are painless), and nipple discharge, which may or may not be bloody (Abd Alkareem et al., 2023). When breast cancer spreads to other areas of the body, it is commonly referred to as a metastatic disease. The liver, bones, lungs, and brain are frequent locations for

breast cancer metastases; symptoms differ according on where the tumour has progressed (Roy et al., 2023).

Breast Cancer Stages

The stage of breast cancer is determined primarily by the extent of the primary tumor, the involvement of regional lymph nodes, and the presence or absence of distant metastasis. The TNM classification system, which evaluates tumor size and local extension (T), regional lymph node involvement (N), and distant metastasis (M), is widely used for this purpose. Breast cancer is classified into stages 0 to IV, ranging from non-invasive disease to cancer that has spread to distant organs. The main characteristics of each stage are described below (Brown et al., 2023; Teichgraeber et al., 2021).

- **Stage 0:** This stage includes ductal carcinoma in situ (DCIS), a non-invasive condition in which abnormal malignant-appearing cells are confined to the breast ducts and have not invaded the surrounding breast tissue. No regional lymph node involvement or distant metastasis is present.
- **Stage I:** This stage represents early invasive breast cancer and is subdivided into stages IA and IB. In stage IA, the primary tumor measures 2 cm or less in its greatest dimension, with no regional lymph node involvement. Stage IB generally refers to cases in which small clusters of cancer cells, measuring no more than 2 mm, are detected in regional lymph nodes, with no primary tumor or a small primary tumor measuring 2 cm or less.
- **Stage II:** This stage includes stage IIA and stage IIB and is characterized by a larger primary tumor and/or limited regional lymph node involvement. In stage IIA, the tumor may be absent or measure 2 cm or less with cancer involvement in one to three axillary lymph nodes, or measure more than 2 cm but no more than 5 cm without regional lymph node involvement. Stage IIB includes tumors measuring more than 2 cm but no more than 5 cm with involvement of one to three axillary lymph nodes, or tumors larger than 5 cm without regional lymph node involvement.
- **Stage III:** This stage represents locally advanced breast cancer and is subdivided into stages IIIA, IIIB, and IIIC. Stage IIIA may involve tumors of various sizes with extensive regional lymph node involvement, including four to nine axillary lymph nodes or certain internal mammary lymph nodes. Stage IIIB includes tumors that have invaded the chest wall or caused ulceration, swelling, or other changes in the breast skin; inflammatory breast cancer is also classified as stage III or higher in the absence of distant metastasis. Stage IIIC is characterized by extensive regional lymph node involvement, including ten or more axillary lymph nodes, infraclavicular lymph nodes, or supraclavicular lymph nodes, depending on the specific pattern of involvement.
- **Stage IV:** This stage, also known as metastatic breast cancer, occurs when cancer has spread beyond the breast and regional lymph nodes to distant organs or tissues, such as the bones, lungs, liver, or brain. The disease may be diagnosed at this stage initially or develop as a recurrence after treatment of earlier-stage breast cancer.

Risk Factors for Breast Cancer Age and Sex

The most important risk factors for breast cancer include being female and getting older. The disease occurs predominantly in women because of differences in the development of breast tissue and in lifetime exposure to sex hormones, particularly estrogen and progesterone. Breast cancer can also occur in men, but it is much less common. The risk of breast cancer generally increases with age due to the cumulative effects of genetic alterations, environmental exposures, and age-related changes in cellular regulation, including DNA methylation and other epigenetic modifications (Anton et al., 2025).

Family History

A family history of breast cancer is linked with an increased risk of developing the disease, especially when a first degree relative such as a mother, sister or daughter has been affected. Women with one affected first-degree relative generally have about twice the risk of women without such a family history, although the magnitude of risk varies according to the number of affected relatives, their ages at diagnosis, and the presence of inherited pathogenic variants (Tran et al., 2023).

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Genetic Mutations

Inherited pathogenic variants in specific genes can substantially increase susceptibility to breast cancer. The most well-established examples are *BRCA1* and *BRCA2*, which encode proteins involved in DNA damage repair and the maintenance of genomic stability. Other susceptibility genes include *PALB2*, *TP53*, *CHEK2*, and *ATM*. By contrast, *HER2* (encoded by *ERBB2*) is primarily important as a tumor biomarker and therapeutic target; increased *ERBB2* gene copy number or HER2 protein expression in tumor cells is usually an acquired molecular alteration rather than an inherited susceptibility mutation (Stella et al., 2022).

Benign Breast Diseases

Benign breast diseases are a heterogeneous group of conditions with varying implications for subsequent breast cancer risk. Generally, nonproliferative lesions convey little or no increase in risk, and proliferative lesions without atypia are associated with a modest increase in risk. Atypical ductal hyperplasia and atypical lobular hyperplasia are associated with a larger risk increment. The histological diagnosis, family history, age and other known risk factors should therefore be included in risk assessment. Benign breast disease is not a single disease with a uniform increase in risk of malignancy (Ren et al., 2023).

Reproductive Factors

Breast cancer risk is influenced by reproductive history, partly through its effect on duration and pattern of exposure to ovarian hormones and differentiation of breast tissue. Increased risk has been associated with epidemiological factors including early menarche, late menopause, nulliparity and older age at first full-term pregnancy in some populations. However, these associations may differ in strength and direction by menopausal status, tumour subtype and other individual characteristics (Obeagu & Obeagu, 2024).

a. Early Menarche

Early menarche is associated with a slightly increased risk of breast cancer . This is in part due to the longer lifetime exposure to ovarian hormones . This association is consistent with the effect of cumulative hormone exposure on breast epithelial cell proliferation. Early menarche is simply one of many factors that add to breast cancer susceptibility and does not alone determine if the disease will develop (Al-Shami et al., 2023).

b. Nulliparity and Age at First Birth

Generally, women who have never been pregnant have a higher long term risk of breast cancer compared to women who have had a full term pregnancy, although the association varies by age at first birth, breastfeeding history, and tumour subtype. A higher risk is also found in women with a later age at first full-term pregnancy than in those with an earlier age at first birth. Pregnancy is associated with dramatic hormonal changes and differentiation of mammary epithelial cells, but there is a transient increase in breast cancer risk after childbirth, followed by a longer-term decline. Hence, protective effects of parity should not be attributed solely to lower concentrations of estrogen and progesterone during pregnancy (Obeagu & Obeagu, 2024).

c. Late Menopause

Late age at menopause is associated with increased risk of breast cancer (particularly estrogen receptor-positive disease). This is partially due to the longer period of exposure to ovarian hormones. After menopause, estrogen is produced mainly by peripheral conversion of androgen precursors to estrogens in adipose and other tissues. Therefore, menopausal age and exposure to hormones should be considered together with body composition and other risk factors (Vatankhah et al., 2023).

Hormonal Factors

a. Oral Contraceptives

Hormonal contraceptives containing estrogen and progestin have been associated with a small increased risk of breast cancer during current or recent use. How strong this link is depends on the formulation, how long it is used and the time since it was stopped. Risk should be considered in the light of the benefits and other health effects of the contraceptive, and not assumed to be similar across all hormonal contraceptives (Curtis et al., 2016).

b. Estrogen

Estrogen has an important role in the development and proliferation of breast epithelial cells. Long-term exposure to endogenous estrogen increases the risk of hormone receptor positive breast cancer. After menopause, adipose tissue is an important source of estrogen production by aromatisation of androgens, including conversion of androstenedione to oestrone. Increased adiposity may therefore contribute to increased circulating estrogen concentrations, and may partially mediate the association of postmenopausal obesity with breast cancer risk (Anton et al., 2025).

c. Menopausal Hormone Therapy

Breast cancer risk in relation to menopausal hormone therapy may depend on hormone formulation, duration of treatment and individual characteristics. In many of the populations studied, combined estrogen–progestogen therapy was associated with a larger increase in breast cancer risk than estrogen-only therapy, particularly with prolonged use. Estrogen alone therapy has a different risk profile and is generally considered separately depending on whether or not the woman has had a hysterectomy. Thus, the effects of hormone therapy should not be summarised by a single risk estimate that applies to all regimens (Støer et al., 2024).

Environmental and Lifestyle Factors

a. Ionizing Radiation

Exposure to ionising radiation, especially in young people, is a well-established risk factor for breast cancer. The risk is relevant in particular to therapeutic or other significant irradiation of the chest in childhood, adolescence or early adult life. The magnitude of risk is a function of age at exposure, radiation dose, and time since exposure. Therefore it is wrong to conclude there is no risk for radiation exposure after age 40, but the association is usually stronger when exposure happens at younger ages (Anton et al., 2025).

b. Obesity

Obesity, typically defined as having a body mass index (BMI) of 30 kg/m 2 or greater, is linked to a higher risk of postmenopausal breast cancer. Possible mechanisms include increased peripheral estrogen production in adipose tissue, insulin resistance, altered insulin-like growth factor signalling, and chronic low-grade inflammation involving adipokines and inflammatory mediators. The link between obesity and breast cancer is more intricate prior to menopause, when associations can differ depending on tumour subtype and other factors (Anton et al., 2025).

c. Diet

The influence of dietary patterns on breast cancer risk may be mediated through their effect on body weight, metabolic health and exposure to specific dietary components. However, data do not support the generalised statement that saturated fat or processed foods are independently associated with increased risk of breast cancer to the same degree in all populations, nor does it support the statement that antioxidant-rich foods are associated with a fixed percentage reduction in risk of 15– 56%. The independent protective effect of specific foods against breast cancer is hard to measure, but a well-rounded eating pattern high in vegetables, fruits, whole grains and other nutrient-dense foods can support overall health and weight management (Krusinska et al., 2018).

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d. Alcohol Consumption

Alcohol consumption is a well recognised risk factor for breast cancer and risk generally increases with the amount of alcohol consumed. These include mechanisms such as changes in estrogen metabolism, acetaldehyde formation, oxidative stress and DNA damage. The association was seen in both premenopausal and postmenopausal women. Therefore, alcohol use is a key modifiable risk factor for breast cancer prevention (Rumgay et al., 2021).

e. Psychological Stress

The relationship between psychological stress and breast cancer development is unclear. Chronic stress can affect neuroendocrine and immune functions, including the signalling of cortisol and catecholamines. However, the current evidence does not support that psychological stress directly causes breast cancer via DNA damage caused by stress hormones in humans. Thus, it is more appropriate to speak of stress as an area of ongoing investigation rather than as a definite independent risk factor (Anton et al., 2025).

Breast Cancer Diagnosis

Diagnosis of breast cancer is based on clinical examination, imaging, histopathology and laboratory tests. Mammography is a commonly used X-ray imaging modality to detect breast abnormalities, both in breast cancer screening and in the diagnostic workup of women presenting with a palpable mass or other signs or symptoms suspicious of breast cancer. Breast ultrasonography is another important imaging modality helping to distinguish solid masses from fluid-filled cysts, characterise suspicious lesions, and guide image-assisted biopsy procedures. It is particularly useful in women with dense breast tissue and can be used to evaluate selected suspicious metastatic lesions, including those involving the liver (Chang et al., 2022; Wang et al., 2019).

The main way to confirm a breast cancer diagnosis is a breast biopsy, which allows for the microscopic examination of tissue or cellular material obtained from a suspicious lesion. The type of biopsy chosen depends on the characteristics and location of the lesion and whether it can be felt or needs imaging guidance. Fine needle aspiration cytology (FNAC) obtains cells for cytological examination with a thin needle, whereas core needle biopsy (CNB) provides tissue samples that preserve the tissue architecture and generally provide more comprehensive information for histopathological diagnosis and tumour characterisation (Obeagu & Obeagu, 2024; Seferin et al., 2022; van der Poort et al., 2022). Another useful imaging modality is magnetic resonance imaging (MRI), which utilises magnetic fields and radiofrequency signals to create detailed images of breast tissue without the use of ionising radiation. It may be used to evaluate the extent of disease, to investigate certain diagnostic conundrums, to screen women deemed at high risk, and to follow therapy in appropriate clinical situations. However, MRI does not exclude the need for histopathological confirmation of suspected malignancy (Faheem et al., 2024).

Serum tumour markers can provide additional information in selected patients with breast cancer. Cancer antigen 15-3 (CA 15-3) is a marker used in clinical practice especially for monitoring some patients with advanced or metastatic disease and changes during treatment. However, its sensitivity and specificity are not high enough for routine breast cancer screening or for initial diagnosis, and the results must be correlated with clinical findings and imaging results (Wang et al., 2017). In addition, in selected cases, multigene panels and genomic profiling are becoming increasingly important as they can identify inherited cancer susceptibility variants, characterise tumour biology, estimate recurrence risk, and guide treatment decisions. The clinical utility of these tests depends on the assay, tumour subtype and individual patient characteristics. The characterisation of breast cancer includes assessment of the hormone receptors and human epidermal growth factor receptor 2 (HER2). The presence or absence of estrogen receptors (ER) and progesterone receptors (PR) are used to determine which tumours may be candidates for endocrine therapy. HER2 testing is used to determine whether HER2-targeted therapy may be appropriate. These biomarkers are generally assessed in newly diagnosed invasive breast cancer to inform therapeutic decisions and assist with prognostic evaluation. The interpretation of these findings in combination with histological type, tumour grade and disease stage contributes to the choice of an individualised treatment strategy (Wang et al., 2019).

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Treatment

Chemotherapy: This treatment option uses chemicals that interfere with DNA synthesis to kill all dividing cells; the cells that divide the fastest are most vulnerable to the drug (Poggio et al., 2022). Chemotherapy works best when a combination of medications is employed. These medications can be used as adjuvants or neoadjuvants; the most popular kinds are: Anthracyclines: Anthracyclines, which include doxorubicin and epirubicin, are the class of drugs most commonly used to treat breast cancer (Cai et al., 2019). A number of solid malignancies have been successfully treated with taxotere, a semisynthetic taxane. Two examples of taxanes (Taxotere) are paclitaxel (Taxol) and docetaxel. 5-FU, or deoxyfluorouridine. Carboplatin (Paraplatin) with Cyclophosphamide (Cytoxan) (Tagliaferri et al., 2020).

High-energy radiation, such as x-rays or particles, can be utilised to damage breast cancer cells following surgery and enhance treatment by effectively lowering the risk of recurrence by almost 50% (Correa et al., 2017). To reduce the recurrence rate following breast-conserving surgery, radiotherapy may be utilised. Intraoperative radiation therapy (IORT), which treats a portion of the breast with a single dose of radiation often administered during surgery, can employ low-energy x-rays or electrons (Watkins, 2019).

The best course of treatment for breast cancer is surgery. Typically, the axillary nodes are removed and the primary tumour is removed for staging. Choosing the appropriate course of action for the breast can be challenging for both the patient and the physician due to the wide variety of surgical procedures available, such as breast reconstruction and breast preservation surgery (lumpectomy). Following a mastectomy, breast reconstruction may be performed right away or later (Riis, 2020).

Tumours that express the progesterone receptor (PR) and/or oestrogen receptor (ER), which function on regulatory pathways to limit cell proliferation, are treated with endocrine treatment. Endocrine therapy medications fall into two categories: tamoxifen and aromatase inhibitors. An enzyme called aromatase is required to produce oestrogen. By inhibiting aromatase, aromatase inhibitors reduce the growth of tumours in postmenopausal women. There is strong evidence to support the use of tamoxifen as an adjuvant endocrine therapy, and it has been used to treat early breast cancer. Tamoxifen reduced the growth of tumours by blocking oestrogens from binding to their receptors in cancerous cells. Tamoxifen Femara Zoladex (Poggio et al., 2022)

Biological treatment is the most sophisticated kind. Together with the immune system, this treatment slows the growth of tumours. Patients with Her 2 positive findings tumours were mostly treated with trastuzumab, an anti-cancer medication known as "monoclonal antibodies that have been humanised antigen" (Riis, 2020).

CONCLUSION

Integrating molecular mechanisms with clinical, pathological, and diagnostic information is essential for improving breast cancer classification, risk assessment, and treatment selection. Advances in targeted therapy, immunotherapy, and molecular profiling have expanded opportunities for personalized management. Further research is required to identify reliable predictive biomarkers, overcome therapeutic resistance, and ensure equitable access to evidence-based breast cancer care.

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