Granular cell tumor of the breast: a multidisciplinary challenge

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ABSTRACT

Granular cell tumors are rare soft tissue tumors; they are almost never malignant, but can mimic a carcinoma clinically, radiologically and microscopically. The finding of a suspicious lump often entails subsequent diagnostic procedures that can pose significant anxiety on patients before reaching a challenging differential diagnosis. The physical and psychological burden is even more significant when such findings occur during the follow up of a previous oncologic condition. Sometimes the fear for a potential local or distant recurrence can be responsible for a misdiagnosis and lead to patient overtreatment.

1. Introduction

Granular cell tumors (GCT) are rare tumors arising from Schwann cells and representing 0.5% of all soft tissue tumors (Jagannathan, 2016; Pohlodek et al., 2018; Aoyama et al., 2012; Chen et al., 2012; Delaloye et al., 2002). They are usually benign and solitary but approximately 2% occur with malignant features and 5–10 % present as multiple lesions. They can develop in any body site (Ordóñez, 1999; Nasser et al., 2011; Machado et al., 2016; Moten et al., 2018), most commonly in the GI-tract, head and neck region, female genital region, breasts, as well as skin or subcutaneous tissue of the trunk or upper extremities.

GCTs of the breast (GCTs-B) account for 5–15 % of all GCTs and mimic scirrhous breast malignancies due to their clinical and radiological characteristics that make diagnosis difficult. Epidemiological findings indicate higher clinical significance than previously thought, with an actual prevalence of 6.7:1000 cases in the overall BC population (Brown et al., 2011; Pieterse et al., 2004; Mariscal et al., 1995; Patel et al., 2008; Irshad et al., 2008) Such clinical incidence should be kept in mind in the differential diagnosis of breast masses, as misdiagnosis can lead to inappropriate treatment and unnecessary physical and psychological burden to the patient.

GCTs-B have been reported also in the male population, accounting for 6.6% of all GCTs-B cases with a 1:9 male:female ratio (Jagannathan,

Abbreviations: GCTs, granular cell tumor (s); GCTs-B, granular cell tumor (s) of the breast; BC, breast cancer; FNAC, fine needle aspiration cytology; PET, positron emission tomography; US, ultrasound; IHC, immunohistochemistry; H&E, hematoxylin eosin; ER, estrogen receptor; PR, progesterone receptor

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Table 1
Fanbourg-Smith Criteria: six microscopic features suggestive for malignancy: when 3 out of 6 of these criteria are present the lesion is classified as malignant.

	Fanbourg-Smith Criteria				
Spindling cells	Increased nuclear/cytoplasmic ratio	Vesicular nuclei, large nucleoli	Pleomorphic nuclei	necrosis	Increased mitotic activity

2016; Brown et al., 2011; Gibbons et al., 2000; Lauwers et al., 2008).

A wide variety of localizations within the breast have been described; some authors have suggested a predilection for the upper inner quadrant, which would be related to their perineural cell origin and the distribution of the cutaneous sensory supraclavicular nerve. (De Simone et al., 2011; Adeniran et al., 2004) GCTs-B usually present as a solitary mass that is identified on palpation, but muticentricity, both within and outside the breast (Delaloye et al., 2002; Chen et al., 2012), has been reported in the literature.

In symptomatic patients there is no uniform presentation. Usually the lumps are described as firm, painless and mobile. Neoplasms with elastic consistency, breast pain and fixation to the pectoralis muscle have also been described. Nodules can range from well-defined and round to irregular and ill-defined masses. Skin involvement with thickening, dimpling and retraction is also possible. Associated lymphadenopathy is unusual.

Since the introduction of breast screening, the identification of asymptomatic cases in the female population has increased. Overall, about 70% of the cases are detected by palpation, 26% through mammographic screening and 4% during follow-up of breast malignancy. (Brown et al., 2011)

Imaging of these tumors can be further misleading, as their presentation often mimics invasive BC, resulting in potential misdiagnosis and overtreatment. The tumors can be investigated by mammography, ultrasound and magnetic resonance (MRI), but none of these radiological modalities is able to identify any specific diagnostic characteristic.

On mammography, GCTs-B often show features that are suggestive for malignancy, including irregularity of the margins, spiculation, stellation, isodensity. Microcalcifications are generally absent. Sometimes skin thickening and/or proximity and local invasion of the greater pectoralis muscle can be seen. (Rickard et al., 1992; Ohnishi et al., 1996; Leo et al., 2006; Gavriilidis et al., 2013; Stavros, 2004)

On ultrasound (US) GCTs-B present as heterogenic masses with ill-defined margins. They may or may not show hypervascular echotexture and sometimes display posterior shadowing, depending upon the degree of reactive fibrosis. US finding are very diverse, yet often suggestive for malignancy without any specific US-features that have been described.

The nodules are usually elliptical or fusiform in shape, no ecogenic capsule. The most unique feature is their anisotropic effect. This is due to their internal fibrillary composition which causes variable ecogenicity depending on the angle of the ultrasound beam. The same effect is seen in the sonographic examination of tendons. GCT can cause intense posterior shadowing, also depending on the angle of incidence of the ultrasound beam. This feature can help in diagnosis. Because of malignant features the lesion is excluded of the BIRADS 3 (probably benign) classification and necessitates always biopsy (Stavros, 2004).

On MRI, GCTs-B are lesions with low to intermediate signals in T1-weighted sequences, but are scarcely visible in T2-weighted sequences. When using gadolinium contrast, they appear as variably enhancing lesions, with both benign and malignant features. Slow enhancement and high-end intensity may be present as well as rapid enhancement, rim enhancement and irregular, ill-defined margins.

In contrast to other imaging modalities, positron emission tomography (PET) can correctly differentiate GCTs from malignant tumors, as they do not show any increased metabolic activity. Benign GCTs usually show a standardized uptake value (SUV) of 1.8, whereas the cut-off for malignant lesion is 2.5 (Hoess et al., 1998). Nevertheless, the sustainability of routine use of PET-CT as non-invasive diagnostic tool is questionable and would need further evaluation.

Given the shortcomings of imaging studies, diagnosis of GCTs often requires tissue analysis, which is obtained with core needle biopsy, followed by microscopic and immunohistochemistry (IHC) evaluation.

Fine needle aspiration cytology (FNAC) has in fact proven to be associated with many pitfalls and is generally considered not adequate for definitive diagnosis: lack of information on cellular architecture, solidity of lesions, insufficient material for IHC, poor quality of the smear with dirty background or defective fixation, limit the use of such pre-operative diagnostic tool.

On the other end, the use of invasive procedures bring along anxiety and fear of cancer, which can be a significant psychological burden for patients.

Being mostly benign, GCTs can be treated with wide local excision and are associated with a good prognosis. Yet these tumors have a certain risk to recur particularly in case of positive resection margins (Mariscal et al., 1995; Patel et al., 2008; Ohnishi et al., 1996; Qureshi et al., 2006; Miller et al., 2000). Six microscopic criteria (Table 1), suggestive for malignancy, have been described so far: when 3 out of 6 of these criteria are present the lesion is classified as malignant (Fanburg-Smith et al., 1998). Metastases, local recurrence and tumor-related death from malignant GCTs have all been described (Chetty and Kalan, 1992; Uzoaru et al., 1992).

In the extremely unusual case of malignant features, standard surgical treatment remains mainstay; lymph node assessment (e.g. sentinel node biopsy) is indicated in such cases as malignant GCTs have the potential to spread both via lymphatic vessels and the blood. Neither systemic treatment, nor local radiotherapy are commonly indicated as adjuvant treatment. (Rose et al., 2009; Koltsidopoulos et al., 2016; Serpa et al., 2016)

Local treatment should be associated with annual follow-up, but its modalities are neither well defined, nor standardized (Patel et al., 2008; Qureshi et al., 2006).

Here we describe two cases of GCTs diagnosed in the breast and in the upper limb respectively, during oncological follow-up for previous breast cancer. In both cases clinical features suspicious for infiltrating local and distant BC recurrence elicited invasive diagnostic procedures with inevitable distress for our patients.

2. Methods

A search in the electronic database PUBMED was performed to identify all publications on GCTs. One-thousand-hundred-thirty-one publications on GCT, published between 1956 and 2018, were found, of which 92 reported specifically on GCTs-B. Of the 92 breast publications, 35 were relevant to our purpose and are listed in the reference section of this paper.

Patients' written consent has been obtained prior to publication.

3. Cases description

We report two cases of GCTs-B, treated in 2017 and 2018 in our certified Breast Unit (EUSOMA, Q-Label) in patients with a personal history of BC. In both cases suspicious findings, cuasing additional clinical and radiological investigations, were discovered during routine follow-up, and the final diagnosis of GCT-B was made after exclusion of local and distant recurrence of BC.

3.1. Clinical case 1

59 year old caucasian female known for metachronous bilateral breast cancer. In 1999 she was diagnosed and treated for an invasive ductal carcinoma (IDC) of the upper outer quadrant of her left breast (pT2pN0M0 (Edge et al., 2010), G2, Luminal-like (Goldhirsch et al., 2013)). After modified radical mastectomy and immediate implant-based reconstruction, she underwent adjuvant anti-hormonal therapy with Tamoxifen (20 mg/die) and ovarian function suppression (monthly GnRh analogue Goserelin 3.6 mg im injections, Zoladex®) from October 1999 to October 2001, followed by Tamoxifen alone. In June 2005, tumor recurrence was diagnosed in the infraclavicular region. Local excision of the recurrence was performed with clear surgical margins followed by local radiotherapy (total do se 64 Gy).

Adjuvant anti-hormonal treatment was reintroduced with an aromatase inhibitor (Letrozole 2.5 mg/day) from July 2005 to June 2011.

In June 2014, mammography of the right breast showed a 4 mm large cluster of microcalcifications in the lower inner quadrant, which at vacuum assisted biopsy proved to be DCIS, grade 3, ER90%, PR5%, Ki-67 15%, c-erbB2 score 0. Wide local excision and oncoplastic remodeling of glandular tissue were performed in association with an implant-based breast augmentation. Implant replacement was also undertaken on the left side to achieve best symmetry.

In December 2017 follow up mammography of the right breast (Fig. 1) indicated a new cluster of 6 mm suspicious microcalcifications (Birads 4a) in the upper outer quadrant, requiring further assessment.

Complementary US showed glandular tissue without any visible microcalcification, deemed compatible with a fibrotic distortion.

Considering the patient's previous medical history and the suspicious reappearance of microcalcifications on mammography, histological evaluation was enforced. Radiographically guided vacuum biopsy was not technically feasible, due to the small size of the breast and peripheral localization of the cluster. Thus, wide wire-guided open excisional biopsy was performed on February 2018.

The intraoperative specimen radiography confirmed microcalcifications in the surgical sample, close to the lateral margin, which was subsequently re-excised for radicality (Fig. 1c)

The postoperative course was uneventful and the patient was discharged on 2nd postoperative day.

The final pathology report showed as incidental finding a 3 mm benign (according to Fanburg-Smith criteria, Table 1) GCT-B excised with adequate surgical margins, adjacent to a large lipogranuloma with calcifications.

Microscopic analysis (Fig. 3) revealed nests of polygonal, cytologically bland appearing cells, with granular eosinophilic cytoplasm and small hyperchromatic nuclei, without atypia (H&E stain). The morphological features were considered characteristic for a GCT but no residual neoplastic tissue was available for confirmatory immunohistochemical studies with antibodies against protein S-100.

At last follow up visit on June 2018 the patient was 4 month out of surgery without early signs of relapse or chronic complications.

3.2. Clinical case 2

The patient, a caucasian 53 year old woman, was known to our Breast Unit since 2007, when she was diagnosed with a right breast invasive ductal carcinoma (IDC), grade 3, pT2pN1a (3/4) M0 (Edge et al., 2010), luminal like (Goldhirsch et al., 2013) (ER70% PR30%, Ki-67 15%, c-erb-B2 score0).

At that time, she was treated with right mastectomy followed by adjuvant chemotherapy (4 cycles of EC), thoracic wall radiation (total dose 54 Gy) and endocrine treatment with ovarian function suppression (monthly GnRh analogue Zoladex® 3.6 mg im injections) and aromatase inhibitors (Letrozole 2,5 mg/day) from 2007 to 2012. The patient refused immediate reconstruction.

In May 2017 she presented with a palpable lump of approximately

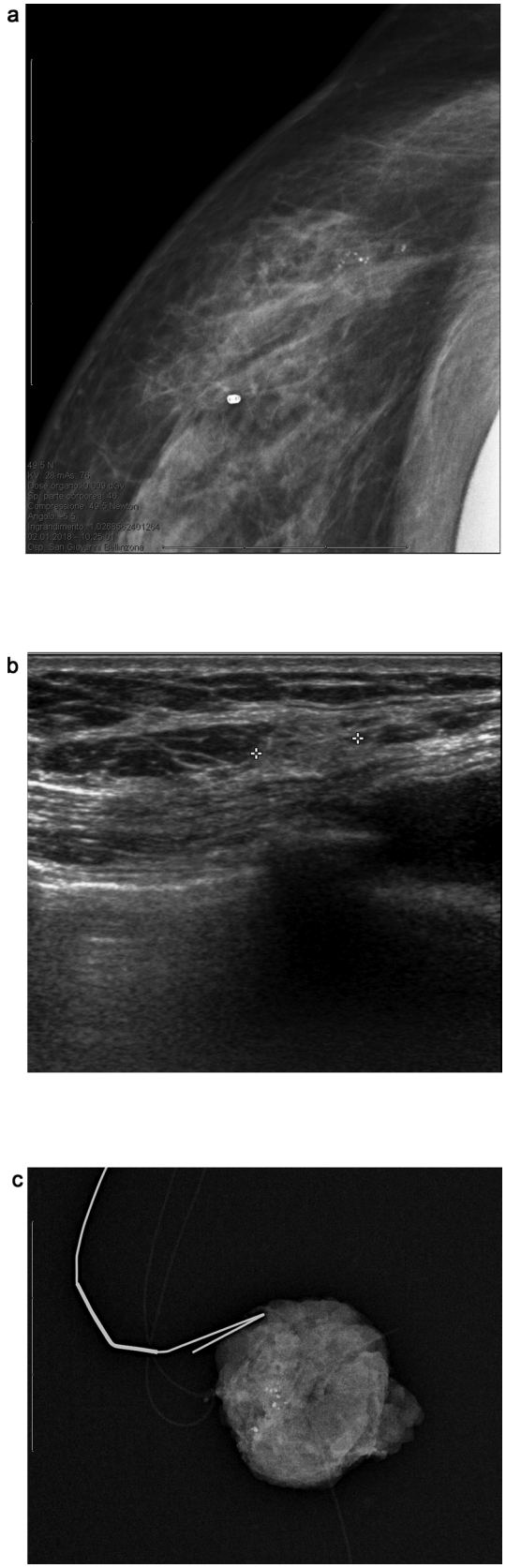

Fig. 1. 1a. Mammography: 6 mm cluster of newly appeared suspicious microcalcifications (Birads 4a) in the upper outer quadrant of right breast; **1b.** enlargement image (spot compression) on the group of calcification; **1c.** surgical specimen x-ray: microcalcifications can be seen close to the lateral margin.

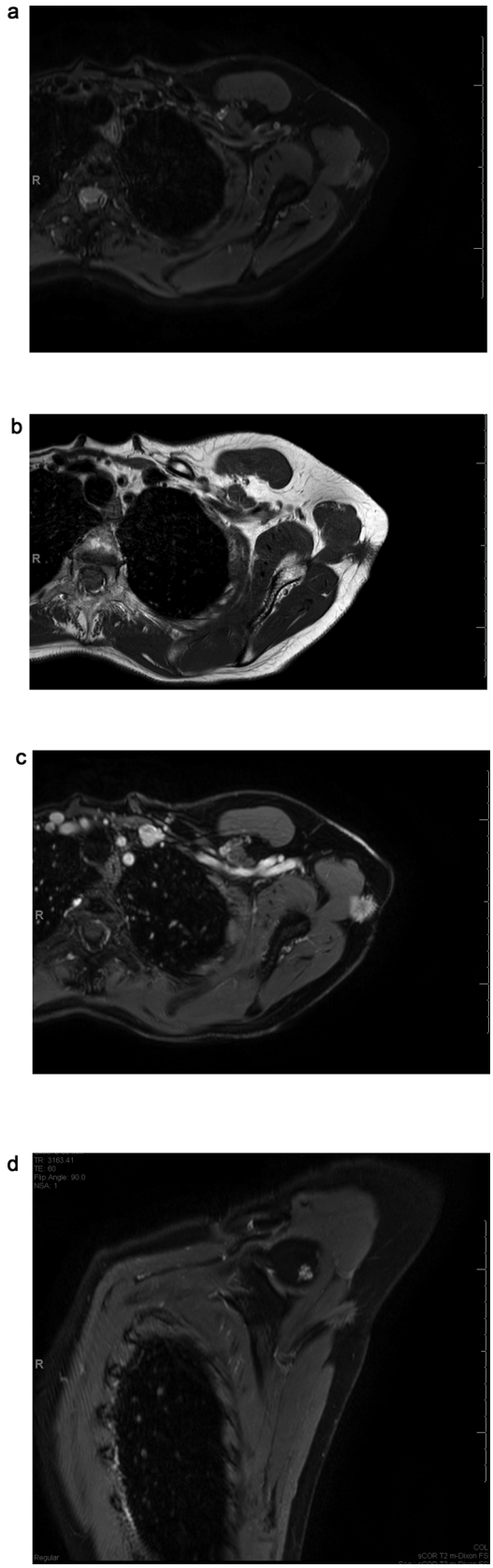

Fig. 2. 2a.thoracic MRI Showing a 18 mm speculated contrast enhancing lesion (arrow) fixed to the superficial skin and deep muscle layers. **2b.** enlarged axial image of the lesion in T1 before gadolinium; **2c.** after gadolinium; **2d.**T2 coronal image.

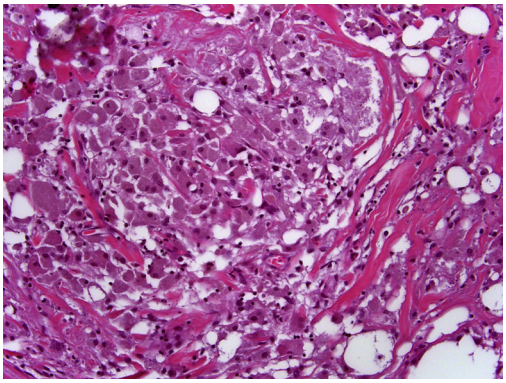

Fig. 3. Nests of polygonal, cytologically bland appearing cells, with granular eosinophilic cytoplasm and small hyperchromatic nuclei, without atypia (H&E stain).

2 cm in diameter in the posterior region of her right axillary crease. The lump was firm at palpation and fixed both to the superficial and deep soft- tissue layers and showed a visible pit mark in the skin.

Further investigation included MRI (Fig. 2) that demonstrated a 18 mm contrast-enhanced lesion with spiculated margins, close superficially to the skin and deeply to the muscle.

Since MRI was not able to exclude soft tissue sarcoma, further investigations included PET/CT and US-guided biopsy. At US the lesion appeared not to be cleavable, either from the skin, or from the muscle, was round and hypoechoic with ill-defined margins and a maximum diameter of about 16 mm. A hyperechoic rim was evident, while no internal color Doppler signal was identified. The PET/CT scan showed only minimal metabolic activity (SUV max 1.7), which, in contrast to current indications (ULN 2.5–3.5), was seen to be suspicious and thus worth for histopathologic examination. A US-guided tru-cut needle biopsy (Biopince 16 G) was performed under local anesthesia and a metal clip was released in site.

Histological evaluation demonstrated diffuse infiltration of tumor cells with large distinctive granular eosinophilic cytoplasm and central nuclei, without increase in nuclear division, atypia or other signs of malignancy. Immunostaining for S100 protein was positive, while anti-cytokeratins antibodies (MNF116 and AE1/AE3) were reported as negative

A diagnosis of GCT was made and large surgical excision was indicated that was performed on September 2017. Thus a 3.5 × 4.5 x 2.5 cm spindle shaped resection was carried out, including the skin overlying the tumor and some striated muscle underlying the tumor (latissimus dorsi).

Intraoperative radiography of the specimen was performed that demonstrated clear macroscopic margins with a well localized nodule in the center of the specimen.

At macroscopic evaluation the nodule was solid, gritty and whitish in color, poorly circumscribed with a maximum diameter of 1.7 cm, close to the posterior resection margin (0.1 cm), with a growth pattern mimicking malignancy. The final pathology evaluation confirmed the diagnosis of benign GCT.

Postoperative course was uneventful and last follow-up visit at 11 months showed no signs of recurrence.

4. Discussion

4.1. Clinical case 1

Several aspects of this first clinical case make it of particular interest. First, the presentation in a previously operated breast might raise the possibility of a rare variant of GCT, i.e. traumatic cell neuroma, described by Rosso et al. (Rosso and Scelsi, 2000) In 2014 the patient's

right breast was operated with an extensive oncoplastic procedure by double glandular flap and implant placement under the pectoral muscle. Such an extensive surgical trauma might induce a surgical scar also in the upper outer quadrant with subsequent formation of GCT.

Microcalcifications are an unusual and interesting feature of this case; very few descriptions of GCTs in association with microcalcifications can be found in literature (Jagannathan, 2016; Delaloye et al., 2002). Their presence, in this particular case could be related to lipogranulomas which have likely developed after extensive surgical oncoplastic breast remodeling. In this case the adjacent GCT can be interpreted as an incidental finding. Microcalcifications contributed to mimic breast malignancy and thus eventually needed excision. Unfortunately, the tumor's peripheral localization in a small breast was deemed inadequate to safely conduct a core needle biopsy. Finally, the patient had to undergo surgical biopsy in the absence of any histological diagnosis. This approach that is not recommended by the EUSOMA quality criteria, may indeed induce significant anxiety for the patient. (Biganzoli et al., 2017)

Concerning the IHC profile, CD 68 is a marker of lysosomal activity and stains positive in 90% of GCT-Bs; PGP9.5 glycoprotein has been indicated, together with inhibin-α, vimentin, calretinin, CD57 and Bcl-2 as a possible marker for GCT-B despite not widely reported. The S100 protein, found also in neural cells, Schwann cells, melanocytes, fat tissue and myoepithelial cells is described as constantly positive in GCTs and considered a sensitive marker for such entity. It is worth to note that the immunostaining for the S100 protein was not assessable in this particular case, contributing to the diagnostic uncertainty.

4.2. Clinical case 2

The complexity of our second case begins with the very unusual site of presentation. Even if GCTs have been repeatedly described in the limbs, their appearance close to the axillary region seems to be extremely rare, adding to the intrinsic difficulty of a differential diagnosis with recurrence of BC distant to the breast and soft tissue sarcoma.

Pohlodek et al. and Aoyama and co-workers reported two cases of axillary GCTs; Delaloye et al. reported a rare case of multiple synchronous benign GCTs, including one in the right shoulder (Pohlodek et al., 2018; Aoyama et al., 2012; Delaloye et al., 2002) In order to avoid overtreatment, clinicians should be aware of this possible finding in the differential diagnosis of masses both in the breast and axillary crease, particularly if patients are known for BC.

Even if PET/CT is described as the only imaging technique able to correctly differentiate GCTSs from malignant tumors, the uncommonness of such a finding can lead the specialist in nuclear medicine, particularly in patients with a previous BC history, to suggest further invasive investigations even in the presence of only modest increase in metabolic activity. Our clinical case clearly exemplifies this.

Histologic examination of the core biopsy pointed out a benign form of GCT and final diagnosis was established using IHC. In line with the typical profile of GCTs, immunostaining for S100 protein was positive, while anti-cytokeratin antibodies were negative. IHC can help to distinguish GCTs from breast malignancies as only a small proportion of BCs stain positive for S100 protein and only carcinomas of the breast stain positive for cytokeratins.

The recognized treatment for benign GCTs is wide local excision followed by annual follow-up. In this case the posterior resection margin (although extending into the superficial region of the posterior area of the latissimus dorsi muscle) accounted for only 1 mm. Although scarce for a tumor that requires wide local excision, no further resection was indicated after multidisciplinary discussion, confirming once again the lack of standardization in treating these rare tumor entities.

5. Conclusions

Granular cell tumors are rare findings arising from cells of mesenchymal origin with neurogenic features. They can be ubiquitous, only rarely affecting the breast, namely 1:1000 breast tumors. The majority of GCTs-B are benign lesions, while tumors with malignant characteristics represent about 1–2 % of GCTs-B (Corso et al., 2018) Only less than 5% of GCT-B arise in patients previously treated for invasive BC.

Although rare, we could envision a possible progressive increase in their clinical significance as a consequence of both the diffusion of secondary prevention programs and the widespread use of plastic surgery procedures for esthetic or oncoplastic purposes.

Breast remodeling surgeries, such as reduction mammoplasties or mastopexis as well as fat grafting procedures are inevitably associated with scarring phenomena and fat necrosis, with subsequent cell debris accumulation and calcium deposition with the final result of microcalcifications formation within the breast parenchima (Khatcheressian et al., 2013; Emens and Davidson, 2003; Noor et al., 2016; Gigli et al., 2017).

As a matter of fact, a granular cell lesion variant, namely *traumatic granular cell neuroma*, slowly growing close to surgical scars and mimicking breast carcinoma has already been described (Rosso and Scelsi, 2000).

In this context, breast screening programs with early detection of microcalcifications might also play a role leading to incidental discovery of GCTs, or their traumatic variants, as in our clinical case 1.

These phenomena can be particularly significant for BC patients, often treated with oncoplastic procedures, sometimes bilateral. Any growing lesion with suspicious radiological features within this particular population must elicit invasive investigations to rule out the occurrence of tumor recurrence and thus induces a high degree of anxiety that might also end up in undue surgical procedures.

Mimicry of BC recurrence induces high psychological distress, both in the patient and the physician throughout the entire diagnostic and therapeutic process. Clinical and radiological investigations usually do not provide pathognomonic findings. Despite a nonspecific macroscopic appearance, their histological features and IHC profile are on the contrary distinctive.

Clinicians should be aware of this rare entity in order to prevent undue psychological distress and overtreatment. Accurate final diagnosis using adequate imaging and core biopsy is essential as misdiagnosis of malignancy can lead to inappropriate radical treatment.

Treatment of choice consists of radical local excision with margin assessment (no tumor on ink) which is commonly associated with a good long-term prognosis. SNB is not indicated, unless preoperative biopsy indicates malignant features (1–2% of GCTs-B). No adjuvant therapy are indicated, however after surgical excision follow-up for 10 years is strongly recommended, as long-term recurrences have been reported, even in the presence of adequate resection margins (Althausen et al., 2000).

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Declaration of Competing Interest

No Author has any conflict of interest to declare.

References

Adeniran, A., Al-Ahmadie, H., Mahoney, M.C., Robinson-Smith, T.M., 2004. Granular cell tumor of the breast: a series of 17 cases and review of the literature. Breast J. 10 (November-December (6)), 528–531 Review.

Althausen, A.M., Kilwaski, D.P., Ludwig, M.E., et al., 2000. Granualr cell tumors: a new clinically important histologic finding. Gynecol. Oncol. 77, 310–313.

Aoyama, K., Kamio, T., Hirano, A., Seshimo, A., Kameoka, S., 2012. Granular cell tumors: a report of six cases. World J. Surg. Oncol. 29 (September (10)), 204. https://doi.org/

10.1186/1477-7819-10-204.
Biganzoli, L., Marotti, L., Hart, C.D., Cataliotti, L., Cutuli, B., Kühn, T., Mansel, R.E., Ponti, A., Poortmans, P., Regitnig, P., van der Hage, J.A., Wengström, Y., Rosselli Del Turco, M., 2017. Quality indicators in breast cancer care: an update from the EUSOMA working group. Eur. J. Cancer 86 (November), 59–81.
Brown, A.C., Audisio, R.A., Regitnig, P., 2011. Granular cell tumour of the breast. Surg. Oncol. 20 (June (2)), 97–105. https://doi.org/10.1016/j.suronc.2009.12.001.
Chen, J., Wang, L., Xu, J., Pan, T., Shen, J., Hu, W., Yuan, X., 2012. Malignant granular cell tumor with breast metastasis: a case report and review of the literature. Oncol. Lett. 4 (July (1)), 63–66. https://doi.org/10.3892/ol.2012.702. Epub 2012 May 2.
Chetty, R., Kalan, M.R., 1992. Malignant granular cell tumor of the breast. J. Surg. Oncol. 49 (February (2)), 135–137 Review.
Corso, G., Di Nubila, B., Ciccia, A., De Camilli, E., Vicini, E., Trentin, C., Lissidini, G., Cairns, L., Veronesi, P., Galimberti, V., 2018. Granular cell tumor of the breast: molecular pathology and clinical management. Breast J. 1.
De Simone, N., Aggon, A., Christy, C., 2011. Granular cell tumor of the breast: clinical and pathologic characteristics of a rare case in a 14-year-old girl. J. Clin. Oncol. 29 (August (22)), e656–7.
Delaloye, J.F., Seraj, F., Guillou, L., Genton, C.Y., Anciaux-Le Teno, D., Schnyder, P., De Grandi, P., 2002. Granular cell tumor of the breast: a diagnostic pitfall. Breast 11 (August (4)), 316–319. https://doi.org/10.1054/brst.2002.0421.
Edge, S.B., Byrd, D.R., Compton, C.C., et al., 2010. AJCC Cancer Staging Manual, 7th ed. Springer, New York, NY.
Emens, L.A., Davidson, N.E., 2003. The follow-up of breast cancer. Semin. Oncol. 30, 338–348.
Fanburg-Smith, J.C., Meis-Kindblom, J.M., Fante, R., Kindblom, L.G., 1998. Malignant granular cell tumor of soft tissue: diagnostic criteria and clinicopathologic correlation. Am. J. Surg. Pathol. 22 (July (7)), 779–794 Erratum in: Am J Surg Pathol 1999 Jan;23(1):136.
Gavriilidis, P., Michalopoulou, I., Baliaka, A., Nikolaidou, A., 2013. Granular cell breast tumour mimicking infiltrating carcinoma. BMJ Case Rep. 18 (February) 2013.
Gibbons, D., Leitch, M., Coscia, J., Lindberg, G., Molberg, K., Ashfaq, R., Saboorian, M.H., 2000. Fine needle aspiration cytology and histologic findings of granular cell tumor of the breast: review of 19 cases with Clinical/Radiologic correlation. Breast J. 6 (January (1)), 27–30.
Gigli, S., Amabile, M.I., Di Pastena, F., Manganaro, L., David, E., Monti, M., D'Orazi, V., Catalano, C., 2017. Ballesio L Magnetic Resonance Imaging after Breast Oncoplastic Surgery: An Update. Breast Care Basel 12 (September (4)), 260–265. https://doi.org/10.1159/000477896. Epub 2017 Aug 10.
Goldhirsch, Winer, E.P., Coates, A.S., Piccart-Gebhart, R.D.G., Thürlimann, B., Senn, H.-J., Panel members, 2013. Personalizing the treatment of women with early breast cancer: highlights of the St Gallen International Expert Consensus on the Primary Therapy of Early Breast Cancer 2013. Ann. Oncol. 24 (September (9)), 2206–2223. https://doi.org/10.1093/annonc/mdt303.
Hoess, C., Freitag, K., Kolben, M., Allgayer, B., Laemmer-Skarke, I., Nathrath, W.B., Avril, N., Roemer, W., Schwaiger, M., Graeff, H., 1998. FDG PET evaluation of granular cell tumor of the breast. J. Nucl. Med. 39 (August (8)), 1398–1401.
Irshad, A., Pope, T.L., Ackerman, S.J., Panzegrau, B., 2008. Characterization of sonographic and mammographic features of granular cell tumors of the breast and estimation of their incidence. J. Ultrasound Med. 27 (March (3)), 467–475.
Jagannathan, D.M., 2016. Benign granular-cell tumor of the breast: case report and literature review. Radiol. Case Rep. 10 (February (2)), 1116. https://doi.org/10.2484/rcr.v10i2.1116.
Khatcheressian, J.L., Hurley, P., Bantug, E., Esserman, L.J., Grunfeld, E., Halberg, F., Hantel, A., Henry, N.L., Muss, H.B., Smith, T.J., Vogel, V.G., Wolff, A.C., Somerfield, M.R., Davidson, N.E., 2013. American Society of Clinical Oncology Breast cancer follow-up and management after primary treatment: american Society of Clinical Oncology clinical practice guideline update. J. Clin. Oncol. 31, 961–965.
Koltsidopoulos, P., Chaidas, K., Chlopsidis, P., Skoulakis, C., 2016. Granular cell (Abrikossoff) tumor in the head and neck: A series of 5 cases. Ear Nose Throat J. 95 (January (1)), 36–39.
Lauwers, K., Bestman, T.J., Bergmans, G., Molderez, C., 2008. Granular cell tumour of the male breast. Acta Chir. Belg. 108 (January-February (1)), 112–114.
Leo, C., Briest, S., Pilch, H., Schütz, A., Horn, L.C., Leinung, S., 2006. Granular cell tumor of the breast mimicking breast cancer. Eur. J. Obstet. Gynecol. Reprod. Biol. 127 (August (2)), 268–270 Epub 2006 Jul 18.
Machado, I., Cruz, J., Lavernia, J., Llombart-Bosch, A., 2016. Solitary, multiple, benign,atypical, or malignant: the "Granular Cell Tumor" puzzle. Virchows Arch. 468 (May (5)), 527–538. https://doi.org/10.1007/s00428-015-1877-6.
Mariscal, A., Perea, R.J., Castellá, E., Rull, M., 1995. Granular cell tumor of the breast in a male patient. AJR Am. J. Roentgenol. 165 (July (1)), 63–64. https://doi.org/10.2214/AJR.09.3994.
Miller, J.A., Karcnik, T.J., Karimi, S., 2000. Granular cell tumor of the breast: definitive diagnosis by sonographically guided percutaneous biopsy. J. Clin. Ultrasound 28 (February (2)), 89–93.
Moten, A.S., Movva, S., von Mehren, M., Wu, H., Esnaola, N.F., Reddy, S.S., Farma, J.M., 2018. Granular cell tumor experience at a comprehensive cancer center. J. Surg. Res. 226 (June), 1–7. https://doi.org/10.1016/j.jss.2018.01.027.
Nasser, H., Ahmed, Y., Szpunar, S.M., Kowalski, P.J., 2011. Malignant granular cell tumor: a look into the diagnostic criteria. Pathol. Res. Pract. 207 (March (3)), 164–168. https://doi.org/10.1016/j.prp.2010.12.007.
Noor, L., Reeves, H.R., Kumar, D., Alozairi, O., Bhaskar, P., 2016. Imaging changes after breast reconstruction with fat grafting - Retrospective study of 90 breast cancer. Pak. J. Med. Sci. 32 (1), 8–12. https://doi.org/10.12669/pjms.321.9460.
Ohnishi, H., Nishihara, K., Tamae, K., Mitsuyama, S., Abe, R., Toyoshima, S., Abe, E., 1996. Granular cell tumors of the breast: a report of two cases. Surg. Today 26 (11), 929–932.
Ordóñez, N.G., 1999. Granular cell tumor: a review and update. Adv. Anat. Pathol. 6 (July (4)), 186–203 Review.
Patel, A., Lefemine, V., Yousuf, S.M., Abou-Samra, W., 2008. Granular cell tumour of the pectoral muscle mimicking breast cancer. Cases J. 1 (September (1)), 142. https://doi.org/10.1186/1757-1626-1-142.
Pieterse, A.S., Mahar, A., Orell, S., 2004. Granular cell tumor: a pitfall in FNA cytology of breast lesions. Pathology 36 (February (1)), 58–62. https://doi.org/10.1080/00313020310001646640.
Pohlodek, K., Jáni, P., Mečiarová, I., 2018. Granular cell tumor in axillary region: a rare entity. Mol. Clin. Oncol. 8 (April (4)), 582–586. https://doi.org/10.3892/mco.2018.1568.
Qureshi, N.A., Tahir, M., Carmichael, A.R., 2006. Granular cell tumour of the soft tissues: a case report and literature review. Int. Semin. Surg. Oncol. 24 (August (3)), 21.
Rickard, M.T., Sendel, A., Burchett, I., 1992. Case report: granular cell tumour of the breast. Clin. Radiol. 45 (May (5)), 347–348.
Rose, B., Tamvakopoulos, G.S., Yeung, E., Pollock, R., Skinner, J., Briggs, T., Cannon, S., 2009. Granular cell tumours: a rare entity in the musculoskeletal system. Sarcoma 2009, 765927. https://doi.org/10.1155/2009/765927. Epub 2010 Feb 7.
Rosso, R., Scelsi, M., 2000. Carnevali L Granular cell traumatic neuroma: a lesion occurring in mastectomy scars. Arch. Pathol. Lab. Med. 124 (May (5)), 709–711.
Serpa, M.S., Costa-Neto, H., de Oliveira, P.T., da Silveira, É., 2016. de Medeiros AM.Granular cell tumor in two oral anatomic sites. Eur. Arch. Otorhinolaryngol. 273 (October (10)), 3439–3441.
Stavros, A.T., 2004. Breast Utrasound, 1 st ed. Lippincott Williams & Wilkins.
Uzoaru, I., Firfer, B., Ray, V., Hubbard-Shepard, M., Rhee, H., 1992. Malignant granular cell tumor. Arch. Pathol. Lab. Med. 116 (February (2)), 206–208.