What the Research Says about Thermography: An Annotated Bibliography of Research on Using Thermography for Detecting Breast Cancer

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August 18, 2014

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What the Research Says about Thermography

The American Cancer Society does not recommend thermography for finding breast cancer, and this view has been espoused by various organizations whose funding depends on promoting mammography. However, clear research supports the use of thermography. The following research citations indicate that thermography is a valid method for early detection, and prevention, of breast cancer. **The purpose of the annotated bibliography is to describe the effectiveness of thermography to detect breast cancer.**

Key Statistics

- Overall percentage of breast cancers found by thermography: 90% (83%–100%)
- Overall percentage of breast cancers missed by thermography: 9%
- Overall percentage of suspicious thermal images that were not cancer: 10%–30%
- Percentage of women who will acquire breast cancer from thermal imaging: 0%
- Years earlier than mammography that thermography can find cancer: 10

Research Conclusions from Published Studies, by Study Number

2. Thermography is a promising screening tool because it is able to diagnose breast cancer at least ten years in advance [of mammograms].

3. As breast cancer remains the most prevalent cancer in women and thermography exhibited superior sensitivity, we believe that thermography should immediately find its place in the screening programs for early detection of breast carcinoma, in order to reduce the sufferings from this devastating disease.

5. DITI [thermal imaging] is a valuable adjunct to mammography and ultrasound, especially in women with dense breast parenchyma.

6. Infrared imaging offers a safe noninvasive procedure that would be valuable as an adjunct to mammography in determining whether a lesion is benign or malignant.

7. Our initial experience would suggest that, when done concomitantly with clinical exam and mammography, high-resolution digital infrared imaging can provide additional safe, practical, and objective information.

8. An abnormal thermogram is reported as the significant biological risk marker for the existence of or continues [sic: continued] development of breast tumor.

9. Thermography is useful not only as a predictor of risk factor for cancer but also to assess the more rapidly growing neoplasms.

11. We have never recommended biopsy on the strength of an abnormal thermogram alone, but any woman with an abnormal thermogram must be considered to be at high risk and reviewed every 6 months, as the abnormal thermogram may be the earliest indications of a malignant lesion.

13. Over 40 years of research and 800 indexed papers encompassing well over 300,000 women participants has demonstrated infrared imaging's abilities in the early detection of breast cancer.

Key Terms

- *Sensitivity:* "...the percentage of breast cancers detected in a given population, when breast cancer is present." Sensitivity is the percentage of cancer cases the technology finds. A 100% sensitivity would mean the technology finds every case of cancer. A 0.50 (50%) sensitivity means the technology correctly finds cancer half the time. (http://www.cancer.gov/cancertopics/pdq/screening/breast/healthprofessional/page4#Section_81)
- *Specificity:* "the likelihood of the test being normal when cancer is absent" (http://www.cancer.gov/cancertopics/pdq/screening/breast/healthprofessional/page4#Section_81) Specificity is the percentage of screenings that correctly indicate that no cancer is present—how good the technology is at identifying healthy, non-cancerous breasts. This rate is difficult to confirm because women who have "clean" screening findings are unlikely to get re-examined within a short enough time period to assess the accuracy of the initial screening. A 100% specificity would mean the technology never indicates cancer when there is no cancer. A 0.50 (or 50%) specificity means the technology correctly indicates the absence of cancer half the time.
- *False Positive:* "...the likelihood of the test being abnormal when cancer is absent" (http://www.cancer.gov/cancertopics/pdq/screening/breast/healthprofessional/page4#Section_81). With a false positive, the screening indicates abnormalities even through no cancer is present.
- *False Negative:* A finding of no abnormalities (i.e., no cancer) when cancer is present. This is the most "dangerous" statistic. A woman has breast cancer, but the technology doesn't find it. Doctors try to avoid false negatives because they can cause a woman not to seek treatment that she needs.

Annotated Bibliography

1. Thermography Is Not a Feasible Method for Breast Cancer Screening.

Brkljacić B[1], Miletić D, Sardanelli F.
Collegium Antroplogicum (2013)
http://www.collantropol.hr/antropo/article/view/69/31

"Thermography was not validated as a screening tool and the only study performed long ago for evaluating this technology in the screening setting demonstrated very poor results. The conclusion that thermography might be feasible for screening cannot be derived from studies with small sample size, unclear selection of patients, and in which mammography and thermography were not blindly compared as screening modalities. Thermography can not be used to aspirate, biopsy or localize lesions preoperatively since no method so far was described to accurately transpose the thermographic location of the lesion to the mammogram or ultrasound and to surgical specimen. Thermography cannot be proclaimed as a screening method, without any evidence whatsoever."

This opinion is wrong, as demonstrated by the following research studies in this bibliography. However, it is included here to demonstrate the prevailing public opinion of various groups that espouse mammography and reject the efficacy of thermography.

First, the truth of this statement: Thermography is not able to indicate the location of a tumor with sufficient accuracy to perform a biopsy, which is the only way to confirm the presence of cancer. For this reason, highly irregular thermal scans, or a series of scans indicating aggressive physiological activity, are typically followed by an ultrasound, which is capable of providing locality without subjecting the patient to the risks of mammograms.

Second, the error of this statement: Given the inaccuracy of mammograms, comparing thermographic images to mammographic images is an invalid process. Comparing thermographic and mammographic findings to biopsy results is the only means to determine their relative abilities to indicate the presence of cancer. Thus, rather than comparing the two methods directly, each is compared independently to findings from tissue biopsies. Completely blind studies are not possible because patients cannot receive biopsies based solely on thermographic findings. Participants must undergo at least one other procedure. As such, most studies involve women who will receive biopsies on the basis of mammograms, clinical breast exam, and other methods. However, once biopsies are performed, the relative sensitivities of mammography and thermography can be compared by determining how well each method identified cancers.

Third, the falsehood of this statement: As the following citations demonstrate, more than one study of thermography has been conducted, recent studies have been performed, studies include large population sizes, patient selection is clear, and results indicate that thermography, whether conducted alone or in conjunction with other screening methods, is capable of identifying breast cancer accurately and long before other methods.

2. Breast Imaging: A Survey
Subbhuraam Vinitha Sree, Eddie Yin-Kwee Ng, Rajendra U Acharya, and Oliver Faust
World Journal of Clinical Oncology (2011)
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3100484/

"Cancerous and pre-cancerous tissues have a higher metabolic rate resulting in growth of new blood vessels supplying nutrients to the fast growing cancer cells. As a consequence, the temperature of the area surrounding the pre-cancerous and cancerous breast tissue is higher when compared to the normal breast tissue temperature...Measurable changes were observed in skin temperatures between clinically healthy and cancerous breasts."

This research survey describes the valid scientific understanding of cancer, which explains how thermography identifies cancer. With infrared technologies to take images of heat, the heat from cancerous and pre-cancerous tissue is observable and distinguishable from healthy tissue.

"Nowadays, breast thermograms are widely used for the accurate detection of breast cancer. Thermography is a promising screening tool because it is able to diagnose breast cancer at least ten years in advance. However, both analysis and interpretation of thermograms depends on analysts."

Thermography finds cancer at least—more than—10 years before mammograms, when it is more easily treated. With a trained thermographer taking the images and a trained analyst interpreting the images, thermography is an effective tool for early cancer detection.

3. Thermography—A Feasible Method for Screening Breast Cancer?
Kolarić D, Herceg Z, Nola IA, Ramljak V, Kulis T, Holjevac JK, Deutsch JA, Antonini S.
*Collegium Antroplogicum (*2013)
http://www.ncbi.nlm.nih.gov/pubmed/23941007

"Statistical analysis of the data has shown a probability of a correct mammographic finding in 85% of the cases (sensitivity of 85%, specificity of 84%) and a probability of a correct thermographic finding in 92% of the cases (sensitivity of 100%, specificity of 79%). As breast cancer remains the most prevalent cancer in women and thermography exhibited superior sensitivity, we believe that thermography should immediately find its place in the screening programs for early detection of breast carcinoma, in order to reduce the sufferings from this devastating disease."

Based on a variety of very large studies, mammograms have a sensitivity of 79% to 84.4% across all age groups (though some studies put sensitivity of mammograms as low as 43%). With an overall 92% probability of a correct thermographic finding, which indicates a high degree of both true positives and true negatives, thermography is a valid and reliable screening tool. Note that thermography identified every case of cancer in study participants—100% sensitivity. In this study, 26 women scheduled for biopsies were screened with thermography. Though a small study, the findings from this study suggest the overall value of thermography for identifying breast cancer.

4. The Accuracy of Digital Infrared Imaging for Breast Cancer Detection in Women Undergoing Breast Biopsy.

Wishart GC1, Campisi M, Boswell M, Chapman D, Shackleton V, Iddles S, Hallett A, Britton PD.

European Journal of Surgical Oncology (2010)

http://www.ncbi.nlm.nih.gov/pubmed/20452740

"Mammography has a lower sensitivity for breast cancer detection in younger women and those with dense breasts. Recent improvements in digital infrared breast imaging suggest there may be a role for this technology and we have studied its performance in 100 women prior to breast needle core biopsy (CB)."

This statement indicates what is well known about limitations of mammograms: they don't work well for younger women and women of any age with dense breasts. This study examined 100 women who would undergo biopsies to determine, definitively, whether suspicious findings were, in fact, cancer.

"DIB using NoTouch is an effective adjunctive test for breast cancer detection in women under 70 and appears to be particularly effective in women under 50 where maximal sensitivity (78%) and specificity (75%) were observed. The combined sensitivity of NoTouch BreastScan and mammography in women under 50 was encouraging at 89%, suggesting a potential way forward for a dual imaging approach in this younger age group."

NoTouch is a commercial name for one thermography system. Note that thermography sensitivity was best in younger women (under 50 years of age), which is the population in which mammography produces the least sensitivity. As such, thermography may be useful for identifying cancers at an early stage, even before most women begin receiving mammograms. Interestingly, the thermography sensitivity found in this study was less than generally found in other studies (see Arora et al., 2008; Parisky et al., 2003), though the combination of mammography and thermography produced sensitivity better than either alone.

5. Effectiveness of a Non-Invasive Digital Infrared Thermal Imaging System in the Detection of Breast Cancer.

Nimmi Arora, M.D., Diana Martins, B.S., Danielle Ruggario, B.S., Eleni Tousimis, M.D., Alexander Swistel, M.D., Michael Osborne, M.D., Rache Simmons, M.D.

Department of Surgery, New York Presbyterian Hospital—Cornell, NY; American Society of Breast Surgeons

American Journal of Surgery (2008)

Abstract: http://www.americanjournalofsurgery.com/article/S0002-9610(08)00475-3/abstract

Full text: http://www.holisticcarehawaii.com/Therm%20Article.pdf

"In this prospective clinical trial of 92 women undergoing DITI with suspicious breast lesions identified on prior mammograms or ultrasound, we have shown that SBS [a commercial name for one thermal imaging system] can detect breast pathology with sensitivity up to 97% and a negative predictive value up to 82%."

Researchers used DITI (digital infrared thermal imaging) on 92 women scheduled for biopsies based on mammographic and ultrasound findings with the intent of learning whether thermography could identify which lesions were cancerous.

The 97% sensitivity means thermography found 97% of all cancers. By contrast, mammograms have a sensitivity of approximately 84% and a false negative rate of 21%. The 82% negative predictive value is the likelihood that a non-suspicious thermograph screening accurately predicts the absence of cancer. This is the rate of true negatives, or specificity. The specificity rate indicated here is fairly consistent across studies.

"DITI identified 58 of 60 malignancies, with 97% sensitivity, 44% specificity, and 82% negative predictive value. Conclusion: DITI is a valuable adjunct to mammography and ultrasound, especially in women with dense breast parenchyma."

60 lesions were cancerous, and thermography found all but 2, producing a 3% false negative rate, meaning thermography would miss 3 cancers among 100 cases, far better than the 21% false negative rate of mammograms. This study did not examine women with "clear" mammogram findings because those women were not eligible for biopsies. Note also that 92 women were biopsied based on mammograms but only 60 had proved cancer cases, for a false positive rate of mammograms of 34.7%.

"While previous studies were limited by equipment, resolution, and sensitivity capabilities, the more sophisticated imaging and analytical tools available today make it possible to use DITI and artificial neural networks to detect malignancy with up to 100% sensitivity."

The central point here is that the technology has significantly improved to the point that it may find every case of breast cancer (see Parisky et al., 2003).

6. Efficacy of Computerized Infrared Imaging Analysis to Evaluate Mammographically Suspicious Lesions.
Parisky YR1, Sardi A, Hamm R, Hughes K, Esserman L, Rust S, Callahan K.
American Journal of Roentgenology (2003)
http://www.ajronline.org/doi/full/10.2214/ajr.180.1.1800263

[A 4-year clinical trial was conducted at five institutions using infrared imaging of patients for whom breast biopsy had been recommended. The blinded subject set included 769 subjects with 875 biopsied lesions.]

"In the 875 biopsied lesions, the index of suspicion resulted in a 97% sensitivity, a 14% specificity, a 95% negative predictive value, and a 24% positive predictive value. Lesions that were assessed as false-negative by infrared analysis were microcalcifications, so an additional analysis was performed in a subset excluding lesions described only as microcalcification. In this restricted subset of 448 subjects with 479 lesions and 110 malignancies, the index of suspicion resulted in a 99% sensitivity, an 18% specificity, a 99% negative predictive value, and a 27% positive predictive value. Analysis of infrared imaging performance in all 875 biopsied lesions revealed that specificity was statistically improved in dense breast tissue compared with fatty breast tissue."

As determined by comparing all thermographic findings to all biopsy results, thermography had a sensitivity of 97%, meaning thermography found 97% of all cancers. Of the overall data set, false negatives on thermal images were actually microcalcifications. They were classified as false negatives because although the thermal image did not indicate the physiological processes associated with cancer, the breast tissue was abnormal. Microcalcifications are usually non-cancerous but they look suspiciously like cancer on a mammogram. Once those cases were

removed from the data set, thermographic sensitivity increased to 99%, meaning the thermography screenings correctly identified 99% of all breast cancer cases. In only one case (see Table 2) did one of the three thermal image evaluators fail to identify a malignant lesion.

Table 2: Infrared Imaging Results for Subset of Biopsied Lesions Excluding Microcalcifications

Infrared Image Result	Number of Lesions Assessed	Pathology Result
True-Positive	291	Malignant
True-negative	171	Benign
False-positive	768	Benign
False-negative	1	Malignant
Total	1231	-

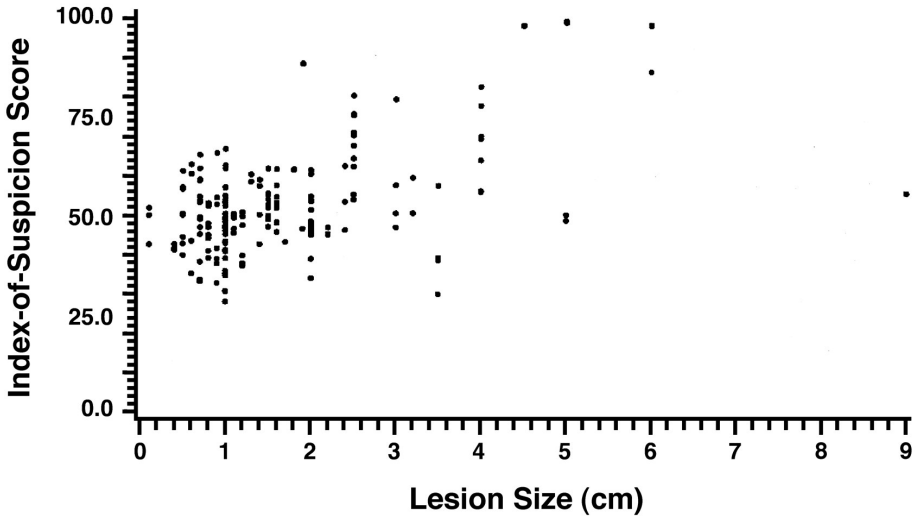
The thermographic images for each of the 479 lesions were provided to three independent evaluators for assessment. The false positive rate is 62.3%, compared to the false positive rate of mammograms of 71% to 95.7%. Other researchers (see Keyserlingk et al.,1998) note that a false positive at the time of thermographic screening may predict a future occurance of breast cancer, meaning the thermal indicators suggest pre-cancer symptoms rather than cancer. If so, the precancerous conditions identified by thermography can be treated and resolved before they become cancer.

"The infrared findings [microcalcifications omitted] had resulted in a sensitivity and negative predictive value of more than 99% (95% CI, 96-100%) with 291 true-positive results and one false-negative result. The false-negative result in this subset was for case 1 (Table 2), which we described earlier in this article. Although all three evaluators attempted to assess this lesion on infrared imaging, two of the three did not think that the quality of the infrared image was acceptable for analysis. When the same subset was restricted further to include only the cases for which all three evaluators had completed an assessment, the sensitivity and negative predictive value were 100%, the specificity was 19%, and the positive predictive value was 27%."

Overall, this indicates that reviewers and image clarity can affect the accuracy of the findings. In a few cases, lesions were not evaluated by all three evaluators. By limiting the data set to only those screenings with three evaluators, thermography increased from 99% to 100% sensitivity—thermal screening found every case of cancer.

"Of 875 lesions evaluated, 55 were found in almost entirely fat breast tissue (sensitivity = 100%); 315 lesions, in scattered fibroglandular breast tissue (sensitivity = 94%); 395 lesions, in heterogeneously dense breast tissue (sensitivity = 98%); 110 lesions, in extremely dense breast tissue (sensitivity = 100%)."

Thermographic screenings were weakest in fibroglandular breast tissue, though the 94% sensitivity rate is still higher than mammographic screening. Note that the specificity was 100% in extremely dense breast tissue, which indicates that, unlike mammography, thermography is well suited to screenings for younger women and may lead to earlier detection of breast cancer.



Thermographic screening found malignant lesions at 0.2 cm size. This indicates that the physiological response detected by thermal imaging begins very early in cancer growth when the tumor is small and most easily treated.

"Infrared imaging offers a safe noninvasive procedure that would be valuable as an adjunct to mammography in determining whether a lesion is benign or malignant."

This is the researchers' conclusion. The FDA has approved thermography as an adjunct to mammography. Although sensitivity was at or near 100%, thermography cannot provide sufficient information to locate a lesion for biopsy. Ultrasounds (i.e., sonography) can provide this missing information.

7. Infrared Imaging of the Breast: Initial Reappraisal Using High-Resolution Digital Technology in 100 Successive Cases of Stage I and II Breast Cancer
J.R. Keyserlingk MD[1,3], P.D. Ahlgren MD[1,3], E. Yu MD, PhD[2,3] & N. Belliveau MD[3]
The Breast Journal (1998)
http://onlinelibrary.wiley.com/doi/10.1046/j.1524-4741.1998.440245.x/abstract

"While the false-negative rate of infrared imaging was 17%, at least one abnormal infrared sign was detected in the remaining 83 cases, including 10 of the 15 patients, a slightly younger cohort, who had nonspecific mammograms."

Although the 17% rate of false negatives in this study is troubling, it is lower than the 21% false negative rate of mammograms. Overall, mammograms miss more tumors than thermal screenings. Thermographic screening did find abnormalities in 83 of 100 cases, for a 83% sensitivity. Of greatest importance, thermal imaging found abnormalies among 10 women with cancer whose mammograms did not clearly suggest the presence of cancer.

"The average size of those tumors undetected by mammography or infrared imaging was 1.66 cm and 1.28 cm, respectively, while the false-positive rate of infrared imaging in a concurrent series of 100 successive benign open breast biopsies was 19%."

Thermography found smaller tumors than mammograms did, meaning it found tumors that were missed by mammograms, resulting in a lower false negative rate and earlier detection.

"Our initial experience would suggest that, when done concomitantly with clinical exam and mammography, high-resolution digital infrared imaging can provide additional safe, practical, and objective information."

This statement is the researchers' final conclusion: thermography is valuable component of early breast cancer detection.

8. A Review of Thermography as Promising Non-invasive Detection Modality for Breast Tumor
E.Y.K. Ng
International Journal of Thermal Sciences (2008)
http://www.breastthermographynyc.com/PDF/A%20review%20of%20thermography%20as%20promising%20non-invasive%20detection.pdf

"From the last 1.5 decades of complying with the strict standardized thermogram interpretation protocols by proper infrared trained personnel as documented in literature, breast thermography has achieved an average sensitivity and specificity of 90%. An abnormal thermogram is reported as the significant biological risk marker for the existence of or continues [sic: continued] development of breast tumor."

Suspicious thermal imaging findings are, indeed, an indicator for breast cancer.

"It was reported that the results of thermography can be correct 8-10 years before mammography can detect a mass and that the error in thermography is that it is 'too right too early.' "

"Too right too early" means seemingly false positives on thermal screenings are accurate indications that a woman has breast cancer before the cancer has grown large enough to be detectable by conventional methods. With the conclusion that thermal imaging finds cancers 8 to 10 years before mammograms, the statement that thermal imaging is "too right too early" is justified.

9. Breast Thermography and Cancer Risk Prediction
Gautherie, M., & Gros, CM
Cancer (1980)
http://www.ncbi.nlm.nih.gov/pubmed/7351006
http://www.dovethermography.com/Portals/1048/Studies/Breast%20Thermography%20and%20Cancer%20Risk%20Prediction%20Gautherie.pdf

"From approximately 58,000 patients, most of whom had breast complaints, examined between August 1965 and June 1977, the conditions or a group of 1,245 women were diagnosed at initial examination as either normal or benign disease by conventional means, including physical examination, mammography, ultrasonography, and fine needle aspiration or biopsy, when indicated, but nevertheless categorized as stage Th III indicating a questionable thermal anomaly. Within five years, more than a third of the group had histologically confirmed cancers."

"Th III" is a term for suspicious thermal imaging findings. Here, women with healthy breasts according to conventional methods had suspicious thermal images. One-third of those women ended up having breast cancer within 5 years. In a standard population, 12.5% of women, not one-third, will get breast cancer. This suggests that while the traditional methods indicated healthy breasts, those methods were wrong and thermal imaging was correct.

"Thermography is useful not only as a predictor of risk factor for cancer but also to assess the more rapidly growing neoplasms."

Note two findings here. First, thermography predicts cancer risk by identifying pre-cancerous conditions. Second, thermography can monitor tumor growth.

"It is worth noting that approximately 90% of patients presenting with Th IV and V have a diagnosis of cancer established on first visit"

This finding corresponds with other research indicating 90% sensitivity. Suspicious and highly suspicious thermographic images accurately identify 90% of breast cancer cases.

"Needless to say, technical skill and expertise in interpretation of the images are required. This is emphasized particularly in view of the criticism that thermography has a high rate of "false-positives," in the range of 10-30%."

In agreement with other research, good images and expert analysis improve the accuracy of thermographic screenings. The same caution applies to all screening methods. Compare this rate of false positives to that of mammography, which has an overall false positive rate of 79%.

"In screening for breast cancer an abnormal thermogram should be regarded as a high risk factor requiring regular follow-up examinations."

Given the early detection by thermography, the rate at which suspicious thermal images predict the future onset of breast cancer, and the ability of tumors to grow quickly, follow-up examinations are critical.

10. Time to Reassess Value of Infrared Breast Imaging?
Cancer Network [Home of the Journal Oncology] (1997)
http://www.cancernetwork.com/articles/time-reassess-value-infrared-breast-imaging

"Researchers from the Ville Marie Breast Center examined infrared imaging in 100 women with noninvasive stage I and II breast cancer. In this study, the 84% sensitivity rate of mammography alone was increased to 95% when infrared imaging was added."

Adding thermal imaging information to the analysis for breast cancer increased the rate at which cancer is accurately identified.

"Clinical examination alone was positive in 61% of the study patients. Mammography was highly suspicious in 65% of patients, with an additional 19% having contributory but nonspecific (intermediate) mammography findings. Infrared imaging was considered abnormal in 83% of patients."

Abnormal (i.e., highly suspicious) mammograms had a sensitivity rate of 65%. Abnormal thermal images had a sensitivity of 83%, which corresponds to other researchers' findings.

"The 16 patients with a noncontributory mammogram were an average of six years younger than the overall group (mean age, 47 years versus 53 years). Among these patients, 11 had an abnormal infrared image, and in eight of these women, who also had negative clinical exams, infrared was the main indicator of a possible abnormality."

Mammograms are less effective for younger women. Thermography detected cancer in younger women whose mammograms were inconclusive or suggested healthy breasts.

"The mean size of tumors undetected by mammography was 1.73 cm versus 1.25 cm for infrared imaging, suggesting that infrared detection is related more to vascular and metabolic changes than strictly to tumor size."

Thermography finds smaller tumors. Tumors missed by thermography are smaller than those missed by mammography. (See also Keyserlingk, 1998, for the same conclusion.)

"Finally, for comparison, the researchers evaluated a series of 100 patients who had benign breast histology at open biopsy. Of these, 19% had an abnormal preoperative infrared study, while 30% had an abnormal mammogram, suggesting sufficient specificity as an adjuvant modality."

Of 100 women with healthy breasts, 19% had suspicious thermal findings. Compare this to the 30% who had suspicious mammograms. The false positive rate for thermography is a third less than for mammograms, indicating far better accuracy.

11. The Screening of Well Women for the Early Detection of Breast Cancer Using Clinical Examination with Thermography and Mammography.
Stark, A. and Way, S.
Cancer (1974)
http://onlinelibrary.wiley.com/store/10.1002/1097-0142(197406)33:6%3C1671::AID-CNCR2820330630%3E3.0.CO;2-4/asset/2820330630_ftp.pdf?v=1&t=hz1xqant&s=20c0986264f0bc61f36fed5b4da6a2f35d7d51b8

We have never recommended biopsy on the strength of an abnormal thermogram alone, but any woman with an abnormal thermogram must be considered to be at high risk and reviewed every 6 months, as the abnormal thermogram may be the earliest indications of a malignant lesion. The highest accuracy in screening occurs in women with both an abnormal thermogram and mammogram.

Although thermography technology has greatly improved since this study, the researchers still found that among their study population of 2,684 women, thermography provided the earliest detection of breast cancer.

12. Value and Interest of Dynamic Telethermography in Detection of Breast Cancer
Amalric, D., et al.
Acta Thermographica (1976)
as cited in *The Biomedical Engineering Handbook: Medical Devices and Systems* by Bronzino, 2006
http://www.medithermclinic.com/breast/BT%20Overview%20Chap%2025.pdf

In a study comprising 25,000 patients screened and 1,878 histologically proven breast cancers, Amalric and Spitalier reported on their results with infrared imaging. From this group a false-negative and false- positive rate of 9% (91% sensitivity and specificity) was found.

In this study, thermography found 91% of all breast cancer cases, with only 9% of cancers missed during thermographic screening, less than half the rate for mammography.

13. The Biomedical Engineering Handbook: Medical Devices and Systems (Chapter 25)
Joseph Bronzino
CRC Press (2006)
http://www.medithermclinic.com/breast/BT%20Overview%20Chap%2025.pdf

Over 40 years of research and 800 indexed papers encompassing well over 300,000 women participants has demonstrated infrared imaging's abilities in the early detection of breast cancer. Infrared imaging has distinguished itself as the earliest detection technology for breast cancer. It has the ability to signal an alarm that a cancer may be forming up to 10 years before any other procedure can detect it. In 7 out of 10 cases, infrared imaging will detect signs of a cancer before it is seen on a mammogram.

Now we turn our attention back to the first citation from Brkljacić et al. (2013), which claimed that "Thermography was not validated as a screening tool and the only study performed long ago for evaluating this technology in the screening setting demonstrated very poor results. The conclusion that thermography might be feasible for screening cannot be derived from studies with small sample size, unclear selection of patients, and in which mammography and thermography were not blindly compared as screening modalities."

The studies cited in this bibliography demonstrate that thermography can be an accurate and useful technology for breast cancer detection. The opinion of Brkljacić et al. and other mammography proponents concerning thermography is wrong. ***Unfortunately, by adhering to this faulty opinion and by unequivocally rejecting thermography, mammography proponents may prevent women from accessing the technology that may save their lives.***